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FOODS

THEIR ORIGIN COMPOSITION AND MANUFACTURE

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FOODS

THEIR ORIGIN, COMPOSITION, AND MANUFACTURE

FOODS

THEIR ORIGIN, COMPOSITION AND MANUFACTURE

LEEDS & WEST RIDING
MEDICO-CHIRURGICAL SOCIETY

BY

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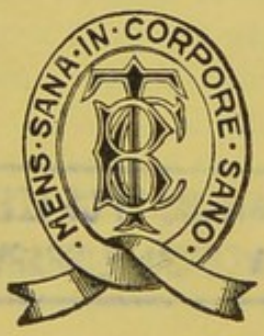

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1912
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PREFACE

THE literature of the chemistry of foods is ever increasing, but it is scattered throughout many books, journals, magazines, the bulletins of Governmental departments, works on the special branches of food analysis, physiological chemistry, and metabolism. In writing the following pages the author had in view the ever-increasing demand for knowledge of this subject by the members of the medical profession, chemists, and others.

The chemistry of foods is closely bound up with the chemistry of the living organism; to apply the former to the science of dietetics, it is necessary to know the chemistry of living tissues; without a knowledge of the chemistry of the human frame, it is impossible to appreciate the difference in the value of various foods to the body. The author has therefore thought it necessary to give an outline of constructive chemistry based on the theory of ions, and also an outline of the chemistry of constituents of the living organism, or what is commonly called "physiological chemistry." It is believed that a careful study of these two branches of science, especially by medical men, is essential to a thorough understanding of the subject of foods and feeding, and without such knowledge the student will fail to grasp the fuller meaning of the science of dietetics.

The great importance of dietetics from a national point of view, as well as from the side of medical science, cannot be too often impressed upon the public. Science alone can establish its necessity. The supply of pure food is a means of establishing the health of the people and the betterment of the human race. The constancy of the Government of progressive countries in their attention to this subject is praiseworthy. Philanthropists cannot better forward the cause of humanity than by the study and application of the science. One of the greatest medical journals says: "A more accurate knowledge of the value of foods in heat units would lead

to a greater precision in the directions given for their administration, and to a more reasonable system of dietetic management, whether in health or disease." The heat value of most foods is given herein. But the remarks of that journal apply with equal cogency to a knowledge of the proportions of protein, fat, carbohydrates, and the mineral salts. A consideration of these substances forms the chief bulk of the following pages.

The author acknowledges his great indebtedness to the published works of Wiley, the late Professor Atwater and his band of co-workers, Robert Hutchison, Bell, Allen, Thorpe, König, and many others whose names are scattered throughout the pages hereof. The journals of chemistry, analysis, physiology, public health, and medicine, have been laid under contribution, besides numerous works on the special departments of food manufacture. To collect the material, bring into line the information from many sources, to draw from opposing parties the pith of their knowledge and apply it to the subject in hand, in order to render the matter as far as possible complete, has been a work of pleasure and source of delight.

W. T.

NOTTINGHAM,
April, 1912.

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FOODS

THEIR ORIGIN, MANUFACTURE, AND COMPOSITION

PART I

CHAPTER I

THE CHEMICAL CONSTITUENTS OF ANIMAL AND VEGETABLE FOODS

Food is necessary to all organisms for their development and growth, to supply them with heat and energy, to make good the losses resulting from the wear and tear of their mechanism, and to keep them in a state of efficiency.

The elements of all our animal and vegetable foods are derived from the inorganic earth, air, and water. It is obvious that animals could not *live* upon inorganic substances or derive nutriment from them, important as such inorganic materials are for many vital processes. The essential parts of animal structures are derived from previously organized materials. Most of these organic compounds arise in the vegetable kingdom as comparatively simple substances, and become elaborated into more complex bodies in the vegetable or animal organism. Therefore it may be said that the constituents of human food, the elements of the human body, are derived from the denizens of the earth, air, and water.

The body of a man weighing 154 pounds consists of the following proximate constituents, which are estimated[1] to be in the proportion stated :

Composition of the Human Body.

	Pounds.	Ounces.
Water	109	0
Albumin, globulin, myosin	16	8
Calcium phosphate	8	12
Fat	4	8
Ossein and collagen	4	7·8
Creatin, creatinin, etc.	4	2
Cartilagen	1	8
Hæmoglobin	1	8
Calcium carbonate	1	0·8
Neurin, lecithin, cholesterin, cerebrin	—	13
Magnesium phosphate	—	7
Inosite and glycogen	—	3
Sodium sulphate, phosphate, and carbonate	—	2·2
Potassium sulphate, phosphate, and chloride	—	1·7
Silica	—	0·1

[1] Bell's "Chemistry of Foods," p. 5.

The materials which compose the structures of man's body are derived from his food, and are in turn composed of elementary inorganic substances to which they can be reduced. The most important of these elements are carbon, hydrogen, oxygen, and nitrogen, which form $\frac{3}{4}$ of the entire weight of the body, and enter into the construction of every cell. There are other elements which, even though they form but a small proportion of the weight of the body, are of prime importance to the proper construction of various special parts of the body—*e.g.*, iron for the blood, and phosphorus for the brain and nerves. A few remarks on these elements will not be out of place.

Carbon occurs free in Nature as graphite, charcoal, and diamond. It forms a very important part of the earth's crust, being a constituent of all the natural carbonates, such as limestone, chalk, and dolomite. It also exists on the surface of the earth as the carbon dioxide of the atmosphere. It is the basis of all organized matter, and leads up to life through a variety of combinations with hydrogen, oxygen, and nitrogen.

Hydrogen occurs in a free state in very small quantities upon the earth, but it is found chiefly in the form of water. It is also abundant in combination with carbon as methane, sulphur as sulphuretted hydrogen, and chlorine as hydrochloric acid. All known acids and almost all organic compounds contain it. It is taken up by plants in the form of water and ammonia. Animals, by using the plants as food, appropriate the compounds containing hydrogen, and assimilate them to their own body. Hydrogen ultimately leaves the body in the form of water and ammonia or such compounds as are speedily reduced to this form.

Oxygen occurs free in the atmosphere, and, in combination with other elements, is the most widely distributed of them all. It forms nine-tenths by weight of water and about half the weight of the rocks which form the earth's crust. It is the only element which enters the animal organism in a free state. Plants take it up principally in the form of water and carbon dioxide ; out of these they synthetize organic substances, which become the most important foodstuffs of man, and, being consumed by him, are utilized, and returned to the atmosphere in the form of water and carbon dioxide. A balance is thus held between the oxygen and carbonic acid of the atmosphere ; animals give to the air the CO_2 required by plants for synthetic processes, and plants yield the oxygen needed by animals and man for the purposes of oxidation. There is an antagonistic relation between the two gases which is beneficial to the entire organic world.

Nitrogen in a free state forms four-fifths of the atmosphere. In combination it is found in ammonia, nitrates, and the nitrogenous constituents of animals and plants. The nitrates and nitrites exist in soils and water. They arise in part from the decomposition of previously-formed organic material, and partly from the action of nitric acid upon inorganic bases. Nitrite of ammonia is, to a small extent, formed in the atmosphere during thunderstorms, by the union of nitrogen with water—$2N + 2H_2O = NH_4NO_2$.

As a general rule, nitrogen can only enter into organic nature in

the form of compounds—*e.g.*, ammonia, nitrites, and nitrates. These simple bodies are transformed by plants into proteins. Vegetable proteins are consumed by animals in their vegetable foods, and converted into the animal proteins of the blood and tissues. During the metabolism of the animal body such proteins become reduced to quarternary or ternary compounds of nitrogen, and leave the organism chiefly in the form of urea, creatin, and ammonia.

Sulphur occurs in a free state in various parts of the world, but in such a form it is of no use to organic bodies. It exists in the soil in the form of sulphates of the alkalies and alkaline earths. As such it is absorbed by vegetable organisms, which utilize it in the construction of the protein molecule. It is in the form of protein only that animals can utilize sulphur, and, having utilized it for metabolic purposes, excrete it in the form of ethereal sulphates or as a constituent of bile, hair, and nails. The advantage or disadvantage of the presence of inorganic sulphur in our food is unknown, but of its importance in the organic form there is no shadow of doubt. The amount of sulphur in various constituents of our food is not well known, but Richet[1] states that it exists in the following proportion in some of them :

SULPHUR IN DRIED PROTEINS.

	Per Cent.
Egg-white	1·80
Syntonin	1·80
Albumin of wheat	1·55
Albumin of peas	0·40
Gluten	0·70

Phosphorus does not occur in a free state, nor could it be used by plants or animals in that form. It is, however, widely distributed in combination with the alkalies and alkaline earths. Calcium phosphate is present in all fertile soils. The presence of phosphates in the soil is essential to the growth of plants. In this form only is it taken up by plants, whence it passes into the animal kingdom and forms an important portion of the bones, brain, and nerves. There is, however, a difference in the form of the phosphorus in these tissues. In the bones it exists as phosphate of calcium and other alkaline earths, which enter the body in an inorganic form, and together form 60 per cent. of the substance of the bones. On the other hand, the phosphorus of the important or vital cellular elements consists of nuclein and various phosphorized fats or lipoids, such as lecithin, cerebrin, and cholesterin, which are constituents of practically every living cell. It enters the animal body in the form of nuclein, lecithin, phospho-carnic acid and glycero-phosphoric acid, and also in the proteins of our food ; and it leaves the body as phosphates—that is, in the inorganic condition in which it originally entered the vegetable kingdom.

[1] "Dictionary of Physiology."

Organic phosphorus is therefore present in all the cellular elements of our food, and especially in the yolk of egg, sweetbread, fish roe, and the germ of cereals and legumes. The amount of phosphorus in various foods, reckoned as phosphoric acid, is shown in the following tables :

P_2O_5 PER CENT. IN FRESH FOODS.[1]

Animal.		*Vegetable.*	
Pork	0·160	Carrot	0·036
Milk	0·220	Turnip	0·058
Beef	0·285	Cabbage	0·089
Eggs	0·337	Potato	0·140
White cheese	0·374	Chestnuts	0·200
Mutton	0·425	Barley	0·230
Gruyère cheese	1·350	Haricot beans	0·924

P_2O_5 PER CENT. IN WATER-FREE SUBSTANCE.[2]

Wheat flour	0·357
Haricot flour	1·077
Camembert cheese	1·102
Brie cheese	1·272
Cabbage	1·625
Lean beef	1·894
Gruyère cheese	2·475
Yolk of egg	2·843

Iron, although one of the most widely distributed elements, occurs in the uncombined state only in small quantities, and as such is of no use in organic nature. It occurs in the earth in combination with oxygen, and is taken up by plants as an inorganic oxide. There are two forms : ferric oxide, which is a weak base, unable to fix carbonic acid ; and ferrous oxide, which is a strong base, and forms neutral salts with all acids. Iron is of extreme value as a carrier of oxygen, and especially so in organic life. It is concerned in the production of chlorophyll ; without it the plant becomes pale and etiolated. As a part of vegetables it is consumed by animals, and utilized in the construction of hæmatogens (iron-containing compounds of nucleo-albumin) and hæmoglobin (the oxygen-carrier of the blood). Boussingault[3] gives the following table showing the percentage of iron in various food materials :

IRON IN FRESH SUBSTANCE.

	Per Cent.		Per Cent.
Blood of pig	0·06340	Maize	0·00360
Blood of ox	0·03750	Veal	0·00270
Oats	0·01310	Apples	0·00200
Lentils	0·00830	White fish	0·00150
Haricots	0·00740	Potatoes	0·00160
Egg	0·00570	Milk	0·00180
Beef	0·00480	Rice	0·00150
Wheaten bread	0·00480	Carrots	0·00090
Spinach	0·00450	Burgundy	0·00190
Cabbage	0·00390	Beer	0·00040

[1] Girard : *Compt. Rend.*, 1896, cxxii. 1387.
[2] Fleurent : *Chemical News*, 1906, ii. 16.
[3] *Compt. Rend.*, 1872, lxxiv. 1356.

Instructive as Boussingault's list may be, it cannot be accepted without confirmation. The proportion given is considered by some authorities to be too high. Bunge gives the following order of foods containing iron, the ash of spinach containing most, and milk least: Spinach, 0·045; yolk of egg, 0·04; beef, 0·02; apples, 0·02; lentils, strawberries, white beans, peas, 0·024; egg-white, 0·026; wheat, 0·026; potato, milk, 0·003 per cent. Stockmann[1] estimates that the average adult diet contains 10 milligrammes of iron per diem, and

1 pint of milk contains 2·2 milligrammes of iron.
100 grammes of oatmeal contain 3·1 milligrammes of iron.
300 grammes of fine bread contain 1·8 milligrammes of iron.
280 grammes of common bread contain 1·1 milligrammes of iron.
120 grammes of beefsteak contain 4·7 milligrammes of iron.

Amongst animal foods, therefore, there is most iron in beef and yolk of egg, and least in milk. Oatmeal and lentils are, according to Stockmann, the vegetables which contain most iron, but spinach and apples contain a good deal, bread and potatoes some. The food is the chief and only natural source of iron in the animal world.

Manganese is a constituent of various foodstuffs; it occurs in considerable quantity in some plants and in animal tissues; but its significance is not well understood.

Silicon exists in abundance in the soil, and, in combination with oxygen, is absorbed by plants. The Graminaceæ are rich in silicates. Animals ingest them with their food; a small portion is absorbed from the alimentary canal, and appears to be of importance for the growth of hair.

Fluorine occurs in small quantities in most animals and vegetables; in the former it occurs especially in the bones and teeth. It is taken up by plants from the soil, where it occurs in combination with calcium. Plants are never without it. Whether it is a necessity of animal existence is unknown, but, considering the small amount of iron in animal blood and its importance therein, it is impossible to say that fluorine is unnecessary. A recognizable quantity has been found in cow's milk, yolk of eggs, and brain. Bunge[2] says: "It is conceivable that milk, although rich in the important substances of nutrition, might yet be useless for the growth of the infant without the necessary trace of fluorine."

Iodine is taken up from sea-water by marine plants. These in turn are consumed by fishes and crustacea, where it forms a compound with other substances in the animal organism. It is only present in very small quantity in the ductless glands of the human body. Bourcet[3] found that mature plants and fish contain the following amount of iodine:

[1] *Brit. Med. Jour.*, 1895, December 14.
[2] "Physiological and Pathological Chemistry," p. 24.
[3] *Bull. Soc. de Chim. de Paris*, (3) xxiii., No. 1.

IODINE IN PLANTS: MILLIGRAMMES PER KILO.

Solanaceæ:		Leguminosæ:	
Potato	0·000	Beans	0·140
Tomato	0·070	Kidney beans	0·013
Egg-plant	0·010	French beans	0·320
Cucurbitaceæ:		Green peas	0·084
Gherkin	0·000	Polygonaceæ:	
Cucumber	0·012	Sorrel	0·047
Pumpkin	0·017	Umbelliferæ:	
Melon	0·060	Carrot	0·000
Cruciferæ:		Parsley	0·000
Radish	0·180	Chervil	0·140
Radish (long)	0·160	Cichorieæ:	
Turnip	0·240	Endive	0·000
Chenopodiaceæ:		Chicory	0·000
Beetroot	0·140	Lettuce	0·096
Spinach	0·021		

IODINE IN FISH: MILLIGRAMMES PER KILO.

Smoked herring	1·7 to 2·0	Periwinkle	0·75
Mussels	1·9	Carp	0·6
Portuguese oysters	1·3	Mullet	0·6
Salmon	1·4	Shrimps	0·7
Gurnard	1·2	Herring roe	0·8
Cod (soft)	1·2	Herring soft roe	0·6
Roach	1·2	Sardines	0·6
Bream	1·2	Pike	0·3
Ling	1·2	Whiting	0·3
Coalfish	0·9	Mackerel	0·3
Eel	0·8	Ray and skate	0·2
Sole	0·8	Gudgeon	0·12

Arsenic occurs in the earth as orpiment or sulphide of arsenic. It is found in minute traces in animals and vegetables, but it has not until recently been considered essential to their well-being. Gabriel Bertrand,[1] however, as the result of numerous experiments, arrived at the conclusion that arsenic, instead of being a constituent of a few tissues only, is a constant element of the living cell, like carbon, sulphur, and phosphorus. He found arsenic constantly present in the eggs of all fowls, in quantities varying from $\frac{5{\cdot}0}{1000}$ to $\frac{0{\cdot}5}{1000}$ milligramme per egg, according to the part examined; two-thirds of the total amount is in the yolk, the remaining third in the white, shell, and lining membrane.

Copper occurs in the earth in a metallic form, and enters into the composition of many vegetable and animal tissues. The quantity is always small, and it is unknown whether its presence has any special significance. It appears to be always present in the liver, and is excreted in the urine by the kidneys. The amount found in vegetables by Galippa and in animal tissues by Lehmann is as follows:[2]

[1] *Bull. de la Soc. Chim. de Paris*, 1904, xxix., No. 15.
[2] *Chemical News*, 1893, ii. 286.

COPPER IN VEGETABLE TISSUES.

1 kilo of grain contained 5 to 10 milligrammes.
" flour contained 8 milligrammes.
" bread contained 1 to 4 milligrammes.
" potatoes contained 2 milligrammes.
" grean beans contained 2·2 milligrammes.
" beans from Soissons contained 11 milligrammes.
" lentils contained 6·8 milligrammes.
" cocoa contained 11 to 29 milligrammes.
" chocolate contained 5·2 milligrammes.

COPPER IN ANIMAL TISSUES.

1 kilo of beef contained 1 milligramme.
" human liver contained 3 to 15 milligrammes.
" sheep's liver contained 18 milligrammes.
" calf's liver contained 48 milligrammes.
" ox liver contained 51 milligrammes.
" dog's liver contained 10 to 20 milligrammes.
" cat's liver contained 10 to 20 milligrammes.
" sheep's kidney contained 3·8 to 8 milligrammes.
" ox kidney contained 3·8 to 8 milligrammes.

Salts of copper are used in the artificial colouring of vegetables, fruit, and sweets. Mayrhofer found from 76 to 151 milligrammes of copper salts in 1 kilo of preserved fruit, and 25 milligrammes in peas and vegetables. Tschirch found as much as 270 milligrammes of copper salts per kilo in carelessly stained vegetables. Lehmann is of opinion that 25 milligrammes per kilo is quite sufficient to fix the chlorophyll of vegetables, and Tschirch considers the chlorophyll is thus fixed as a copper phyllocyanate. The regular consumption of small quantities of copper with the food appears to be harmless. The proportion of copper in the urine is not increased thereby, as it is retained by the liver.

Chlorine does not occur in Nature in an uncombined form, but it is very abundant in the form of chlorides of the metals and alkaline earths. The commonest form is chloride of sodium and potassium, and as such chlorine enters and leaves the animal body, exercising an influence upon metabolism, but taking no part in the formation of cellular elements.

The alkalies and alkaline earths—sodium, potassium, calcium, and magnesium—occur freely as inorganic salts. As such they enter into plants, and are consumed by animals. Though present in vegetable and animal organisms to a considerable extent, only a small amount is combined with organic matter, and that very loosely. But their presence is necessary for keeping in solution the proteins of the blood, milk, and various other secretions.

Potassium and Sodium.—Potassium is necessary for the development of cells, especially those of the blood and muscles. Sodium is required to keep certain proteins in solution, and to make the secretions of a proper composition. It has been shown that when young animals are deprived of potash salts they do not develop muscle properly. Scurvy has been attributed to the absence of

potassium salts, and this idea receives support from the beneficial effects of fresh vegetables and fruit upon the course of the disease. Possibly the chief use of potassium in the human organism is that of an acid-carrier; at any rate, the organic acids combined with it undergo oxidation in the system, becoming transformed into alkaline carbonates, which render the blood and urine alkaline. Potassium salts are chiefly found in vegetable foods, sodium salts in animal foods. This is shown in the following table:

POTASSIUM AND SODIUM IN 1,000 PARTS OF DRIED SUBSTANCE.

According to Increase of Potassium.	K_2O.	Na_2O.	According to Increase of Sodium.	Na_2O.
Rice	1·0	0·03	Rice	0·03
Bullock's blood ..	2·0	19·00	Apples	0·07
Oats, wheat, rye, barley	5 to 6	0·1 to 0·4	Beans	0·13
Dog's milk	5 to 6	2 to 3	Peas	0·17
Human milk ..	5 to 6	1 to 2	Rye, oats, wheat, barley	0·1 to 0·4
Apples	11·0	1·0	Potatoes	0·3 to 0·6
Peas	12·0	0·2	Hay	0·3 to 1·5
Milk of herbivora ..	9 to 17	1 to 10	Human milk ..	1·0 to 2·0
Beef	19·0	3·0	Dog's milk	2·0 to 3·0
Beans	21·0	0·1	Milk of herbivora ..	1·0 to 10·0
Strawberries ..	22·0	0·2	Beef	3·0
Potatoes	20 to 28	0·3 to 0·6	Bullock's blood ..	19·0

RATIO OF SODIUM AND POTASSIUM.

In blood	the Na : K :: 1 : 0·07
,, egg-albumin	,, 0·70
,, yolk of egg	,, 1·00
,, milk of carnivora	,, 0·8 to 1·6
,, ,, herbivora	,, 0·8 to 6·0
,, ,, women	,, 1·0 to 4·0
,, beef	,, 4·0
,, wheat	,, 12·0 to 23·0
,, barley	,, 14·0 to 21·0
,, oats	,, 15·0 to 21·0
,, rice	,, 24·0
,, rye	,, 9·0 to 57·0
,, potatoes	,, 31·0 to 42·0
,, peas	,, 44·0 to 50·0
,, strawberries	,, 71·0
,, apples	,, 100·0
,, beans	,, 110·0

Sodium enters the human system chiefly as chloride of sodium and as common salt in the form of a condiment.

Calcium and Magnesium are important constituents of food-stuffs, and essential for the growth of young animals. The ordinary foods contain enough lime for animal needs, and even more than is necessary for the adult. One of the chief sources of lime is hard water, but milk contains more lime than there is in lime-water.

According to Bunge, lime-water contains 1·3 grammes per litre, whereas milk contains 1·5 grammes per litre. Eggs come next to milk in the proportion of lime, and a less but still important amount occurs in cereals, especially rice, spinach, asparagus, and radishes. Magnesium is a less important constituent of foodstuffs, and enters very little into the animal organism. According to Richet,[1] most foods contain about the same proportion of magnesium as of calcium; but milk contains less, meat rather more, and bread has five times as much magnesium as calcium.

The elements of the various foodstuffs, however, do not by any means all exist therein in the crude and inorganic condition. Though comparatively few in number, the fifteen or twenty elements found in food enter into almost numberless combinations, with carbon as the centre of attraction to the other elements. Nearly all the combinations or compounds which occur in the food of man are formed primarily in the vegetable kingdom, and mankind consumes the vegetables, or animals which have been nourished by them. Animals therefore are all dependent—herbivora directly, carnivora indirectly—upon plant life for the chief elements of their sustenance, viz., proteins, carbohydrates, and fats. It will not, therefore, be out of place to give some idea of the constructive process in the evolution of organic from inorganic matter. Although the whole scheme is not clear to us, and we cannot see what is going on in Nature's laboratory, we may by comparison judge of the unknown from known facts.

Carbohydrates form the bulk of all our vegetable foods, whereas proteins predominate in the animal foods, and the fats form a variable proportion in both kinds. These bodies all take their rise from a few simple combinations of ions dissociated by the solar rays from carbon dioxide and water. The equation $CO_2 + H_2O = CH_2O + O_2$ represents in gross the primary synthetic process which occurs in the leaves of plants. CH_2O is methylic aldehyde. Now, a very strong characteristic possessed by all aldehydes is the tendency to polymerization. A polymer consisting of two molecules of CH_2O linked together is $C_2H_4O_2$, or glycollic aldehyde; and so on through the entire group of materials known as "carbohydrates."

The credit of having first suggested that organic synthesis was begun in plants by the formation of formaldehyde or methylaldehyde from carbonic acid and hydrogen peroxide is due to Baeyer.[2] This suggestion, however, was not accepted, because both formaldehyde and hydrogen peroxide are fatal to protoplasm. But the hypothesis has since received confirmation from the experiments of other observers, notably Usher, Priestley, and Euler. The former showed that the chlorophyll of plants is capable of transforming carbon dioxide and water—*i.e.*, true carbonic acid (CH_2O_3)—into formaldehyde and hydrogen peroxide; that in Nature these substances are utilized *while in their nascent condition* in

[1] "Dictionary of Physiology."
[2] *Ber. d. Deutsch. Chem. Ges.*, 1870, iii. 63.

synthetic work. They further showed that the vital mechanism of the plant is protected from the injurious action of hydrogen peroxide by a catalase or enzyme, which transforms it into oxygen and water, while the formaldehyde is polymerized and transformed into sugar by the living protoplasm.[1]

It is not necessary that the carbonic acid utilized in synthetic processes should be taken directly from the air: it may be derived from the organic acids or salts absorbed by the rootlets. Stutzer[2] found that tartaric and citric acids, in the form of tartrate and citrate of lime, furnish carbon to plants which are grown in the air. These acids are oxidized to carbonic acid, which, being assimilated and polymerized, produce carbohydrates. Water-plants derive carbon in the same way from dilute solutions of oxalates. Acetates and succinates also furnish carbon in the same way to plants, but not so effectively as oxalates and tartrates. Stutzer concluded that tartaric and oxalic acids, which contain carboxyl, cannot be directly assimilated by plants, but that the alcohol group of tartaric and other acids affords direct nourishment to them. Schmoeger[3] gives an account of his experiments on carbon assimilation, and considers that oxalates and tartrates only nourish the plants by furnishing carbonic acid.

Monosaccharides.—Polymerization and condensation form the keynote of the synthesis which is constanly going on in plants, and producing the organized compounds known as "carbohydrates." Three molecules of methylic aldehyde linked together form the **Trioses** ($C_3H_6O_3$)—*e.g.*, glycerose; four molecules form the **Tetroses** ($C_4H_8O_4$)—*e.g.*, erythrose; five molecules form the **Pentoses** ($C_5H_{10}O_5$)—*e.g.*, arabinose and xylose; six molecules form the **Hexoses** or Glucoses ($C_6H_{12}O_6$)—dextrose, levulose, galactose, etc.

These are monosaccharides, and technically are all aldehydes or ketones of polyhydric alcohols. Those formed from aldehydes are called *Aldoses*—*e.g.*, dextrose; those formed from ketones are called *Ketoses*—*e.g.*, levulose; the difference is shown by their synthetical formulæ:

Dextrose: $CH_2(OH).CH(OH).CH(OH).CH(OH).CH(OH).CHO.$
Levulose: $CH_2(OH).CH(OH).CH(OH).CH(OH).CO.CH_2(OH).$

The monosaccharides are transformed into the corresponding alcohols by the action of nascent hydrogen—*i.e.*, H ions—dextrose, levulose, galactose, becoming respectively sorbite, mannite, and dulcite. The same sugars may again be derived from the corresponding alcohols by oxidation of the latter—that is, by the action upon them of hydroxyl, or OH ions.[4] As a matter of fact, it is usually stated that the sugars are all derived from the hexatomic alcohol *mannite* ($C_6H_{14}O_6$).

Disaccharides.—Monosaccharides are condensed in such a manner that two molecules are joined together to form a disaccharide molecule. The two monosaccharide molecules are not the same in all cases, but sometimes of two different kinds. During con-

[1] *Proc. Roy. Soc.*, 1906, lxxvii. 369, lxxviii. 318.
[2] *Ber. der Deutsch. Chem. Ges.*, 1876, 1395.
[3] *Ibid.*, 1877, 753-758.
[4] Hammarsten's "Physiological Chemistry," p. 85.

densation one molecule loses an atom of hydrogen, and the other an atom of hydroxyl, forming a molecule of water—thus :

$$\underset{\text{Dextrose.}}{(C_6H_{12}O_6—H)} + \underset{\text{Dextrose.}}{(C_6H_{12}O_6—OH)} = \underset{\text{Maltose.}}{C_{12}H_{22}O_{11}} + H_2O.$$

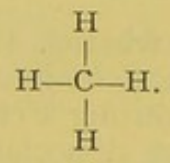
$$\underset{\text{Dextrose.}}{(C_6H_{12}O_6—OH)} + \underset{\text{Levulose.}}{(C_6H_{12}O_6—H)} = \underset{\text{Cane-sugar.}}{C_{12}H_{22}O_{11}} + H_2O.$$

$$\underset{\text{Dextrose.}}{(C_6H_{12}O_6—H)} + \underset{\text{Galactose.}}{(C_6H_{12}O_6—OH)} = \underset{\text{Lactose.}}{C_{12}H_{22}O_{11}} + H_2O.$$

Polysaccharides.—The carbohydrates undergo still further condensation, examples being found in all plant structures. In this manner the polysaccharides, or **Amyloses,** are formed—that is, by linking together three or more molecules of the hexoses or glucoses in the sugar-cane fashion. The amyloses therefore must be regarded as anhydrides of the glucoses. Starch is formed in the leaves of plants from sugar. Arthur Meyer thinks that it may also be formed from mannite;[1] and there is no reason for denying this, especially as sugar may be derived from mannite. Starch is stored in many parts of vegetable organisms. When it is wanted for the use of the plant, it is converted into monosaccharides by *amylase*, an enzyme whose existence in the leaves was discovered by Léon Brasse, and confirmed by Schimper. This hydrolysis of amyloses also occurs under the action of diastase and other enzymes, and dilute acids and alkalies.

Still further combinations of the hexoses occur, to form **Glucosides,** wherein the molecules are joined together in regular ether fashion —that is, one molecule drops an atom of hydrogen, the other hydroxyl, whereby a molecule of water is lost.

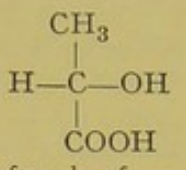
Hydrocarbons.—Carbon is probably the most plastic of all the elements, and is admitted to be the basis of organized matter and of life. By its combinations with hydrogen it forms the series known as the " hydrocarbons," the simplest member of the series being methane (CH_4). It consists of a single atom of carbon, each valency of which is joined to a single atom of hydrogen, thus:



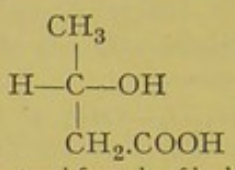
It is believed by some authorities that the whole organic world is constructed out of methane, by repeatedly removing one or more of the atoms of hydrogen and replacing or substituting something else for it. We know, at any rate, that the assimilation of carbon is the characteristic feature of all living bodies. That the existence of an asymmetrical carbon atom is the nucleus around which the other elements congregate in the growth and development of all organisms is also the accepted belief of many scientists.

[1] *Centralb. für Agrik. Chem.*, xv. 7.

The asymmetric carbon atom is one which has each of its four valencies saturated by a different element or radical, as in the following examples :



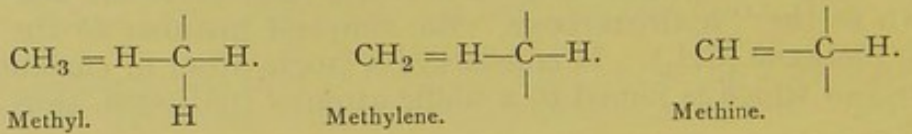
Structural formula of sarcolactic or ethylidene lactic acid ($C_3H_6O_3$).



Structural formula of hydroxybutyric acid ($C_4H_8O_3$).

Carbon usually presents four valencies, which must be saturated by union with other elements or atoms of carbon. The valency is the power of an atom to combine with other atoms or combinations of atoms. The capacity of carbon for self-saturation or union with other atoms of carbon is truly marvellous. It is probably owing to this capacity that its compounds exist in such endless variety. By its complex combinations with hydrogen, nitrogen, and oxygen, it occupies an important position in the constructive processes which lead up to the vitalization of matter.

An element of such remarkable power displays its plasticity in the exhibition of affinity for various elements. In its combinations with hydrogen it may show a greater affinity for some other element ; or some ion which is more strongly charged with electricity has the power of displacing some of the hydrogen and occupying its place. Thus hydroxyl, or OH ions, are capable of displacing hydrogen from a carbon compound or hydrocarbon, because they carry a greater charge of electricity and are electro-negative. Hydroxyl ions may also rob the hydrocarbon of hydrogen, uniting with it to form a molecule of water, and thereby leave the rest of the molecule with one or more free valencies, which demand satisfaction by union with another substance — *e.g.*, $CH_4 + OH = H_2O + CH_3$, etc. Thus we have CH_3, CH_2, and CH, derived from CH_4, forming respectively monovalent, divalent, and trivalent ions, as shown by the formulæ—



Methyl. Methylene. Methine.

The question arises as to whether these bodies, the unsaturated compounds of carbon atoms, exist in a free state. They probably do not, except temporarily during a chemical action ; but they are important ions separated or dissociated from more complicated compounds. *By reason of their unsatisfied affinities they could not remain free ;* when no other element is at hand which will satisfy their demand, they unite together to form the hydrocarbons, and thus we have a series :

Methane, CH_4 ; methyl, CH_3 ; methylene, CH_2 ; methine, CH
Ethane, C_2H_6 = $CH_3.CH_3$.
Propane, C_3H_8 = $CH_3.CH_2.CH_3$.
Butane, C_4H_{10} = $CH_3.CH_2.CH_2.CH_3$.
Pentane, C_5H_{12} = $CH_3.CH_2.CH_2.CH_2.CH_3$.
Hexane, C_6H_{14} = $CH_3.CH_2.CH_2.CH_2.CH_2.CH_3$.

Alcohols.—An instance of the oxidation of hydrocarbons by hydroxyl ions is seen in the alcohol group; one hydroxyl ion, by means of its more powerful electrical charge, is able to displace and occupy the position of an atom of hydrogen in the hydrocarbon molecule—thus:

$C_2H_6 + OH = H + C_2H_6O$, or $C_2H_5(OH)$, ethyl alcohol.
$C_2H_6 + 2OH = H_2 + C_2H_6O_2$, ethylene alcohol or glycol.
$C_3H_8 + 3OH = 3H + C_3H_8O_3$, triatomic alcohol or glycerine.
$C_4H_{10} + 4OH = 2H_2 + C_4H_{10}O_4$, butyl alcohol.
$C_6H_{14} + 6OH = 3H_2 + C_6H_{14}O_6$, hexyl alcohol or mannite.

Ethers.—In the polymerization of aldehydes, such as was shown under the heading of carbohydrates, two or more molecules become linked together after each has dropped an atom of hydrogen or hydroxyl. This is the usual manner of the formation of ethers from alcohol—that is, one molecule of alcohol loses an atom of hydrogen, the other hydroxyl, and the radicals become linked together in true *ether fashion*. This mode of the formation of new molecules in living bodies is an important one, much used in cellular processes, and is clearly seen in the construction of fatty and other bodies.

Acids.—The hydroxyl ion is a very potent provocative of change, and takes an active share in the chemical processes of the cells of plants and animals. It can react upon alcohol, and by dehydrogenizing it or oxidizing it reduce it to an aldehyde or ketone—*e.g.*:

$$\underset{\text{Mannite.}}{C_6H_{14}O_6} + 2OH = \underset{\text{Dextrose.}}{C_6H_{12}O_6} + 2H_2O.$$

In the same way a primary alcohol—*e.g.*, ethyl alcohol—would be reduced to an aldehyde—ethyl aldehyde: $C_2H_6O + 2OH = 2H_2O + C_2H_4O$. If a secondary alcohol be the subject of its action, the result is a ketone—*e.g.*, secondary propyl alcohol is converted into dimethyl ketone: $C_3H_8O + 2OH = 2H_2O + C_3H_6O$. When still further acted upon by hydroxyl ions, the aldehydes and ketones are oxidized and transformed into **acids.**

Methyl aldehyde, $CH_2O + 2OH = H_2O + CH_2O_2$ (formic acid).
Ethyl aldehyde, $C_2H_4O + 2OH = H_2O + C_2H_4O_2$ (acetic acid).
Propyl aldehyde, $C_3H_6O + 2OH = H_2O + C_3H_6O_2$ (propionic acid).
Butyl aldehyde, $C_4H_8O + 2OH = H_2O + C_4H_8O_2$ (butyric acid).

There are monobasic, dibasic acids, etc. Monobasic acids all have only one carboxyl (COOH) in the structure of their molecule. Those formed from the hydrocarbons of the paraffin series are termed **fatty acids,** because some of the members of the series combine with glycerine to form fat. The foregoing are examples of their derivation from aldehydes. The adjoining table (p. 14) shows the relation of hydrocarbon, alcohol, and fatty acid to each other.

Fundamental dibasic acids have two carboxyl groups in their chain, and they are formed from fundamental monobasic acids by the two basic molecules dropping their hydroxyls and becoming

THE ALIPHATIC SERIES.

Hydrocarbon.	Alcohol.	Acids (Saturated).	Acids (Unsaturated).
(a) Volatile Fatty Acids, soluble in Water.			
Methane, CH_4	Methyl alcohol, CH_4O	Formic acid, CH_2O_2	
Ethane, C_2H_6	Ethyl alcohol, C_2H_6O	Acetic acid, $C_2H_4O_2$	
		Oxalic acid, $C_2H_2O_4$	
Propane, C_3H_8	Propyl alcohol, C_3H_8O	Propionic acid, $C_3H_6O_2$	Acrylic acid, $C_3H_4O_2$
		Malonic acid, $C_3H_4O_4$	
		Tartronic acid, $C_3H_4O_5$	
Butane, C_4H_{10}	Butyl alcohol, $C_4H_{10}O$	Butyric acid, $C_4H_8O_2$	Maleïc acid, $C_4H_4O_4$
		Hydroxy-butyric acid, $C_4H_8O_3$	
		Succinic acid, $C_4H_6O_4$	
		Malic acid, $C_4H_6O_5$	
		Tartaric acid, $C_4H_6O_6$	
Pentane, C_5H_{12}	Amyl alcohol, $C_5H_{12}O$	Valeric acid, $C_5H_{10}O_2$	Angelic acid, $C_5H_8O_2$
Hexane, C_6H_{14}	Hexyl alcohol, $C_6H_{14}O$	Caproic acid, $C_6H_{12}O_2$	Hydromuconic acid, $C_6H_8O_4$
		Adipic acid, $C_6H_{10}O_4$	Sorbic acid, $C_6H_8O_2$
		Citric acid, $C_6H_8O_7$	
Heptane, C_7H_{16}	Heptyl alcohol, $C_7H_{16}O$	Œnanthylic acid, $C_7H_{14}O_2$	
Octane, C_8H_{18}	Octyl alcohol, $C_8H_{18}O$	Caprylic acid, $C_8H_{16}O_2$	
Nonane, C_9H_{20}	Nonyl alcohol, $C_9H_{20}O$	Pelargonic acid, $C_9H_{18}O_2$	
Decane, $C_{10}H_{22}$	Decyl alcohol, $C_{10}H_{22}O$	Capric acid, $C_{10}H_{20}O_2$	
(b) Non-Volatile Fatty Acids, insoluble in Water, soluble in Ether and Alcohol.			
Undecane, $C_{11}H_{24}$	—	Undecylic acid, $C_{11}H_{22}O_2$	
Dodecane, $C_{12}H_{26}$	Dodecyl alcohol, $C_{12}H_{26}O$	Lauric acid, $C_{12}H_{24}O_2$	
Tridecane, $C_{13}H_{28}$	—	Tridecylic acid, $C_{13}H_{26}O_2$	
Tetradecane, $C_{14}H_{30}$	Tetradecyl alcohol, $C_{14}H_{30}O$	Myristic acid, $C_{14}H_{28}O_2$	
Pentadecane, $C_{15}H_{32}$	—	Pentadecylic acid, $C_{15}H_{30}O_2$	
Hexadecane, $C_{16}H_{34}$	Cetyl alcohol, $C_{16}H_{34}O$	Palmitic acid, $C_{16}H_{32}O_2$	Hypogæic acid, $C_{16}H_{30}O_2$
Heptadecane, $C_{17}H_{36}$	—	Margaric acid, $C_{17}H_{34}O_2$	Oleomargaric acid, $C_{17}H_{30}O_2$
			Therapic acid, $C_{17}H_{26}O_2$
Octadecane, $C_{18}H_{38}$	Octadecyl alcohol, $C_{18}H_{38}O$	Stearic acid, $C_{18}H_{36}O_2$	Oleic acid, $C_{18}H_{34}O_2$
Nondecane, $C_{19}H_{40}$	—	Nondecylic acid, $C_{19}H_{38}O_2$	Jecoleic acid, $C_{19}H_{36}O_2$
Eicosane, $C_{20}H_{42}$	—	Arachidic acid, $C_{20}H_{40}O_2$	
Decosane, $C_{22}H_{46}$	—	Behenic acid, $C_{22}H_{44}O_2$	Erucic acid, $C_{22}H_{42}O_2$

linked together; thus, oxalic acid is derived from acetic acid, malonic from propionic acid, succinic and tartaric from butyric acid, citric from caproic acid. Many organic acids arise in that way. Oxalic acid is the first in a series of homologous dibasic acids:

Oxalic acid, $HOOC + COOH$.
Malonic acid, $HOOC + CH_2 + COOH$.
Succinic acid, $HOOC + CH_2 + CH_2 + COOH$.
Glutaric acid, $HOOC + CH_2 + CH_2 + CH_2 + COOH$.
Adipic acid, $HOOC + CH_2 + CH_2 + CH_2 + CH_2 + COOH$.

The **Fats** are compound ethers or *esters* of the triatomic or trihydric alcohol glycerine, or more properly *glycerol*—$C_3H_8O_3$ or $C_3H_5(OH)_3$. As a trihydric alcohol, glycerol can combine with three molecules of a monobasic acid, and thus form a neutral ether. In this form—*i.e.*, as an ester of the fatty acids—glycerol is a component of the tissues of all animals and plants.

The fats are triglycerides—that is to say, the three hydroxyls in the molecule are replaced by three molecules of a fatty acid, the glycerol gives up OH, the acid gives up H, and they become linked together in true ether fashion. To express the change in another way: The allyl radical C_3H_5 of glycerol has a stronger affinity for the fatty acid than for hydroxyl, and, dropping OH, it unites with fatty acid by replacing an atom of H from each molecule. This exchange is probably aided by the fatty acid radical conveying a greater electrical charge, by which it is enabled to displace OH from the glycerol. However the change is brought about, it is in constant progress in the organic kingdom. The reaction is exemplified as follows:

$$\underset{\text{Glycerine.}}{C_3H_5\begin{Bmatrix}OH\\OH\\OH\end{Bmatrix}} + \underset{\text{Palmitic acid.}}{\begin{Bmatrix}C_{15}H_{31}.COOH\\C_{15}H_{31}.COOH\\C_{15}H_{31}.COOH\end{Bmatrix}} = \underset{\text{Palmitin.}}{C_3H_5\begin{Bmatrix}C_{15}H_{31}.COO\\C_{15}H_{31}.COO\\C_{15}H_{31}.COO\end{Bmatrix}} + 3H_2O.$$

Fats in turn undergo various changes in the presence of ions, which have a greater affinity for them than the fatty acid has for the allyl radical. This is particularly so with regard to metallic ions. Saponification is due to the presence of an overpowering metallic ion. This is readily exemplified in the laboratory. When palmitin is agitated with a solution of caustic potash, the potassium cation replaces the allyl group—thus:

$$\underset{\text{Palmitin.}}{C_3H_5(C_{15}H_{31}.COO)_3} + 3KHO = \underset{\text{Glycerine.}}{C_3H_5(OH)_3} + 3\underset{\text{Potassium palmitate.}}{C_{15}H_{31}.COOK}.$$

This influence of the metallic ion is constantly being exercised in the vital processes, and it occurs regularly in the alimentary tract, where saponification is the regular means of assimilating the fats of the food.

In the vital processes of plants and animals this interchange is aided by enzymes such as lipase or steapsin, which is a carrier of hydroxyl, and by its stereometric construction is enabled to split the fat into glycerine yielding OH to the allyl radical, and fatty

acid ; the free fatty acid then displaces the acid radical from alkalies such as sodium, potassium, or magnesium carbonate :

$$\underset{\text{Palmitic acid.}}{2C_{15}H_{31}.COOH} + Na_2CO_3 = \underset{\text{Sodium palmitate.}}{2C_{15}H_{31}.COONa} + CO_2 + H_2O.$$

The fats which enter into the structure of nervous tissues are more complex than the ordinary fats, and, from possessing different characteristics, are called **lipoids**—*e.g.*, cholesterin, lecithin, cerebrin. Like ordinary fats, they are esters formed by the union of glycerine with acids in the true ether fashion. But instead of all the hydroxyls being replaced by fatty acids, only two are so replaced ; while the third is replaced by phosphoric acid. Their construction is probably in this manner :

$$\underset{\text{Glycerine.}}{C_3H_5\begin{Bmatrix}OH\\OH\\OH\end{Bmatrix}} + \underset{\text{Phosphoric acid.}}{H_3PO_4} = \underset{\text{Glycero-phosphoric acid.}}{C_3H_5\begin{Bmatrix}OH.\\OH.\\PO_4H_2.\end{Bmatrix}}$$

In turn two fatty acid radicals replace the remaining hydroxyls, and glycero-phosphoric acid becomes lecithin—*e.g.* :

$$\text{Di-stearyl-lecithin} = C_3H_5\begin{Bmatrix}C_{17}H_{35}.COO.\\C_{17}H_{35}.COO.\\PO_4H_2.\end{Bmatrix}$$

Finally, cholin, $C_2H_4.N(CH_3)_3.(OH)_2$, replaces oxygen or hydroxyl from the phosphoric acid group in the molecule, and thus gives rise to the special lecithins or nitrogenized fats of the nervous tissues. Such lecithins alway's contain one atom of nitrogen and one atom of phosphorus.

Besides the carbon, oxygen, and hydrogen, taking part in the formation of the nutritive materials of foodstuffs, there are other elements. Plants absorb by their roots the inorganic phsophates, sulphates, nitrates, and chlorides, of the soil. The majority of these, however, only exist in the sap of the plant in a very dilute solution and in the form of ions. All dilute solutions contain a portion of their salts in a dissociated or ionized form. Thus the phosphates are chiefly dissociated into a metallic cation and an acid anion. The latter is a trivalent anion ready for union with other ions for which it has an affinity. One of its important compounds is the glycero-phosphoric acid $C_3H_9PO_6$ already named, and the formation of which leads in vital processes to the construction of lecithin, which in turn is the chief link between the unorganized phosphorus of the earth and the organized phosphorus of our foodstuffs and living cells.

Proteins.—The construction of living proteins is not clearly understood, but various links in the chain are well known, and have been produced even in the laboratory. Proteins are formed exclusively by plants, so far as our knowledge goes. Chlorophyll, as we have seen, forms aldehydes out of ions dissociated from water and the carbon dioxide of the atmosphere. Successive changes lead to the formation of aspartic aldehyde and aspartic acid. The salts which are absorbed by the roots of plants in a dilute solution are

some of them dissociated into their respective ions, and among ions so formed there is ammonia. From these two facts we may formulate two equations of interest to us :

1. (*a*) $4CH_2O + NH_3 = C_4H_7NO_2 + 2H_2O$.
Formic aldehyde. Aspartic aldehyde.

(*b*) $C_4H_7NO_2 + 2OH = C_4H_7NO_4 + H_2O$.
Aspartic aldehyde. Aspartic acid.

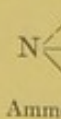
Some authorities are of opinion that the proteins arise by polymerization of aspartic aldehyde in the presence of sulphuretted hydrogen, and that by this means we arrive at one of the proposed formulæ for albumin—$C_{72}H_{112}N_{18}SO_{22}$. Other authorities consider the latter merely a hypothetical compound. Aspartic acid, however, is a well-known compound, known also by the name of "amino-succinic acid," and it combines with ammonia to form asparagin :

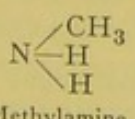
2. $C_4H_7NO_4 + NH_3 = C_4H_8N_2O_3 + H_2O$.
Aspartic acid. Asparagin.

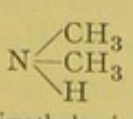
Asparagin is the amide of aspartic acid. It is widely distributed throughout the vegetable kingdom, where it is used as a protein-building material. It is especially abundant in young growing tissues, as in young leaves, the sprouts of peas, beans, vetches, in potatoes and other tubers, in beetroot, and particularly in asparagus.

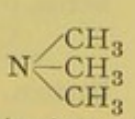
By a similar combination of caproic acid and ammonia there is formed leucin ; indeed, all fatty acids are capable of forming such combinations, thereby giving rise to the organic materials known as "amino-acids," through which the fatty acids enter into the construction of the protein molecule. All proteins yield amino-acids on hydrolysis. It is necessary, therefore, to learn something about them.

The combinations of ammonia and hydrocarbons are called **Amines**, or Amido-compounds—*e.g.*, methylamine, ethylamine, propylamine. In their formation the ammonia may drop one or more atoms of nitrogen, and thus becomes an amido-group or "ammonia-rest." If the ammonia drops one atom of hydrogen, it becomes NH_2, which is called *amidogen*, a monovalent ion. This is a base, and its compounds are called "primary ammonia bases," or *monamines*—*e.g.*, methylamine, a substance of importance in the synthesis of creatin and sarcosin. When the ammonia drops two atoms of hydrogen, the "ammonia-rest" is called the imido-group NH ; it is a divalent ion. It forms secondary ammonia bases, the two hydrogen atoms being replaced by hydrocarbons, as in dimethylamine. Indol and skatol are derivatives of this group. Tertiary ammonia bases, such as trimethylamine, occur when all the three atoms of hydrogen have been replaced by hydrocarbon radicals. These ammonia products are as follows :


Ammonia.


Methylamine.


Dimethylamine.


Trimethylamine.

Trimethylamine is of physiological importance because it may arise from the decomposition of cholin, which in turn is the product of the decomposition of lecithin or neurin. When ammonia is approached by certain electro-negative groups or bodies, it loses its trivalent character and becomes a pentad. In this condition it is capable of forming quarternary ammonia bases, examples of which are found in the following group; they are all derivatives of ethyl-trimethylammonium hydroxide, and really belong to the fatty series.

Cholin, $CH_2(OH).CH_2.N(CH_3)_3.OH$.
Muscarin, $CHO.CH_2.N(CH_3)_3.OH$.
Betaïn, $COOH.CH_2.N(CH_3)_3.OH$.
Neurin, $CH_2.CH.N(CH_3)_3.OH$.

Hydroxylamine ($NH_2.OH$) is a monamine—that is, an ammonium base in which one of the H atoms has been replaced by hydroxyl, and forms salts by direct union with acids and without loss of water. It is of importance in some synthetic processes. It can be prepared by the action of nascent hydrogen on nitrates or nitric oxide:

$$2NO + 3H_2 = 2NH_2(OH).$$
$$HNO_3 + 3H_2 = 2H_2O + NH_2(OH).$$

If this compound arises in plants by the union of H and NO ions obtained from nitrates in dilute solution in the sap, or by the replacement of H from NH_3 by OH ions, it stands as an example of the formation of nitrogen compounds in plants.

The **Amino-Acids** are derived from the monamines and diamines. The monamino-acids include glycocoll, alanin, leucin, aspartic acid, glutaminic acid, tyrosin, and taurin; the diamino-acids include lysin, arginin, and histidin. Their formulæ and relationship to the fatty acids is shown in the following table:

I. MONAMINO-ACIDS.

Glycocoll (glycin), or α-amino-acetic acid:
$C_2H_5NO_2$, or $CH_2(NH_2).COOH$.

Sarcosin, or methyl-amino-acetic acid:
$C_3H_7NO_2$, or $CH_2.CH_3(NH).COOH$.

Taurin, or amino-ethyl-sulphonic acid:
$C_2H_7NSO_3$, or $NH_2.CH_2.CH_2.SO_3H$.

Alanin, or α-amino-propionic acid:
$C_3H_7NO_2$, or $CH_3.CH(NH_2).COOH$.

Serin, or α-amino-β-oxypropionic acid:
$C_3H_7NO_3$, or $CH_2(OH).CH(NH_2).COOH$.

Cystein, or α-amino-β-thio-propionic acid:
$C_3H_6NSO_2$, or $CH_2(SH)\ CH(NH_2).COOH$.

Phenyl-alanin, or β-phenyl-α-amino-propionic acid :
$C_9H_{11}NO_2$, or $CH_2.C_6H_5.CH(NH_2).COOH$.

Tyrosin, or oxy-phenyl-alanin :
$C_9H_{11}NO_3$, or $C_6H_4(OH).CH_2.CH(NH_2).COOH$.
Tryptophan is indol-amino-propionic acid.

Aspartic Acid, or α-amino-succinic acid :
$C_4H_7NO_4$, or $COOH.CH(NH_2).CH_2.COOH$.

Asparagin, or amino-succinamic acid :
$C_4H_8N_2O_3 = CH_2(NH_2).CH(NH_2).CO.COOH$.

Glutaminic or Glutamic Acid, or α-amino-glutaric acid :
$C_5H_9NO_4$, or $COOH.CH(NH_2).CH_2.CH_2.COOH$.

Prolin, or α-pyrrolidine-carboxylic acid :
$C_5H_9NO_2$, or $CH_2.CH_2.CH_2.CH(NH).COOH$.
Oxy-prolin is oxy-α-pyrrolidine-carboxylic acid.

Valin, or α-amino-iso-valeric acid :
$C_5H_{11}NO_2$, or $\begin{matrix}CH_3\\CH_3\end{matrix}\!\!\rangle CH.CH(NH_2).COOH$.

Leucin from animal proteins, or amino-caproic acid :
$C_6H_{13}NO_2$, or $CH_3.CH_2.CH_2.CH_2.CH(NH_2).COOH$.

Leucin from vegetable proteins, or α-amino-iso-caproic acid :
$C_6H_{13}NO_2$, or $CH_3.CH.CH_3.CH_2.CH(NH_2)\ COOH$.

II. Diamino-Acids or Hexon Bases.

Diamino-acetic Acid :
$C_3H_7NO_2$, or $CH_2.CH_3(NH).COOH$.

Histidin, imidazole, or α-diamino-propionic acid :
$C_6H_9N_3O_2$, or $\begin{matrix}(NH)\text{—}(CH)\\|\quad\quad\|\\(CH)\ .\ CN\end{matrix}.CH_2.CH(NH_2).COOH$,
or $CH(NH).CH(CN).CH_2.CH(NH_2).COOH$.

Arginin, δ-guanidin-α-amino-valeric acid :
$C_6H_{14}N_4O_2$, or $(HN)C\langle\begin{matrix}NH_2\\NH.\end{matrix}CH_2.CH_2.CH_2.CH(NH_2).COOH$.

Lysin, α-ϵ-diamino-caproic acid :
$C_6H_{14}N_2O_2$, or $CH_2(NH_2).CH_2.CH_2.CH_2.CH(NH_2).COOH$.

Diamino-tri-oxy-dodecanic Acid :
$C_{12}H_{26}N_2O_5$.

Most of the above-mentioned amino-acids arise from the corresponding fatty acids by substituting the amido-group (NH_2) for one atom of hydrogen, which it has the power of replacing. For example, propionic acid becomes alanin or amino-propionic acid by substitution in the manner stated :

$$\underset{\text{Propionic acid.}}{CH_3.CH_2.COOH} + NH_2 = \underset{\text{Amino-propionic acid.}}{CH_3.CH(NH_2).COOH} + H.$$

Still further substitution occurs in serin by hydroxyl replacing another atom of hydrogen, or in cystein by that atom being replaced by the ion SH.

The true proteids or albuminous substances exist in a living and a non-living form. The former are the most interesting substances known to the chemist, but our knowledge of them is practically nil. They consist of exceedingly complex molecules of a very unstable character, and in a state of constant change—*i.e.*, of being built up and broken down by the physio-chemical processes of the living organism. At the moment of death, however, their character changes: they become more stable and are capable of being investigated. In such a condition they are more properly called **proteins.** They undergo hydrolytic cleavage by means of reagents or enzymes, and the products of that cleavage chiefly include the amino-acids. We do not know how these are linked together to form the protein molecule; but they are probably joined in the ether fashion—that is, by junction of the alkyl part of their alcohol radicals.

Of the importance of amino-acids in the construction of proteins there can be no doubt whatever. Aspartic acid or asparagin (its derivative) and phenylalanin are present in most animal and vegetable proteins; tyrosin and prolin, in all animal proteins; glycocoll forms 25 per cent. of elastin; leucin forms 10 per cent. of casein, 15 per cent. of fibrin, 20 per cent. of serum albumin, 21 per cent. of elastin, and 29 per cent. of hæmoglobin; glutaminic acid forms 8 per cent. of serum globulin, 8 per cent. of egg-albumin, 10 per cent. of casein, and 30 per cent. of gliadin. The adjoining table shows the percentage of amino-acids in various proteins.

The protein molecule is not entirely composed of amino-acids, for some proteins have a carbohydrate group in their structure. This, however, is always an amino-sugar, usually **glucosamine,** united to the protein in a glucoside-like combination. Carbohydrate can be obtained by the hydrolytic cleavage of proteins from egg-yolk, egg-globulin, serum-globulin, pea-globulin, and the albumins of the Graminaceæ. No carbohydrate can be separated from casein, myosin, fibrin, vitellin, and some of the vegetable proteins. It has also been debated whether the carbohydrate exists as a part of the protein molecule or is an impurity; but the fact of its being always present in particular proteins has led to the establishment of a group called *gluco-proteins.*

Starting with amino-acids, Fischer undertook to chain together these ultimate fragments into which proteins break up, and has formed from them various substances related to the proteins. Thus he caused glycocoll to unite with glycocoll with loss of water, forming glycocyl-glycin; similarly, alanyl-alanin, leucyl-leucin, lysyl-lysin, and other chains were formed, which he called "polypeptides." A large number of "peptides" have also been formed which give the biuret reaction characteristic of the natural peptones. The albumoses and peptones are much higher units, and consist

AMINO-ACIDS IN PROTEINS.

100 Grammes of Protein yield—	Fibrin.	Globin from Hæmo-globin.	Serum Albumin.	Serum Globulin.	Casein.	Edestin from Hemp-seed.	Gelatin.	Elastin.	Horn.	Histon.
	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.
Glycocoll	3·0	—	—	3·52	—	3·80	16·50	25·75	0·34	0·5
Alanin	3·6	4·19	2·69	3·22	·90	3·60	·80	6·58	1·20	3·5
Leucin	15·0	29·04	20·00	18·70	10·50	20·90	2·10	21·38	18·30	11·8
Prolin	2·5	2·34	1·04	2·76	3·10	1·70	5·20	1·74	3·60	1·5
Phenyl-alanin	2·0	4·24	3·08	3·84	3·20	2·40	·40	3·89	3·00	2·2
Glutaminic acid	8·0	1·73	1·52	2·20	10·70	6·30	·88	·76	3·00	·5
Aspartic acid	2·0	4·43	3·12	2·54	1·20	4·50	·56	—	2·50	—
Cystein	—	·31	2·30	·67	·06	·25	—	—	—	—
Valin	1·0	—	—	—	1·00	—	—	1·00	—	—
Serin	present	·56	·60	—	·23	·33	—	—	5·70	—
Oxy-prolin	—	1·04	—	—	·25	2·00	3·00	—	—	—
Tyrosin	3·5	1·33	—	—	4·50	2·13	—	·34	·68	5·2
Lysin	—	4·28	—	—	5·80	2·00	2·75	—	—	6·9
Arginin	—	5·42	—	—	4·84	11·80	7·62	·30	2·25	11·5
Histidin	—	10·96	—	—	2·59	1·00	·40	—	—	1·5
Tryptophan	—	present	present	present	1·50	present	—	—	—	—
Diamino-tri-oxy dodecanic acid	—	—	—	—	·75	—	—	—	—	—

of far more complex molecules, their constitution being nearly as obscure as that of the protein molecule itelf.

Little is known of the formation of proteins in living organisms ; but there is evidence to show that the assimilation of the nitrates, sulphates, and phosphates, containing the necessary elements for protein formation, can only take place in plants and in the presence of light. The first stage in protein formation in plants is the production of the comparatively simple amino-acids leucin and asparagin. Where and how the formation of protein from amino-acids takes place is not exactly known, but Emmerling[1] favours the theory that the amino-acids asparagin and leucin are formed chiefly in the leaves from simple inorganic compounds of nitrogen, absorbed by the roots. These acids are used in the synthesis of albumin and other proteins. As time goes on, and the amount of protein produced is in excess of that required for leaf production, it is used up in the development of seeds.

The albumins are very sparingly present in vegetables, but globulins are very common. Plants, however, contain vegetable myosin, which is believed to be the precursor of gluten-fibrin. The latter, being coagulated, forms gluten, from which in turn phyto-albumose (*gliadin* or *mucedin*) can be separated. Aleuron consists of such globulins and albumoses accumulated about a crystal or crystals of double phosphate of lime and magnesia. It is, in fact, a mixture of homologous proteins, beginning with hetero-albumose, and ending with globulins and albumins.

The proteins of animal structures are derived from those of vegetable organisms. Being consumed, they are broken by digestion from colloids to crystalloids—viz., into amino-acids. Having entered the organism, such crystalloids are polymerized to form the colloid proteins, or globulins and albumins, of the blood and tissues. The cells of the alimentary canal provide the system regularly with a supply of specific proteins, despite considerable variations in the character of the proteins of the food. The conclusion arrived at is that the cells of the alimentary canal hydrolyze the proteins of the food, and reconstruct the amino-acids into proteins of the blood ; that the cells of the tissues also hydrolyze the proteins brought to them by the blood, and out of the amino-acids so formed are reconstructed the special proteins of the tissues. This conclusion is confirmed by the argument that an infant constructs all its tissues out of the proteins, carbohydrates, and fats, of its mother's milk.

Living proteins, called " biogens " by Verworn, are probably more unstable than any other organic compounds. This is due to intramolecular changes produced mainly by oxygen or hydroxyl ions, which readily oxidize or hydrolyze the molecule, and thereby cause the formation of new groups. Various theories have been advanced to account for this instability. Pflüger believed it to be due to the presence of a cyanogen radical in the protein molecule,

[1] *Lander-versuch Stat.*, 1900, liv. 215

and that the descent from living protein to dead protein is due to the substitution of amidogen (NH_2) for the cyanogen (CN) of the living molecule. The cyanogen radical can combine with alcohols or aldehydes by displacing an atom of hydrogen; thus C_2H_6O becomes C_3H_5NO, or cyanhydrine. That cyanhydrines follow out the tendency of aldehydes to polymerize and form the self-decomposable albumin of living matter is the theory of Pflüger and his followers.

The origin of living material has baffled scientists for ages, and continues to baffle them. Protein-like substances have been synthetically prepared by Fischer, Curtius, Siegfried, and others. They have linked together amino-acids into peptides and polypeptides, which give the biuret reaction, and are considered to be the beginning of a protein synthesis. But peptones, proteoses, albumin, and globulin, have not been formed. The necessary organic or vital processes resist solution or continue to baffle the investigator.

On the other hand, the plant is able to construct carbohydrates, fats, and proteins, by the help of the sun's rays, out of the simple inorganic compounds absorbed by its roots and leaves. Animals are unable to do this, but are dependent on the vegetable world for the organic materials to supply their necessity.

Synthesis is the chief characteristic of the organic processes in the vegetable kingdom, analysis that of the animal kingdom. In other words, vegetable metabolism is chiefly constructive, animal metabolism destructive.

The building up and breaking down of protoplasm depend upon molecular movement in the plasm, and this is as little understood as the chemical constitution of living protoplasm in general or of albumin in particular.

CHAPTER II

THE CLASSIFICATION AND CHARACTERS OF THE PROXIMATE PRINCIPLES OF THE FOODSTUFFS

Proteins.

THE older terms of "proteid" and "albuminoid," which were long in use by chemists and physiologists to designate collectively the nitrogenous substances of our foods, have now given place to the term **protein,** as recommended by the Chemical and Physiological Societies of Great Britain and America, and according to the usage of many Continental scientists. The proteins include all the *organized* nitrogenous substances which occur in animal or vegetable tissues, excepting the *lipoids*, or nitrogenous fats. As protein substances contain an average of 16 per cent. of nitrogen, the term is used to represent the total nitrogenous substances estimated by multiplying the percentage of nitrogen by the factor $\frac{16}{100}$ or 6·25. Proteins include all the nitrogenous compounds, except such as may be called non-protein nitrogenous substances. (*a*) In animals these are the *meat bases*, or "extractives"—*e.g.*, creatin, creatinin, xanthin, hypoxanthin, etc.—which arise from destructive metabolism; and (*b*) in vegetables they include certain amides and amino-acids—*e.g.*, asparagin, leucin, and tyrosin. The word "albuminoid," if used at all, should be considered synonymous with "protein," and the word "proteid" should be abolished, or reserved for **living** organized substances.

Proteins are the most important constituents of animal and vegetable cells; they are therefore an indispensable element of our food. They are various, and differ from one another by their physical characters and chemical constitution. They consist essentially of amino-acids, linked together in various combinations. Some amino-acids are present in all proteins, but the same amino-acids are not present in all. Thus egg-albumin contains no glycocoll; gliadin from wheat has no lysin; gelatin is devoid of tyrosin and tryptophan. A table showing the proportion of amino-acids in various proteins is given in the preceding chapter.

The proteins are colloids, and their solutions do not diffuse through colloidal membranes. They never occur in an actual solution. But they are capable of three modifications or states—*i.e.*, they may be coagulated, crystallized, and apparently dissolved. Some proteins may be dissolved in water alone; these are the

albumins. Others require the presence of a small quantity of a neutral salt to keep them in solution; these are the *globulins*. Both kinds of protein are present in blood-serum, white of egg, etc. If the white of egg or blood-serum be put into a dialyzer, the sodium chloride will diffuse out, and the globulin be precipitated as a flocculent coagulum in consequence, while the albumin remains in solution. There are other proteins which require a basic salt to keep them in solution. Thus caseinogen is kept in solution by its combination with a calcium salt. If milk is treated with acetic acid until its reaction becomes distinctly acid, the caseinogen is precipitated in flakes, because the lime is detached from it, whereas the globulin and lactalbumin remain in solution.

The change of state or modification of proteins known as "coagulation" is brought about by exposing them to the temperature of boiling water, or by the action of alcohol or acids. But many proteins of the living tissues have such a tendency to pass into the coagulated condition that they assume this state as soon as the life of the tissue is extinguished. This characteristic of proteins gives rise to natural changes, such as the coagulation of the blood and rigor mortis.

Certain proteins are found in the crystalline state. Such proteins, moreover, are never quite pure, but are usually compounds of protein with an inorganic salt. "*Pure protein never occurs in Nature*. When converted into ash, the residue contains calcium magnesium or potassium; ash-free protein has only been obtained artificially."[1] Proteins have both acid and basic properties, corresponding to the amino-acids which predominate in them. It is therefore by no means extraordinary that they should combine with the inorganic bases, which are everywhere met with in the tissues. The crystalloid materials, or aleuron grains, which occur in the seeds and tubers of plants, and similar crystalloidal matters in the yolk of eggs, consist of incompletely-formed crystals of protein. Hæmatin, as well as globulin and albumin from blood, and white of egg have been crystallized.

CLASSIFICATION OF PROTEINS.

1. **Protamins**—*e.g.*, salmin and sturin from fish sperm.
2. **Histons**—*e.g.*, from blood-corpuscles and thymus.
3. **Albumins**—*e.g.*, ov-albumin, ser-albumin, lactalbumin, myo-albumin, and cell-albumin.
4. **Globulins**—*e.g.*, serum-globulin, myo-globulin, myosinogen, fibrinogen. Myosin and fibrin are derivatives.
5. **Scleroproteins** (formerly called albuminoids)—*e.g.*, gelatin, collagen, keratin, chondrin, elastin, chitin.
6. **Phosphoproteins** (formerly called nucleo-albumins)—*e.g.*, ovo-vitellin, caseinogen and its derivative casein.
7. **Conjugated Proteins**:
   (*a*) *Nucleo-proteins*, or combinations of protein and nucleic acid—*e.g.*, nucleo-histon, leuco-nuclein, cyto-globin.
   (*b*) *Gluco-proteins*, or combinations of protein and carbohydrate—*e.g.*, mucin, euglobin.
   (*c*) *Chromo-proteins*, or combinations of protein and chromogenic compounds—*e.g.*, hæmoglobin.

[1] Bunge's "Organic Chemistry," p. 232.

8. **Derivatives of Protein**—*i.e.*, products of protein hydrolysis:
   (*a*) *Metaproteins*—*e.g.*, acid-albumin, alkali-albumin.
   (*b*) *Proteoses*—*e.g.*, albumose, globulose, gelatose.
   (*c*) *Peptones*—*e.g.*, albumin-peptone, gelatin-peptone.
   (*d*) *Polypeptides*—*e.g.*, glycyl-glycin, alanyl-alanin.

1. **Protamins** are the simplest of all proteins, and probably form the base or nucleus of all true proteins; they have been called *basic proteins*. Up to the present time the chief examples obtainable are salmin and sturin, which can be got from fish-sperm. They differ from true protein by yielding chiefly diamino-acids, and especially arginin.

2. **Histons** are more complex than protamins, but they are basic proteins standing between protamin and true protein. They are distinguished from protamins by being precipitated on the addition of ammonia—*e.g.*, histons from the blood.

3. **Albumins**: Serum-albumin, egg-albumin, myo-albumin, lactalbumin, vegetable-albumin. They are soluble in pure water, coagulated by heat, precipitated by strong mineral acids or metallic salts, but are not precipitated by common salt, dilute acids, or alkalies. They give a violet colour with cupric sulphate and potassium hydrate. Egg-albumin is precipitated by ether; serum-albumin is not precipitated. Vegetable-albumin occurs in the juices of plants, especially in papaw-fruit and latex of caoutchouc plants.

On hydrolytic cleavage the albumins yield: Leucin, 15 to 20 per cent.; phenyl-alanin, aspartic acid, tyrosin, prolin, cystein, pyrrolidin, glutaminic acid, 8 per cent., etc. The serum-albumin of the blood-serum, plasma, lymph, and other tissue fluids, is probably a mixture of two proteins, from one of which Langstein obtained amino-sugar, or glucosamine.

4. **Globulins**: Serum-globulin, myo-globulin, paramyosin, myosinogen (myosin), fibrinogen (fibrin), vegetable myosin, legumin or vegetable casein, crystallin, globin, vitellin, etc. They are insoluble in pure water, but are soluble in 1 per cent. solution of sodium chloride, also in weak saline or acid solutions. They are coagulated by heat, and are precipitated by saturated solutions of magnesium sulphate or sodium chloride. Weak acids convert them to acid-albumin—*e.g.*, syntonin—weak alkalies to alkali-albumin. They give the violet colour with KOH and $CuSO_4$.

The globulins yield on hydrolysis: Phenyl-alanin, tyrosin, aspartic acid, glutaminic acid, prolin, cystein, and 15 to 30 per cent. of leucin. A carbohydrate radical is also separable from them in a small quantity, but this is probably not a prothetic group, as it is in the gluco-proteins.

While albumins are only sparingly present among vegetable proteins, the globulins are common. They enter largely into the formation of aleuron; while other vegetable proteins consist chiefly of albuminates or compounds of acid-albumin with saline bases.

Serum-globulin, paraglobulin, or fibrinoplastin, occurs in blood-serum, plasma, lymph, red corpuscles, leucocytes, and also prob-

ably in the cells of many tissues. It consists of a mixture of bodies which can be separated, including a nucleo-protein called "thrombin" or "prothrombin," fibrin-globulin, and true serum-globulin. The latter is still further separable into *euglobulin* or *ser-globulin* and pseudo-globulin. Euglobulin itself probably belongs to the gluco-proteins, for a carbohydrate group can be split off from it.

Fibrinogen occurs in blood, lymph, chyle, and certain transudates, and is said to arise from the destruction of leucocytes. It is converted into fibrin by the fibrin ferment called *thrombin*, which is regarded as a globulin or nucleo-protein.

Vitellin, the globulin of egg-yolk, is not precipitated by sodium chloride.

The proteins of muscle plasma should be termed *myosinogen* and *paramyosinogen*. The term "myosin" should be restricted to the final product formed in rigor mortis. The term "soluble fibrin" should replace Fürth's "soluble myogen-fibrin."

The *plant-globulins* are: (*a*) PHYTO-VITELLIN, which, like animal vitellin, is soluble in saturated solution of sodium chloride. In yolk of egg and eggs of certain fishes it has a semi-crystalline form, but in the aleuron of many plants it is distinctly crystalline. It is the purest protein known, and, according to Weyl, consists of—C 52·43, H 7·12, N 18·1, S 0·55, O 21·8, per cent. It occurs in oats, maize, peas, Para nuts, mustard, etc.

(*b*) PLANT-MYOSIN, PHYTO-MYOSIN, occurs in wheat, oats, peas, white mustard, and sweet almonds. In wheat it is called "gluten-fibrin," and is the basis of gluten, into which it is converted by enzyme action. Like animal myosin, it coagulates at 56° C.

(*c*) PARA-GLOBULINS occur in papaw juice, latex, abrus seeds, etc. They coagulate at 75° C., and are precipitated by sodium chloride.

(*d*) GLUTEN is a coagulated protein consisting of a combination of gluten-fibrin or plant-myosin, and phyto-albumose, the gliadin and mucedin of Ritthausen. It is an example of proteins coagulated by the influence of an enzyme.

5. **Scleroproteins**—*i.e.*, gelatinoids—consist of the group formerly called "albuminoids."

(*a*) *Collagen* is the chief constituent of connective-tissue fibrils, of chondrin in cartilage, and of ossein in bone. It is transformed by boiling into gelatin, the composition of which is given by Chittenden as C 49·38, H 6·8, N 17·98, S 0·7, O 25·13, per cent. It is split by hydrolytic cleavage into glycocoll, leucin, serin, pyrrolidine, aspartic and glutaminic acids, etc. It gives no tyrosin or aromatic substances on decomposition. It is converted by digestion into gelatin-peptone and proteoses, which diffuse more or less readily.

(*b*) *Keratin* is the chief constituent of skin, hair, wool, and horny substances. It contains sulphur. On hydrolytic decomposition it yields leucin, alanin, lysin, arginin, glycocoll, aspartic, glutaminic, amino-valeric, and other amino-acids. It is incapable of digestion by mammals, and consequently does not come into the category of foodstuffs. It is, however, digested by certain insects; the caterpillar and clothes-moth feed almost entirely upon

keratin. It therefore replaces other proteins in those animals who can digest it. It differs from gelatin and other proteins by its high percentage of sulphur (4 or 5 per cent.), and the small amount of tyrosin occurring in its decomposition products.

(*c*) *Elastin* occurs as the chief constituent of elastic tissue, and in other tissues—*e.g.*, sarcolemma—of animals. It differs from gelatin and chondrin by the appearance of a small amount of tyrosin in its decomposition products. It yields 25 per cent. of glycocoll, but is said to contain *no* sulphur. It is completely digested by dogs, but only partially and very slowly by human beings. Horbaczewski introduced, through a gastric fistula in the stomach of a man, a small bag containing powdered elastin, which he found to be only partially digested in twenty-four hours.

(*d*) *Spongin*, chitin, reticulin, silk, etc., in invertebrates, also belong to this group. They contain no sulphur. Their decomposition products include glycocoll, asparagin, phenyl-alanin, etc.

6. **Phosphoproteins.**—The term **nucleo-albumins,** formerly used as a name for this group, was incorrect and misleading. They stand close to the nucleo-proteins by their proportion of phosphorus, and have been confused with them. But they differ from them in not yielding any nuclein or purin bases on cleavage. The group includes egg-vitellin, caseinogen and the derivative casein, etc. They resemble the globulins and albuminates as regards solubility and precipitation; they are nearly insoluble in water, but dissolve in weak acids and alkalies. They give a violet colour with $CuSO_4$ and KOH.

They do not yield nuclein or nuclein bases, but they yield pseudo-nuclein or paranuclein. The products of hydrolytic decomposition contain leucin (10 per cent.), glutaminic acid (10 per cent.), asparagin, phenyl-alanin, tyrosin, lysin, serin, pyrrolidine, etc.

Phosphoproteins are widely distributed throughout the animal and vegetable kingdom. They behave like weak acids. They contain phosphorus and iron. Ovo-vitellin also contains a considerable amount of lecithin in combination with the protein; such a combination is known as a *lecith-albumin*. In addition to the animal phosphoproteins, there are vegetable phosphoproteins. The distribution of these is extensive. The sap of nearly all plants, after being heated to coagulate albumin, yields various precipitates which differ little from casein, such as the *legumin* of peas, beans, and lentils, the *avenin* of oats, the *conglutin* of almonds, and vegetable casein of other plants.

The term "caseinogen" is that applied by Halliburton to the principal protein of milk, and "casein" to its derivative resulting from the action of rennin. In America and parts of the continent of Europe, the principal constituent of milk is called "casein," and the derived product "paracasein."

7. **Conjugated Proteins.**—In this class the protein molecule is united to a prothetic group. The principal subdivisions are—

(*a*) Nucleo-proteins, or combinations of protein and nucleic acid.

(*b*) Gluco-proteins, or combinations of protein and carbohydrate —*e.g.*, mucin.

(*c*) Chromo-proteins, or combinations of protein and chromogenic compounds.

THE CHROMO-PROTEINS: The chief example is hæmoglobin, which forms 14 per cent. of the blood of man. The amount varies in different animals, being 14 per cent. in blood of the pig, 10 per cent. in sheep and oxen, 11 per cent. in goats' and 13 per cent. in rabbits' blood.

THE GLUCO-PROTEINS are compounds of protein with glucosamine, the amino-sugar, and other sugars. They all yield protein and a carbohydrate on hydrolysis, but no xanthin or purin bodies. The group includes mucin, mucinoid, icthulin, etc. The proteins of egg-yolk, egg-globulin, serum-albumin, serum-globulin, pea-globulin, and the albumins of the Graminaceæ, all contain gluco-protein in their molecules.[1] Serum-albumin is probably a mixture of two proteins, from one of which Langstein obtained glucosamine. The ser-globulin or euglobulin which can be separated from serum-globulin and leucocytes is a gluco-protein, from which Langstein obtained dextrose, levulose, and another sugar which is not glucosamine, but is probably a levo-rotatory aldose of unknown constitution.[2]

Mucin is a gluco-protein whose distribution is very wide, as it forms the cement substance between the cells of the tissues, the ground substance of connective tissues, and largely composes the bodies of many invertebrates. It is soluble in cold dilute alkalies, such as baryta or lime water, and is precipitated by acetic acid. It yields a carbohydrate or non-fermentable sugar of the formula $C_6H_{12}O_6$ on treatment with sulphuric acid.

THE NUCLEO-PROTEINS are combinations of protein and nucleic acid; the combination may be fast or loose. They contain a considerable proportion of protein, and give the ordinary protein reactions. The group includes the hyaline substance of cells, the chromatin of nuclei, the stroma of muscle fibres, and other materials. The nucleo-proteins are therefore very widely distributed, as they constitute a portion of all cells. They consist of nucleo-histon, leuco-nuclein, cyto-globin, präglobin, etc. They are somewhat like mucin, but contain an abundance of phosphorus. During digestion or hydrolysis the combination of protein and nuclein is broken, and the latter is split into xanthin or purin bodies.

Thrombin, the fibrin-ferment of the blood, is considered to be a nucleo-protein produced by the thymus gland, where it exists partly as nucleo-histon, and partly in another form. According to Schmidt, it exists in the blood-plasma as *pro-thrombin*, and is converted into the fibrin-ferment by the influence of calcium salts. The *blood-platelets* also consist of a nucleo-protein derived from cell-nuclei, and are closely associated with the coagulation of the blood. Nucleo-histon occurs in leucocytes and most cells of the lymphatic glands, and is the chief nuclein substance in the thymus gland. The nucleo-proteins of cell-protoplasm are rich in protein, but poor in phosphorus; those of the nucleus are richer in phosphorus and poorer in protein, but they have a marked acid reaction.

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[1] Hammarsten's "Physiological Chemistry," p. 23.
[2] *Ibid.*, art. "Blood."

THE NUCLEINS.—When the nucleo-proteins are digested, some of the protein is split off from the molecule, and leaves a protein still richer in phosphorus. This is nuclein, or *true nuclein*, so called to distinguish it from the pseudo- or para-nuclein which is split off by digestion from phosphoproteins (formerly called "nucleo-albumins").

Nuclein is the generic name of a large number of organic phosphorous compounds, which are to be found in all animal and vegetable tissues, but particularly in the nuclei of cells. They have as yet been little investigated, and it has not been established beyond dispute that the substances isolated are chemical individuals. *They are acids*, soluble in alkaline solutions, but are nearly all insoluble in water, alcohol, ether, and dilute mineral acids. They give up their phosphorus in the form of phosphoric acid when they are boiled with water, acids, or alkalies. But the organic substance left after splitting off the phosphoric acid varies much in character in different nucleins; in most cases it is a protein, but not in every one.[1] Nucleins occur in the tissues mostly as compounds of protein, but the molecule also contains lecithin in some substances. The proportion of phosphorus averages 5 per cent., but varies from 3 to 9 per cent. The following is the percentage composition of some that have been analyzed:

COMPOSITION OF NUCLEIN, PER CENT.

Source.	C.	H.	N.	S.	P.	Fe.	O.
Yeast nuclein[2]	40·8	5·4	16·0	0·40	6·20	—	31·30
Egg-yolk nuclein[3]	42·1	6·1	14·7	0·55	5·19	0·29	31·05
Carp-roe nuclein[4]	47·8	7·2	12·7	—	2·90	0·25	—

The nucleins arise in the living body by synthesis. This is clearly shown in the case of fish. During the spawning season the ovaries continue to grow in spite of the absence of food. The ovaries and the ova are rich in nuclein and lecithin. They are probably derived, in this case, from the constituents of the muscles, because the latter waste correspondingly, and, although the muscles are poor in nucleins, they contain phosphoric acid, loosely combined with the proteins in the form of potassium phosphate.

There are in the muscles certain organized compounds of phosphorus called **nucleons,** which stand in very close relation to the nucleins. Phospho-carnic acid is an example. It is a complicated substance, obtainable from extracts of meat, etc. On digestion it yields a peptone (*carnic acid*); and on hydrolysis it splits into carnic acid, succinic acid, carbonic acid, paralactic acid, phosphoric acid, and a carbohydrate group.[5]

[1] Bunge's "Organic Chemistry," p. 77.
[2] Kossel, *Zeit. f. Physiol. Chem.*, 1879, iii. 284.
[3] Bunge, *Ibid.*, 1895, ix. 56.
[4] Walter, *Ibid.*, 1901, xv. 489.
[5] Hammarsten's "Physiological Chemistry," p. 305.

THE NUCLEIC ACIDS.—During digestion the nucleins break up into protein and nucleic acids ; the latter in turn are transformed into nuclein bases or purin bodies, pyrrimidine bases, and phosphoric acid. The nucleic acids are not all of the same composition, although they generally contain four atoms of phosphorus, and they yield different products. Neither have they been thoroughly investigated, but several of them are well known—*e.g.* :

(*a*) *Thymo-nucleic acid*, which occurs in the thymus gland and fish-sperm. Nucleic acids which are obtained from the spleen and pancreas are closely related to it.

(*b*) *Guanylic acid* is also obtained from the pancreas. It decomposes into guanine, xylose (a pentose), glycerine, and phosphoric acid.

(*c*) *Inosinic acid* is also a nucleic acid.

(*d*) *Phospho-carnic acid*, mentioned above, is another.

(*e*) *Nucleic acids* are also present in plants, the best known being those obtained from yeast and the embryo of wheat.

THE NUCLEIN BASES OR PURIN BASES.—Only four nuclein bases —xanthin, hypoxanthin, guanine, and adenine—have actually been found among the decomposition products of cell-nuclei and nuclein. But other nuclein bases arise from the food, and occur in the flesh and urine ; it is therefore convenient to include these among the other constituents of animal and vegetable foods.

While the cells remain in their original and normal state, as in the glands, the nuclein bases are not free, but are combined with the nucleins to form nucleo-proteins. But in those tissues which are poor in cell-nuclei, the nuclein bases contained therein are in a free state. The nuclein bases therefore stand in close relation to the nucleus of the cell ; they are most abundant in those tissues which contain a large quantity of nucleated cells ; while in some diseases, such as leukæmia, the blood contains 1·04 per 1,000, whereas normal blood only contains traces of these bodies.

The nuclein bases, purin bodies, alloxuric bases, or xanthin bodies, as they are indifferently called, are a group of allied substances related to one another and to uric acid, which is also a member of the group. They are all considered, chemically, to consist of urea and an alloxuric nucleus ; all to be ultimately reduced to uric acid, while some are in the intermediate stage of transformation to it. They are chemically derived from alloxur, or purin, $C_5H_4N_4$. Those which occur in the food, in the body, and in the urine, are as follows :

PURIN BODIES.

Alloxur, or purin, $C_5H_4N_4$.	Carnine, $C_7H_8N_4O_3$.
Hypoxanthin, sarkin, or oxypurin, $C_5H_4N_4O$.	Methyl-xanthin, Hetero-xanthin } $C_6H_6N_4O_2$.[1]
Xanthin, or dioxypurin, $C_5H_4N_4O_2$.	Dimethyl-xanthin, Theophyllin, Paraxanthin, Theobromin } $C_7H_8N_4O_2$.[1]
Uric acid, or trioxypurin, $C_5H_4N_4O_3$.	Caffein, or trimethyl-xanthin, $C_8H_{10}N_4O_2$.[1]
Adenine, or amino-purin, $C_5H_5N_5$.	
Guanine, or amino-oxypurin, $C_5H_5N_5O$.	
Epiguanine, $C_{10}H_{13}N_9O_2$.	
Episarkine, $C_4H_8N_4O_3$.	

[1] These are separate and distinct substances.

Xanthin, $C_5H_4N_4O_2$ (=2, 6-oxypurin): It is found in muscle, liver, spleen, pancreas, thymus, and brain. It is amorphous, or forms granular masses of crystals or thin rhombic plates. It is very insoluble in water, only 1 part dissolving in 14,000 parts at 16° C., and only 1 in 1,300 of boiling water. It is readily dissolved by alkaline solutions.

Hypoxanthin, or sarkin, $C_5H_4N_4O$ (=6-oxypurin): This substance occurs in the same situations as xanthin, also in bone-marrow, and *an extremely small quantity in milk.*[1] It occurs in normal urine, but there are considerable quantities in the blood and urine of leukæmic patients. It forms colourless crystalline needles, scarcely soluble at all in cold water, but 1 part dissolves in 80 of boiling water ; it dissolves in acid or alkaline solutions.

Adenine, $C_5H_5N_5$ (=6-amino-purin): It occurs in all nucleated cells, especially in thymus. It is found in leukæmic urine, and may be obtained in large quantity from tea-leaves.[2] It crystallizes in long needles ; is very soluble in warm water, dilute acids, and alkalies ; but cold water only dissolves 1 in 1,086 parts. It is more soluble in ammonia solution than guanine, but less so than hypoxanthin.

Guanine, $C_5H_5N_5O$ (=2-amino-6-oxypurin), occurs in all those organs which are rich in cells—*e.g.*, spleen, pancreas, liver, and thymus—but only a small amount is obtainable from muscle. It is a colourless and amorphous powder, insoluble in water, alcohol, and ether ; it is easily dissolved by acids and alkalies, but dissolves with difficulty in ammonia.

Epiguanine and *episarkine* are found only in urine.

Carnine ($C_7H_8N_4O_3$) is a substance found in meat extracts ; it is transformed into hypoxanthin by oxidation. It is a white crystalline mass, soluble in warm water.

The Guanadine Bases—creatin and creatinin—should be mentioned here.

Creatin ($C_4H_9N_3O_2$), or methyl-guanidine-acetic acid, is a derivative of the xanthin or purin bodies, and is found in conjunction with them. It occurs in considerable quantity in the muscles of all vertebrate animals, but most of all in birds. It crystallizes in hard colourless monoclinic prisms, and 1 part is soluble in 74 of water. It is converted into creatinin ($C_4H_7N_3O$), the anhydride of creatin. Creatinin is more soluble than creatin, 1 part being soluble in 11 parts of water, and is more soluble in warm water. It occurs in mammalian muscle, the flesh of certain fishes, and to a slight extent in milk.

The guanadine bases are complicated compounds. Guanadine (CH_5N_3) is a crystalline substance which may be looked upon as urea (CH_4N_2O) in which the oxygen has been replaced by an imido-group (NH). On heating creatin with soda, methylamine and ammonia are evolved. Methylamine is important in the synthesis of creatin and sarcosin.

[1] Hammarsten's "Physiological Chemistry," p. 135.

[2] *Ibid.*

Heteroxanthin ($C_6H_6N_4O_2$), *monomethyl-xanthin* ($C_6H_6N_4O_2$), and dimethyl-xanthin, or *paraxanthin* ($C_7H_8N_4O_3$), are derived from the theobromin, caffein, and theophyllin, which occur in various foods. They form the chief mass of the purin bases of the urine.[1] Heteroxanthin has a formula identical with that of monomethyl-xanthin, but is said to have a different molecular constitution. Monomethyl-xanthin is the purin body which passes into the urine after feeding with cocoa or coffee (*i.e.*, theobromin or caffein). It forms shining needles, which dissolve with difficulty in cold water, but more readily in solution of ammonia or other alkalies. It does not give the xanthin reaction.

Purin Bodies in Food.—The quantity of purin bodies in various foods, estimated by Walker Hall, is as follows :

The Purin Bodies in Food.

Food.	Per Cent.	Grammes per Kilo.	Grains per Pound.
(*a*) Animal : Pork (neck) ..	·056	·56	3·97
Tripe	·057	·57	4·00
Codfish	058	·58	4·07
Plaice	·079	·79	5·56
Mutton	·096	·96	6·75
Rabbit	·097	·97	6·81
Halibut	·102	1·02	7·14
Beef-ribs	·113	1·13	7·96
Ham (fat)	·115	1·15	8·08
Veal (loin)	·116	1·16	8·14
Salmon	·116	1·16	8·15
Pork (loin)	·121	1·21	8·49
Turkey	·126	1·26	8·82
Chicken	·129	1·29	9·06
Beef (sirloin)	·130	1·30	9·13
Beefsteak	·206	2·06	14·45
Liver	·275	2·75	19·26
Sweetbread	1·006	10·06	70·43
(*b*) Vegetable : Potatoes ..	·002	·02	·14
Onions	·009	·09	·66
Asparagus	·021	·21	1·50
Peameal	·039	·39	2·54
Oatmeal	·053	·53	3·45
Haricot beans	·063	·63	4·16
(*c*) Beverages : Lager-beer ..	·012	·12	1·09
Pale ale	·014	·14	1·27
Porter	·015	·15	1·35

Practically *no purin bodies* are contained in milk, butter, cheese, eggs, wheaten bread (white), macaroni, rice, sago, tapioca, cabbage, cauliflower, lettuce, sugar, fruit, sherry, port, volnay, and claret.

The Pyrrimidine Bases.—Several bodies known by this name are also derived from nucleic acids ; they are—

[1] Hammarsten's "Physiological Chemistry," p. 135.

Uracil, $C_4H_4N_2O_2$ (=2, 6-di-oxy-pyrrimidine): It is derived from thymo-nucleic acid, and from the nucleic acids of spleen, pancreas, yeast, and herring testicles. It forms rosettes of needle-shaped crystals; readily soluble in hot water, not very soluble in cold water, and almost insoluble in alcohol and ether.

Thymin, $C_5H_6N_2O_2$ (5-methyl-uracil): This results from the splitting of thymo-nucleic acid, and crystallizes in stellar form or dendric leaves.

Cystosin, $C_4H_5N_3O$ (=6-amino-di-oxy-pyrrimidine): It is the result of splitting up the nucleic acids of the spleen, pancreas, yeast, etc. It crystallizes in thin leaves which look like mother-of-pearl, and dissolves in water with difficulty.

8. **The Derivatives of Protein.**—These consist of metaproteins, proteoses, peptones, and polypeptides. These are usually regarded as the products of protein digestion or hydrolysis only; but seeing that they frequently occur among the constituents of vegetables, it would be impossible to say that some of them are not in course of being transformed into proteins of a higher grade.

METAPROTEINS are the most complex; they consist of acid-albumin and alkali-albumin, and were formerly called "albuminates." But the latter is considered to be an objectionable term, because metaproteins are obtained from both albumins and globulins, and the suffix *ate* implies a salt. They are insoluble in pure water and neutral solutions containing no salt; they are soluble in acid or alkaline solutions or weak salines. They are not coagulated by heat; but, like globulins, they are precipitated by neutral salts—*e.g.*, sodium chloride and magnesium or ammonium sulphate in excess.

(*a*) Acid-albumin, or syntonin, is precipitated from its solution by neutralization even in the presence of alkaline phosphates. (*b*) Alkali-albumin is also precipitated by neutralization. Alkali-albumin contains less sulphur than acid-albumin.[1] A very insoluble alkali-albumin (Lieberkuhn's jelly) is formed by adding strong potash to the white of egg. **Legumin**, or vegetable casein, is simply alkali-albumin formed from native globulins by reagents of the analyst.[2]

Conglutin is the legumin from almonds and lupins.

PROTEOSES are less complex than metaproteins; they include albumoses, globuloses, gelatose, vitellose, caseinose, myosinose, etc., according to their origin. In plants they are called "phyto-albumoses"—*e.g.*, in gluten. They are most commonly proteins which have undergone some chemical change, usually as the result of enzymic action, as in the process of digestion. They give the biuret reaction—*i.e.*, rose-red colour with KHO and $CuSO_4$. They are not coagulated by heat, but most of them are precipitated by saturation with sulphate of ammonia and other neutral salts, also by tannic acid and nitric acid. They are classified as—

(*a*) *Proto-proteose* or albumose: Soluble in pure water; precipitated from solution by $MgSO_4$, $CaSO_4$, and $(NH_4)_2SO_4$. α-Phyto-albumose in wheat flour and papaw juice is a proto-albumose.

[1] Halliburton's "Chemical Physiology," p. 128. [2] *Ibid.*

(*b*) *Hetero-proteose* or albumose: Differs from the former by being insoluble in pure water, but is soluble in 0·5 to 15 per cent. cold solution of sodium chloride; precipitated by heat. *β*-Phyto-albumose in papaw juice is a hetero-albumose.

(*c*) *Deutero-proteose* or albumose: Differs from both the foregoing in not being precipitated by $MgSO_4$. Soluble in hot and cold water. Precipitated by $(NH_4)_2SO_4$.

Proto-proteose yields a considerable amount of tyrosin, indol, and a little leucin, but no glycocoll. Hetero-proteose yields abundance of leucin and glycocoll, but only a little tyrosin and indol.

PEPTONES are still less complex than the former groups, and are the result of definite chemical changes usually due to enzymic action. They are hemi-peptone and anti-peptone. They are soluble in water, but are not precipitated by nitric acid, sulphate of ammonia, or other neutral salts. They are, however, precipitated by tannin and an excess of pure alcohol. Although they differ from proteoses, inasmuch as they cannot be salted out from a solution, they resemble those bodies in giving the biuret reaction.

Hemi-peptone is split into amino-acids similar to those of the proteoses, and especially leucin and tyrosin, by the action of the pancreatic juice. Anti-peptone is no further reduced.

Vegetable peptones occur as the result of the action of enzymes in the plant tissues. Such enzymes are separable from papaw, pine-apple, etc. *True* peptone, however, does not occur as such in vegetable tissues, but only *phyto-albumoses* are formed—*e.g.*, **gliadin**; but the vegetable enzymes are capable of producing true peptones from animal proteins.

POLYPEPTIDES are at present known chiefly as synthetic compounds prepared from amino-acids; some, however, have been separated from the products of protein hydrolysis. The majority of those synthetized do not give the biuret reaction, although some of them do so.

Some vegetable proteins are compounds of several. Gluten consists of glutin, glutin-fibrin, gliadin, and mucedin, or vegetable mucin. The presence of gliadin (an albumose) appears to be necessary in wheat flour, as well as glutin-fibrin, to make good bread. The flours of barley, rye, and oats, only contain a trace of gliadin, and the seeds of Leguminosæ none at all, whence it arises that they are incapable of being made into a light and porous bread.

Carbohydrates.

In the analysis of foods, the percentage of carbohydrates as stated in ordinary tables represents the total amount of starch, dextrin, gum, sugar, cellulose, fibre, etc. The calculation is very frequently "by difference"; that is, after estimating the proportion of protein, fat, and ash, the remainder shows the total amount of carbohydrates in the substance analyzed. The determination of *fibre* in vegetable foods, when separately stated, consists of the amount of carbo-

hydrate which is not soluble in dilute acids or alkalies. The separation of the total carbohydrates into percentages of starch, dextrin, sugar, etc., requires more careful analysis, and the process is more elaborate when the *kinds* of sugar have to be stated.

The carbohydrates consist of a homologous series of aldehyde or ketone alcohols of the general formula $CnHn_2On$, and having the following properties in common: (1) A sweet taste; (2) they are optically active; (3) they reduce alkaline metallic solutions; (4) they yield characteristic crystalline compounds with phenylhydrazine. Those containing multiples of three carbon atoms are fermentable by yeast, and yield alcohol. Individual carbohydrates have special characteristics—*e.g.*, when heated with strong acids they yield characteristic derivatives; for instance, the pentoses yield furfurol, and the hexoses yield levulinic acid. They are classified by Tollens[1] as monosaccharides, disaccharides, trisaccharides, and polysaccharides, according to the number of C_6 groups in the molecule.

1. Monosaccharides.

This is the grape-sugar group, the glucoses or **monoses.** They are aldehydes or ketones of the alcohols, formed in various ways. The aldehydes are characterized by their well-known tendency to polymerize. Beginning with simple forms, we have CH_2O, or methaldehyde, two molecules of which, being linked together, form $C_2H_4O_2$, or glycollic aldehyde, a syrupy liquid; three molecules linked together form $C_3H_6O_3$, or glycerose, an alcoholic aldehyde derived from glycerine; and so on through the series.

Trioses, $C_3H_6O_3$—*e.g.*, glycerose.
Tetroses, $C_4H_8O_4$—*e.g.*, erythrose.
Pentoses, $C_5H_{10}O_5$: arabinose, ribose, xylose, and rhamnose
Hexoses, $C_6H_{12}O_6$—(*a*) *Aldoses:* glucose or dextrose, mannose, galactose, fructose, formose, gulose, β-acrose, talose, rhamno-hexose ($CH_3.C_6H_{11}O_6$). Each kind has a dexto-rotatory, levo-rotatory, and an inactive form of sugar. (*b*) *Ketoses:* levulose and sorbinose.
Heptoses, $C_7H_{14}O_7$: mannoheptose, galaheptose, fructoheptose, glucoheptose.
Octoses, $C_8H_{16}O_8$: mannoctose, glucoctose.
Nonoses, $C_9H_{18}O_9$: mannonose, gluconononose.

The monosaccharides are converted into corresponding alcohols by nascent hydrogen, and, conversely, the alcohols are convertible into monosaccharides by the loss of hydrogen. It is the general opinion that all carbohydrates, except inosite, are derived from the hexatomic alcohol mannite—thus:

$$\underset{\text{Mannite.}}{C_6H_{14}O_6} - H_2 = \underset{\text{Dextrose.}}{C_6H_{12}O_6}.$$

All the sugars named above are known.

[1] "Die Kohlenyhdrate," Breslau, 1888.

2. Disaccharides.

This is the cane-sugar group, or saccharoses ($C_{12}H_{22}O_{11}$), also called sucroses, bioses, or di-hexoses. The chief members of the group are—

Saccharose (cane-sugar).
Maltose (malt-sugar).
Lactose (milk-sugar).

They are condensed glucoses or anhydrides, formed by two molecules of any of the grape-sugar group becoming joined together in ether fashion, with the loss of a molecule of water. They are capable of hydrolytic cleavage into two molecules of the same carbohydrates.

3. Trisaccharides.

This is the raffinose group, formed by linking together three molecules of the monosaccharides, with loss of water. The chief representative is raffinose, or melitose, which occurs in manna and beetroot molasses. It is a combination of one molecule each of dextrose, levulose, and galactose, and can be hydrolyzed into the same.

4. Polysaccharides.

These consist of more than three molecules of monosaccharides or hexoses, linked together and condensed. They include a great number of very complex substances whose chemical constitution is unknown, but which have the general formula $n(C_6H_{10}O_5)$. They are most of them amorphous, and devoid of sweet taste. Some are soluble in water; others swell up, but are changed no further. They are split into monosaccharides or hexoses by hydrolytic cleavage. The principal forms are—

(*a*) *The Starch Group, or Amyloses:*
Starch.
Inulin.
Glycogen.
(*b*) *Vegetable Gums and Mucilages:*
Dextrin.
Gums.
(*c*) *The Celluloses.*

The foregoing classification of carbohydrates is, however, incomplete, and has been replaced by the following, which was constructed by C. O'Sullivan:

Class I.—Saccharans: $n(C_6H_{10}O_5)$.

These are amorphous carbohydrate substances occurring in growing plants. They are soluble in water, insoluble in alcohol, and yield glucoses $n(C_6H_{12}O_6)$ by the action of acids, without any intermediate change.

- Amylan, α and β.
- Dextran, α and β.
- Galactan, α and β.
- Levulan, α and β, γ and δ.

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CLASS II.—SACCHARENS: $n(C_6H_{10}O_5)$.

Insoluble in water and in alcohol; they yield $n(C_{12}H_{22}O_{11})$ bodies—*e.g.*, maltose, and cane-sugar—under the influence of enzymes or acids, and are finally converted by acids into $n(C_6H_{12}O_6)$ bodies.

- Cellulose.
- Starch.
- Inulin.
- Levulin.
- Tunicin. Etc.

A molecule of starch is supposed to consist of five amylin groups, each containing, according to different authorities $(C_{12}H_{20}O_{10})$, or $10(C_{12}H_{20}O_{10})$, or $(C_{12}H_{20}O_{10})_3$.

CLASS III.—SACCHARINS: $n(C_6H_{10}O_5)$.

Amorphous bodies, soluble in water, insoluble in alcohol. Under the influence of enzymes they are converted into $n(C_{12}H_{22}O_{11})$ bodies; under the influence of acids they are first converted into $n(C_{12}H_{22}O_{11})$ and afterwards into $n(C_6H_{12}O_6)$ bodies.

- (*a*) Dextrins or amylins.
  - Amylo-dextrin (i.) gives a blue colour with iodine.
  - Amylo-dextrin (ii.) gives a red-violet colour with iodine.
  - Erythro-dextrin gives a red colour with iodine.
  - Achroodextrin, α, β, γ, δ, ϵ, ζ, and η, give no colour with iodine.
- (*b*) Malto-dextrins or amyloïns. Compounds of maltose and dextrin.
- (*c*) Glycogen.
- (*d*) Dextrin-like products from inulin.

CLASS IV.—SACCHARONS (SUGARS).

1. SACCHAROSES, $n(C_{12}H_{22}O_{11})$. They are sweet and crystalline bodies; soluble in water and weak alcohol; converted by acids and enzymes into $n(C_6H_{12}O_6)$.
   - (*a*) Sucrose (cane-sugar), maltose (amylon), lactose.
   - (*b*) Raffinose (melitose), trehalose (mycose), melizitose, synanthrose.
2. GLUCOSES, $n(C_6H_{12}O_6)$: Soluble in water and alcohol; broken down by acids into substances which are no longer carbohydrates.
   - (*a*) Dextrose, levulose, galactose, etc., fermentable by yeast.
   - (*b*) Arabinose, xylose, sorbinose, acrose, etc.; not fermentable by yeast.
3. AROMATIC BODIES—*e.g.*, inosite $(C_6H_{12}O_6)$—which have little in common with other carbohydrates.

CLASS. V.—GUMS, MUCILAGES, GLUCOSIDES, AND PECTINS.

These bodies are compounds related to the carbohydrates, and capable of yielding these substances by the action of acids, and some of them under the influence of enzymes.

The Sugars.

Monosaccharides are all reducing bodies. With phenyl-hydrazine they yield *hydrazones*; with further action of the hydrazine and acetic acid they yield *osazones*. With ammonia they form *osamines* and *osimines*—*e.g.*, glucosamine, or amino-sugar, and glucosaminic acid; and with hydroxylamine they give corresponding *oximes*. Further, with HCN they take up the cyanogen radical, and become *cyanhydrines*—*e.g.*, gluco-cyanhydrine—which are regarded by some authorities as of great importance in the construction of the proteins.

The **Pentoses** ($C_5H_{10}O_5$) do not as a rule occur free in Nature, but are combined as **pentosans** with more complex carbohydrates, from which they may be obtained by hydrolytic cleavage. The pentoses are of great physiological importance, as they are constituents of nucleic acids, and consequently are contained in the nuclei of cells.[1] As pentosans they are widely distributed throughout the vegetable kingdom, where, particularly as **xylan** and **araban,** they form a considerable proportion of the building material. Pentosans occur in solution in the juices of a large variety of green plants, being more abundant in the morning than in the evening. They are probably assimilation products, existing in a soluble form, but undergoing changes into something of an insoluble nature, and again dissolved and transformed as the needs of the plant require.[2] Xylan can be extracted from straw by treatment with quicklime, as in the manufacture of paper, the liquid being a good source of xylan and xylose.[3] Pentosans also exist to a considerable extent in the seeds of Graminaceæ and Leguminosæ, straw, grasses, etc. Water-free cassava contains 3·96 per cent., and eleven kinds of gum reveal the presence of pentosans. They are not very digestible—probably less so than any other amorphous carbohydrates of the same degree of solubility.

The chief pentoses are arabinose and xylose, which are both aldoses, and differ only in the arrangement of the groups attached to their three asymmetric carbon atoms. Arabinose can be obtained from gum arabic, cherry-gum, and many other gums, by boiling them with sulphuric acid. It is sometimes found in the contents of the stomach and in the urine. It reduces Fehling's solution, but is not fermentable. Xylose is a crystalline reducing sugar obtained from wood-gums, straw, etc., by boiling them with acetic acid. It is very widely distributed as a pentosan throughout the vegetable kingdom, and has been obtained from the proteins of the pancreas. Rhamnose is another pentose sugar obtainable by the action of acids on quercitin, rhamnin, hesperidin, and other glucosides ; and fucose from similar action on fucus. The latter yields an osazone melting at 158° to 160° C., and having the formula $C_6H_{12}O_5$. The pentoses are converted into furfurol during the manufacture of alcohol; arabinose yields 43 per cent., and xylose 52 per cent.

Experiments undertaken to ascertain if the pentoses (*e.g.*, xylose) might be taken in cases of diabetes mellitus, as a substitute for other sugars, have shown that, although the pentoses are soluble, they are not readily digested or assimilated by human beings, and that the portion which is absorbed readily passes into the urine, where even slight traces of the pentoses are shown by the phlorglucin reaction.

The **Hexoses** ($C_6H_{12}O_6$) are the most important of the aldoses and ketoses, both practically and physiologically. The best-known examples are dextrose and levulose, but there are two groups :

[1] Bunge's " Organic Chemistry," p. 108.
[2] De Chalmot, *Amer. Chem. Jour.*, xv. 21, 276.
[3] Stone and Test, *Amer. Chem. Jour.*, xv. 21, 295.

(*a*) *Aldoses:* Dextrose, mannose, galactose, gulose, formose, acrose, talose, etc.

(*b*) *Ketoses:* Levulose, sorbinose, etc.

Dextrose, Glucose, or *d*-**Glucose,** also called "grape-sugar" and "diabetic sugar." This is physiologically the most important sugar. In an impure state it occurs abundantly in sweet fruits, such as grapes, also in seeds, roots, and honey. Ripe grapes contain 10 to 25 per cent. of it, dried figs 60 to 70, fresh cherries 11, mulberries 9, currants 6, whortleberries 6, and raspberries 4 per cent. It is frequently associated in the vegetable kingdom with levulose. It exists in blood, lymph, and other animal fluids and tissues, and arises in the alimentary canal as the result of enzymic action upon carbohydrates, especially upon starch, dextrin, and more complex carbohydrates, such as glucosides. It can also be formed in the body from proteins, and especially does this occur in starvation and severe forms of diabetes mellitus. It is manufactured commercially by the hydrolysis of carbohydrates, such as starch or woody fibre, and is sold as a syrupy liquid or solid glucose (see Glucose). Pure dextrose is soluble in hot and cold water, sparingly soluble in cold alcohol, but freely soluble in boiling alcohol. It is insoluble in ether. When free from water it forms needles or six-sided prisms; with a molecule of water it crystallizes to form warty masses, small leaves, or plates. It is dextro-gyrate. It reduces a solution of copper sulphate made alkaline by the addition of caustic soda, red oxide of copper being thrown down. Dextrose also reduces Fehling's solution, red cupric oxide being produced; in quantitative measurements, 10 c.c. of Fehling's solution reduced corresponds to 0·05 gramme of sugar. It is not blackened by sulphuric acid in the cold, but it unites with it to form a yellowish compound. It is transformed into caramel on the application of great heat. When dry dextrose is heated to 170° C., it loses a molecule of water, and becomes **dextrosan** ($C_6H_{10}O_5$); if the temperature is raised to 200° C., more water, gas, and volatile acids, are formed, and driven off; and a continuance of this heat converts it into a brownish-black mass called **caramel,** which is used for cooking purposes, and for colouring various articles, such as wine or beer. Dextrose is not so sweet as cane-sugar, 2½ parts of dextrose being equal to 1 part of cane-sugar. It ferments with yeast; bacteria convert it to lactic and butyric acids, and it gives an osazone with phenyl-hydrazine and acetic acid. It forms compounds with certain acids and bases—*e.g.*, lime or potash; these are called "glucosates."

Dextrose or glucose is an aldose which, upon oxidation, yields three acids—viz., glycuronic or glucuronic, glyconic, and saccharic acids. Glycuronic acid is of dietetic importance, because it is formed in the animal organism at the commencement of the oxidation of grape-sugar. "The oxidation of sugar in our tissues normally goes on rapidly and without cessation; but occasionally glycuronic acid is met with, especially when substances which are difficult of oxidation are allowed to enter the organism—*e.g.*, camphor and chloral. By the combination of these substances with glycuronic acid they prevent the oxidation of the latter. It is in this form that they pass out of the body

in the urine, and, according to Fischer, the organism protects itself against the poisonous action of camphor and chloral by this mode of dealing with them."[1]

Levulose, Fructose, or fruit-sugar, like dextrose, is widely distributed throughout the vegetable kingdom, frequently in company with it, especially in fruit and honey. When pure, levulose forms shining needles or crystals of the rhombic system, but it crystallizes with difficulty. It is soluble in water and boiling alcohol, but is barely soluble in cold alchool. It ferments with yeast, and yields alcohol, but more slowly than dextrose. It gives the same reactions as dextrose, but does not reduce Fehling's solution to quite the same extent. Levulose may be dried in a vacuum at 50° C. without change; it then has the composition $C_6H_{12}O_6$. It is levo-gyrate. The specific rotatory power of a 20 per cent. solution is $-71{\cdot}4°$ at a temperature of 20° C. Alcohol reduces the rotatory power of levulose, just as it slightly augments that of dextrose. Levulose forms a compound or alcoholate with alcohol—$C_6H_{11}O_6(C_2H_5)$. Levulose is formed by the action of enzymes or acids upon various carbohydrates—*e.g.*, cane-sugar (saccharose), inulin, raffinose, etc.; the process is called *inversion*, and is the result of hydrolytic cleavage.

The sugar in fruit is usually a combination of dextrose and levulose, and is called **invert-sugar**; it is uncrystallizable, and forms granular masses in dried fruit; consists of 4 parts of levulose and 3 parts of hydrated dextrose, some of which arise by inversion of saccharose. It is levo-rotatory. A mixture of equal parts of levulose and dextrose does not give the same optical properties as invert-sugar, while a mixture of 2 parts of levulose and 1 part of hydrated dextrose form a crystalline compound.[2]

Sorbinose is a ketose; crystalline, levo-gyrate; convertible into sorbite by reduction. It is the sugar in the fruit of the service-tree and mountain-ash, and appears to arise from the hydrolysis of a glucoside, or, according to Freund, from the oxidation of a gelatinous substance in service fruit.[3]

Agavose is a sugar from *Agave Americanus*. It is very sweet; reduces Fehling's solution five-eighths as strongly as dextrose. It yields no mucic acid on oxidation. After inversion it is levo-rotatory.

Mannose, or **Seminose,** does not occur free in Nature, but is in combination with other carbohydrates. It is fermentable with yeast, and is dextro-gyrate. It is obtained by the hydrolysis of carbohydrates, especially in the shavings of ivory-nut, and by the oxidation of mannite.

Mannite ($C_6H_{14}O_6$) occurs naturally in many vegetable substances, notably in manna, of which it forms 30 to 60 per cent. It also occurs in celery, roots of *Scorzonera hispanica*, and numerous other

[1] Bunge's "Organic Chemistry," p. 113.
[2] Winter, *Moniteur Scientifique*, February, 1888.
[3] *Chemical News*, 1891, ii. 260.

roots and barks. It is produced in the lactic fermentation of sugar, in the spontaneous fermentation of sugar-cane juice in tropical countries, and in the viscous fermentation of sugar; it is also produced in the reduction of mannose by means of a sodium amalgam. In viscous fermentation, 100 parts of sugar yield 51 parts of mannite and 46 parts of gum.

Inosite, or Phaseomannite.—This sugar occurs in muscle, heart, liver, kidney, spleen, nervous and other animal tissues, and to a slight extent in the normal urine of man. But, like other monosaccharides, it is also widely distributed in the vegetable kingdom, but especially in unripe fruits, green kidney beans, the green pods and seeds of unripe peas, unripe lentils, green asparagus and its berries, common cabbage, the young shoots of potatoes, etc. The name "phaseomannite," frequently applied to this sugar when of vegetable origin, is derived from *Phaseolus vulgaris*. Hammarsten says it is not really a carbohydrate, but *hexa-hydroxy-benzene*, although its ordinary formula is identical with that of the glucoses. It does not appear to be an aldehyde. According to Maquenni,[1] it is a hexatomic alcohol of simple function derived from hexamethylamine, and should be regarded as mannite with a closed chain, but is not a polyphenol. Inosite is soluble in water, and crystallizes in colourless rhombic prisms. It does not rotate polarized light; it is not fermentable, and does not reduce Fehling's solution.

Galactose arises by the hydrolytic cleavage of natural carbohydrates, especially certain gums and slime-bodies—*e.g.*, the gum-arabic, the gum of plum, peach, and other fruit trees, agar-agar, carrageen moss, lactosin, and especially from lactose or milk-sugar, during digestion. It is dextro-rotatory, less soluble than dextrose, and crystallizes in needles or leaves. It reduces Fehling's solution, but is feebler in this respect than dextrose. It is completely fermentable by various yeasts, but not by *Saccharomyces apiculatus*.

Glucosamine. — This is an amino-sugar ($C_6H_{13}NO_5$ or $C_6H_{11}O_5.NH_2$), one of the hydroxyls of a monosaccharide being replaced by an amido-group. It is derived from one of the hexoses, probably dextrose or mannose. It is an intermediate substance between the glucoses and amino-acids, and is to be regarded as a bridge between carbohydrates and proteins in the developmental process of matter. It has a reducing action similar to that of glucose, and gives the same osazone, but is not fermentable. It can be obtained from gluco-proteins, such as mucin and mucinoid, and also from chitin, the shells of lobsters, crabs, and other invertebrates, by the action of strong hydrochloric acid.

Glycuronic or **Glucuronic Acid** ($C_6H_{10}O_7$) is another derivative of dextrose. It occurs to a slight extent in normal urine in the form of phenyl-indoxyl-glycuronic acid and skatoxyl-glycuronic acid. The excretion of these bodies by the kidneys is increased by the ingestion of aromatic bodies and other substances of the aliphatic series, and especially by camphor and chloral; and by the decomposition of proteins.

[1] *Compt. Rend.*, 1887, civ. 24.

Glucosides are compounds occurring almost entirely in the vegetable kingdom; they consist of a combination of glucose with various organic radicals. Their composition is similar to that of the gluco-proteins, and they are split by hydrolysis into a sugar and some substance which is not a sugar. The sugar produced in this hydrolysis is usually one of the ordinary or special forms of glucose; it, however, may not be a glucose, but some related body, such as iso-dulcite or chinosite.

The glucosides are usually etheroid derivatives of the sugar in question. The other body combined with such sugar belongs either to the aromatic or fatty acid series. It may be a hydrocarbon, alcohol, aldehyde, diketone, phenol, or a base. In many glucosides this body has not been determined. The combination can be split by enzymes or by heating the glucoside with a dilute acid. Among the glucosides are salicin, consisting of saligenin and glucose; tannin, consisting of gallic acid and glucose; amygdalin, sinalbin, indican, coniferin, quercitin, rutin, hesperidin, apiin, etc. The importance of these bodies to the vegetable organism is probably not yet fully understood, but it seems probable that *gluco-succinic acid* and several allied glucosides must rank among the first products of assimilation. The numerous glucosides are resolved into their proximate constituents by the action of enzymes, the most familiar being *emulsin*, or synaptase, which decomposes amygdalin of bitter almonds thus:

$$\underset{\text{Amygdalin.}}{C_{20}H_{27}NO_{11}} + 2H_2O = \underset{\text{Benzaldehyde.}}{C_7H_6O} + \underset{\text{Prussic acid.}}{HCN} + \underset{\text{Glucose.}}{2C_6H_{12}O_6}.$$

The decomposition of other glucosides is represented by the following equations:

$$\underset{\text{Potassium myronate.}}{C_{10}H_{18}KNS_2O_{10}} = \underset{\text{Hydrogen-potassium sulphate.}}{KHSO_4} + \underset{\text{Oil of mustard.}}{C_3H_5.CS.N} + \underset{\text{Glucose.}}{C_6H_{12}O_6}.$$

$$\underset{\text{Salicin.}}{C_{13}H_{18}O_7} + H_2O = \underset{\text{Saligenin.}}{C_7H_8O_2} + \underset{\text{Glucose.}}{C_6H_{12}O_6}.$$

$$\underset{\text{Tannin.}}{C_{27}H_{22}O_{17}} + 4H_2O = 3\underset{\text{Gallic acid.}}{C_7H_6O_5} + \underset{\text{Glucose.}}{C_6H_{12}O_6}.$$

The **animal glucosides** are—Cerebrin, in nervous tissues; mucin, which yields a protein and animal gum, and is almost everywhere in the tissues; chitin, in epithelial structures; carminic acid, in pigments, etc.

Chlorophyll is an exceedingly unstable body; attempts to isolate it have failed, its solution being destroyed by air, sunlight, and acids. It is defined as the whole of the pigments producing the green colouring matter in plants, but the pigments include yellows or greens. The chlorophylls therefore are divided into two groups:

(*a*) The *chlorophyllin* group, including chlorophyllin blue (phyllocyanin).

(*b*) The *xanthophyllin* group (yellow), including carotin, erythrophyll, chrysophyll, etc.

A plant may contain several chlorophylls, and each pigment is a separate entity. It is considered by Etard[1] that each pigment should have a name derived from the botanical name of the plant; thus, *lucern* contains two chlorophylls which have the following composition, and for which he proposes the names—

Medicagophyll-α, $C_{25}H_{45}NO_4$.
Medicagophyll-β, $C_{42}H_{63}NO_4$.

The chlorophylls appear to be simple organic colouring matters, but they are not so; *they are glucosides*, stable in the presence of alkalies, but decomposed by acids.[2] Chlorophylls are obtained by extracting the green leaves with boiling alcohol. After standing some time the deposit is collected on a filter, and mixed with its own weight of ether. The liquid now separates into two layers—a lower or yellow one, which gives a glucose reaction; and an upper layer, which on evaporation leaves a bright green residue. On being mixed with water this residue gives a dark green precipitate, consisting of the phyllocyanin and xanthophyllin of Fremy,[3] which are the blue and yellow colouring matters of the chlorophyll.

The **Alkaloids** are organic bases containing nitrogen, but they have a glucoside-like constitution. They are divisible into those which contain oxygen and those which do not. The latter are liquids volatile without decomposition; the former are crystalline bodies, and with few exceptions do not volatilize without decomposition. In plants they are combined with organic acids Thus, pepper contains the alkaloid *piperidine*, a colourless liquid having strong basic properties. It is combined with *piperic acid* ($C_{12}H_{10}O_4$). Some of the alkaloids, however, are distinctly glucoside combinations; thus, *solanine* is a poisonous glucoside in potatoes, tomatoes, and other foodstuffs. It consists of the poisonous alkaloid *solanidine*, in a glucoside-like combination with sugar. It is true that the proportion of this alkaloid in foodstuffs is usually negligible; but occasionally[4] it rises in young or diseased potato tubers to such a degree that severe, though non-fatal, wholesale poisoning in man has been recorded.

The *Disaccharides*, or saccharoses ($C_{12}H_{22}O_{11}$), form the cane-sugar group. They are also called bioses, di-hexoses, and sucroses. The chief members of the group are saccharose, lactose, and maltose. They are condensed glucoses or anhydrides, formed by two molecules of any of the grape-sugar group becoming linked together in the ether fashion—that is, with the loss of one molecule of water. They are also capable of being split into two molecules of the same carbohydrates.

Cane-Sugar, Saccharose, or **Sucrose** ($C_{12}H_{22}O_{11}$) is the ordinary domestic sweetening substance or "sugar" of commerce. It is

[1] *Compt. Rend.*, 1895, cxx. 6.
[2] Schunk, *Chemical News*, 1884, i. 2.
[3] *Compt. Rend.*, lx. 188.
[4] Bunge, *ibid.*, p. 224.

widely distributed through the vegetable kingdom in the juices of plants and fruits, but is especially abundant in the stalk of sugar-cane and sugar-millet, the roots of beet, carrot, and other vegetables, the trunks of maple and palm trees, etc. As a food it occupies a very high position, and in this respect will be fully dealt with in another chapter (see Sugar).

It is a combination of dextrose and levulose. It is dextro-rotatory, forms monoclinic, colourless prisms, and when heated to 210° C. is converted to caramel. The solid substance or a strong solution of cane-sugar is carbonized or " blackened " by the action of cold sulphuric acid. A solution of cane-sugar will not reduce Fehling's solution ; but if it is boiled for some time with dilute sulphuric acid, it undergoes hydrolysis, taking up water, and splitting into dextrose and levulose (invert-sugar), when it will readily reduce Fehling's solution. By oxidation cane-sugar is transformed into saccharic acid and oxalic acid.

• *Inversion of Cane-Sugar.*—As already indicated, cane-sugar splits into its component monosaccharides under the influence of various agents, the resulting mixture being levo-rotatory, uncrystallizable, and called **invert-sugar** (see under Levulose). This inversion is brought about by the action of—

(*a*) *Enzymes—e.g.*, diastase—in vegetables and fruit, and in the alimentary canal.

(*b*) *Yeast*, by its enzyme invertase.

(*c*) *Malt-extract*, by the enzyme diastase.

(*d*) *Heat*, as in prolonged boiling.

(*e*) *Dilute acids—e.g.*, sulphuric acid—after treatment of sugar by chalk.

Cane-sugar is fermentable with yeast, but a preliminary inversion of the saccharose into dextrose and levulose occurs before the fermentation takes place. *Commercial* cane-sugar almost always contains a small amount of other sugars as impurities, and these reduce Fehling's or Trommer's solution to a small extent.

Malt-Sugar, or **Maltose** ($C_{12}H_{22}O_{11}$), also called " malto-biose " and " amylon," occurs in commercial " glucose," beer or beer-wort, in germinated cereals, probably in bread, and is regularly formed during the digestion of amylaceous foods. It is a saccharose arising from the hydrolysis of starch by the enzymes, such as diastase of malt, and those of the saliva, pancreas, and liver. It occurs in leaves of plants as a product of assimilation. It forms as much as 51 per cent. of the dry matter of malt.

It is soluble in water, forms acicular crystals, and acts like dextrose in reducing Fehling's solution, but not to the same extent, and is dextro-rotatory. It is completely fermented by yeast, but not so readily as dextrose, and it is first inverted into that substance before fermentation occurs. During the digestion of starch in the alimentary canal maltose is formed ; but the blood of the mesenteric vessels only contains dextrose, wherefore it must be still further split before it is assimilated, either by an enzyme in the succus

entericus previous to absorption, or in its passage through the cells of the intestinal mucosa. If maltose is injected into the veins, it reappears in the urine untransformed.

Iso-maltose is a variety of sugar consisting of a combination of dextrose and dextrin,[1] instead of two molecules of dextrose; it occurs in beer-wort as the result of the action of diastase on starch and also by the action of the enzymes of the salivary and pancreatic glands.

Trehalose, or mycose, a sugar found in fungi, especially in ergot, yields only dextrose on hydrolysis or inversion. It resembles maltose, excepting that it does not form an osazone or reduce Fehling's solution. It is not susceptible to the action of diastase, invertase, or emulsin; but *Aspergillus nigra* converts it into dextrose. *Synanthrose* is a sucrose which occurs in certain roots; it has no action on polarized light.

Milk-Sugar, or **Lactose** ($C_{12}H_{22}O_{11}$), occurs naturally only in the animal world, and chiefly in milk; but it is obtainable by hydrolysis of certain carbohydrates and other vegetable substances by enzymes or acids. It is a combination of dextrose and galactose, and can be split into these substances. It forms hard rhombic crystals, which are soluble in six times their weight of cold water, and 2·5 times that of boiling water. It is dextro-gyrate, capable of combining with bases; it is not fermentable by pure yeast, but by certain other *schizomycetes*, the lactose being first inverted by the enzyme *lactase* of the yeast into dextrose and galactose. Koumiss, from mare's milk, and kephir, from cow's or goat's milk, is the result of such fermentation; but other organisms are present besides yeast, and they produce lactic acid from a portion of the sugar. Lactose reduces Fehling's solution, but has only seven-tenths the strength of dextrose in this respect.

The purity of commercial milk-sugar has been called in question by various writers, who assert that it is rarely free from bacteria; that when it is taken in food the attendant bacteria give rise to lactic and butyric fermentation of this and other carbohydrates. Thus, bacillus acidi lactici and *Penicilium glaucum* will produce lactic acid from dextrose, milk-sugar, or cane-sugar.

The *Trisaccharides*, or raffinose group of sugars: These sugars consist of three molecules of monosaccharides linked together in ether fashion—that is, with loss of water. The chief member of the group is **raffinose,** or **melitose** ($C_{18}H_{32}O_{16}\cdot 5H_2O$), which occurs in manna and beetroot molasses. It is a combination of one molecule each of dextrose, levulose, and galactose, which it gields on inversion, while on hydrogenization it yields dulcite and mannite. **Stachyose** is a very sweet sugar, but does not act on Fehling's solution. It is dextro-rotatory; has the formula $C_{18}H_{32}O_{16}$; is hydrolyzed into dextrose, levulose, and galactose. It is obtained most abundantly from the tubers of *Stachys tuberifera*, which

[1] Luig and Baker, *Chemical News*, 1895, ii. 45.

contains from 14 to 19 per cent. *Melizitose* is a sugar which forms 40 per cent. of the "honey dew" secreted on the leaves of various trees,[1] and also occurs in larch-manna.

The *Polysaccharides* consist of more than three molecules of hexoses or monosaccharides linked together in ether fashion and condensed. They include a great number of very complex substances, whose chemical constitution is unknown, but which have the general formula $n(C_6H_{10}O_5)$. They are split by hydrolysis into monosaccharides. They include the starch group, the vegetable gums and mucilages, and the celluloses. But these are not all. There is a group of bodies called by O'Sullivan the *Saccharans*—$n(C_6H_{10}O_5)$; it includes amylan, dextran, galactan, levulan, and there are α, β, γ, and δ, varieties of most of these bodies. They are amorphous carbohydrates occurring in growing plants, and are probably intermediate substances in the development of starch, dextrin, and other more complex carbohydrates. They are soluble in water, but insoluble in alcohol, and they yield monosaccharides ($C_6H_{12}O_6$) by the action of acids and enzymes without any intermediate change. One of the best known is the **amylan** found in cereals. O'Sullivan[2] distinguished two forms of this carbohydrate: α-Amylan $[n(C_6H_{10}O_5)]$ which occurs in barley, oats, wheat, and rye, but most plentifully in the two first-named cereals. It is a gum-like body, soluble in water, insoluble in alcohol; 2 per cent. dissolved in water will set into a jelly. It is converted entirely into dextrose by acids, and probably by enzymes also, since *none exists in malted grain*. In unmalted grain the proportion varies according to the season of the year, and is greater in some years than others. β-Amylan $[n(C_6H_{10}O_5)]$ is a substance closely allied to the former, occurs in the same cereals, and *does exist in malted grain*. It is more soluble than α-amylan in water, is insoluble in alcohol, and is completely converted by H_2SO_4 into dextrose. Apparently it is not affected so readily by enzymes, as it exists in malted grain, which contains active diastase. **Dextran** $[n(C_6H_{10}O_5)]$ is a gummy substance in unripe beetroot, carrots, etc.; it is also secreted by the louse (*Schizoneura lanuginosa*) which causes the galls in elms.

The starch group, Amyloses or *Saccharens* $[n(C_6H_{10}O_5)]$, include starch, inulin, levulin, etc.

Starch, fecula or amylum $[n(C_6H_{10}O_5)+H_2O]$, is very widely distributed in the vegetable kingdom. It occurs in different parts of plants, but is especially abundant in the roots and rhizomes of perennial plants, in the trunks of some trees, and as a reserve of food in tubers and seeds, such as potatoes, wheat, and beans. It is the most abundant constituent of vegetable foods. It exists in the form of granules which are produced by the plastids. The granules consist of two isomeric compounds which are arranged in alter-

[1] Stone, *Chemical News*, 1894, ii. 118.
[2] *Jour. Chem. Soc.*, xli. 24.

nate layers around a hilum. These compounds are *granulose* and *cellulose*, or starch-granulose and starch-cellulose. There are several distinct varieties of starch, which, although chemically identical, are physically distinguishable from one another ; in other words, the characteristic structure of the granules varies with the nature of the plant, so that the starch of rice, potato, maize, beans, sago, and tapioca, are distinct from each other. These variations in physical character will be noticed when treating of different plants, etc.

Starch is obtained by maceration of the parts which contain it. It is a dry, white, odourless and tasteless powder, consisting of granules varying in size from $\frac{1}{3000}$ inch in rice to $\frac{1}{200}$ inch in tous-les-mois, their size, shape, and appearance, varying with their origin. Starch is a colloid substance ; it is insoluble in cold water, but swells up in warm water, the granules bursting and forming a paste, which sets on cooling. When boiled with water the granulose dissolves, but the cellulose remains unaltered. It is dextro-rotatory. Starch paste does not ferment with yeast, nor give Moore's or Trommer's test ; the best test for it is the intense blue coloration produced by free iodine, even when a small quantity of starch is present. This colour disappears on heating, and re-appears on cooling. It also gives with tannic acid a yellow precipitate, which dissolves on heating. Starch is insoluble in alcohol and ether. Dilute mineral acids invert it to "glucose," the mixture containing dextrin, maltose, iso-maltose, and dextrose. Diastatic enzymes convert it into sugar, also consisting of a mixture of dextrin, maltose, iso-maltose, and a little dextrose. The sugars produced in the intermediate stages of the transformation are not clearly known.

Starch is a complex molecule consisting of monosaccharides, not differing in any particular of constitution from cane-sugar or malt-sugar. Some authorities consider it to be a higher and more complex form of cane-sugar (saccharose), just as they consider maltose to be a form of dextrin. On the other hand, there are authorities who hold the theory that starch is a complex which breaks down by successive subtraction of glucose molecules, the more or less complex residue constantly changing in character. Five stages of this process are recognized :[1]

1. Amylodextrin, $(C_{12}H_{20}O_{10})_{54}$.
2. Erythrodextrin, $(C_{12}H_{20}O_{10})_{18}$.
3. Achroodextrin, $(C_{12}H_{20}O_{10})_{6}$.
4. Iso-maltose, $m(C_{12}H_{22}O_{11}) + n(C_{12}H_{12}O_{10})$.
5. Maltose, $(C_{12}H_{22}O_{11})$.

The unknown value of the starch molecule, $n(C_6H_{10}O_5)$, may be taken as being $10(C_{12}H_{20}O_{10})$. Then the changes occurring by hydration under the influence of the diastatic enzyme, which produces maltose from starch, will be as follows ; the maltose increases and the dextrin decreases with each reaction, while higher and still higher types of dextrin are produced at each stage :

[1] Linter and Düll, *Ber. d. Chem. Ges.*, xxvi. 2533.

Specific Rotation of Starch = 216·0.	Specific Rotation of Mixture.	Cu_2O reduced.
(1) Soluble starch. Water. Maltose. Erythrodextrin-α.		
$10(C_{12}H_{20}O_{10}) + H_2O = C_{12}H_{22}O_{11} + 9(C_{12}H_{20}O_{10})$:	209·0	6·4
(2) Erythrodextrin-α. Maltose. Erythrodextrin-β.		
$9(C_{12}H_{20}O_{10}) + H_2O = C_{12}H_{22}O_{11} + 8(C_{12}H_{20}O_{10})$:	202·2	12·7
(3) Erythrodextrin-β. Maltose. Achroodextrin-α.		
$8(C_{12}H_{20}O_{10}) + H_2O = C_{12}H_{22}O_{11} + 7(C_{12}H_{20}O_{10})$:	195·4	18·9
(4) Achroodextrin-α. Maltose. Achroodextrin-β.		
$7(C_{12}H_{20}O_{10}) + H_2O = C_{12}H_{22}O_{11} + 6(C_{12}H_{20}O_{10})$:	188·7	25·2
(5) Achroodextrin-β. Maltose. Achroodextrin-γ.		
$6(C_{12}H_{20}O_{10}) + H_2O = C_{12}H_{22}O_{11} + 5(C_{12}H_{20}O_{10})$:	182·1	31·2
(6) Achroodextrin-γ. Maltose. Achroodextrin-δ.		
$5(C_{12}H_{20}O_{10}) + H_2O = C_{12}H_{22}O_{11} + 4(C_{12}H_{20}O_{10})$:	175·6	37·3
(7) Achroodextrin-δ. Maltose. Achroodextrin-ε.		
$4(C_{12}H_{20}O_{10}) + H_2O = C_{12}H_{22}O_{11} + 3(C_{12}H_{20}O_{10})$:	169·0	43·3
(8) Achroodextrin-ε. Maltose. Achroodextrin-ζ.		
$3(C_{12}H_{20}O_{10}) + H_2O = C_{12}H_{22}O_{11} + 2(C_{12}H_{20}O_{10})$:	162·6	49·3

The total result of the reaction, shortly expressed, is as follows :

$$\underset{\text{Starch.}}{10(C_{12}H_{20}O_{10})} + 8H_2O = \underset{\text{Maltose.}}{8(C_{12}H_{22}O_{11})} + \underset{\text{Dextrin.}}{2(C_{12}H_{20}O_{10})}.$$

That is to say, taking the atomic weights, 100 parts of starch are converted, by diastase at 140° F., into 80·8 parts of maltose and 19·2 parts of dextrin. That is the most favourable temperature for the action of this enzyme. At a higher temperature less maltose is produced; *e.g.*, at 169° F., Squire found the following reaction to be pretty constant :

$$\underset{\text{Starch.}}{10(C_{12}H_{20}O_{10})} + 3H_2O = \underset{\text{Maltose.}}{3(C_{12}H_{22}O_{11})} + \underset{\text{Achroo-dextrin.}}{7(C_{12}H_{20}O_{10})};$$

or 100 parts of starch are converted into 31·15 per cent. of maltose and 68·85 per cent. of dextrin ; and at that temperature achroo-dextrin, which gives no colour reaction with iodine, is produced. If the temperature at which the reaction takes place is still higher, the proportion of maltose would be even lower, and the dextrin would be an erythro-dextrin, which gives a red colour with iodine.

Inulin [$n(C_6H_{10}O_5) + H_2O$ or $2(C_{36}H_{62}O_{31})$] is a starch-like substance in solution in the sap of many plants, but especially in that of N.O. Compositæ—*e.g.*, the tubers of dahlia, Jerusalem artichoke, and potato, roots of chicory, dandelion, elecampane (*Inula helenium*), and in lichens (*Lichen fastigeatus* and *fraxineus*). It is obtainable from these sources as a white powder, consisting of spheroidal crystals, soluble in hot water, sparingly in cold water, and is levo-gyrate. It turns yellow on the addition of iodine, and does not reduce Fehling's solution. It stands in the same relation to levulose as starch does to dextrose—*i.e.*, on boiling with dilute acids it is split up, with hydration, to form levulose, just as starch is changed into dextrose ; it is, in fact, inverted into twelve parts

of levulose and one part of dextrose.[1] Inulin, however, is not so readily acted upon by enzymes; diastase has little influence over it; ptyalin and amylopsin do not convert it into sugar; it is, however, converted into sugar, as we have seen, by dilute acids, and it is probably digested—*i.e.*, transformed into sugar—in the stomach of all animals by means of hydrochloric acid.[2] As inulin is chiefly inverted to levulose, this point is of importance in the case of diabetic persons, who, it is stated, can consume levulose without injury or increasing their glycosuria, but are unable to properly utilize starch and its resulting dextrose.

In many plants, such as some of those named above, the reserve carbohydrate is not starch, but inulin; and, from a physiological point of view, it serves the same purpose. It has long been known that, when plants draw upon their reserves for biological purposes, the starch is transformed into sugar (dextrose and maltose) by means of the enzyme diastase which is usually present in plants. Where the reserve carbohydrate consists of inulin, the diastase is without effect; but J. R. Green[3] discovered that the corresponding enzyme for the inversion of inulin is **inulase,** and that it exists in the same plant as this carbohydrate. Inulin is also converted into fermentable sugars by pure cultures of *Aspergillus niger*.

Inulin from *Helianthus tuberosus* is a mixture of different forms—viz., inulin, pseudo-inulin, and inulenin—which appear to be different aggregation forms of the same material.

According to Tanret,[4] the carbohydrate known as "inulin" is a mixture of two or three substances, the proportions of which differ according to the method of preparation. He says its composition approaches $30(C_{12}H_{10}O_{10}).5H_2O$; and when air-dried it consists of $[6(C_{12}H_{10}O_{10}).H_2O]_5$. It does not swell up in water like starch. It is sparingly soluble in cold water (only 1 in 15,000 at 15° C.) after agitation for several days. It is very soluble in boiling water; insoluble in cold dilute alcohol, but dissolves readily on the application of heat. It melts on the application of heat at 178° C., when it becomes yellow, slightly acid, and very soluble in cold water; at 185° C. it becomes very acid, and is converted to pyro-inulin. Dried at 130° C., inulin has S.G. = 1·539, while the hydrated compound has S.G. = 1·478. Heated with dilute acetic or other acid, it yields levulose, and a little dextrose in the proportion of 12 to 1. Iodine does not colour it in the same way as starch. It does not reduce Fehling's solution. Yeast and diatase have no action on it. It forms irregular granules out of its solution in water, varying from 0·0005 to 0·002 millimetre; from alcoholic solutions it forms nearly globular granules of about 0·008 millimetre in diameter. It has no appreciable action on polarized light.

Lichenin $[n(C_6H_{10}O_5) + H_2O]$ is the peculiar starch of Iceland moss and algæ. It is not soluble in cold water, but, like ordinary starch, it swells up in hot water, and forms a jelly on cooling. It turns yellow on the addition of iodine. It is not affected by diastatic ferments, such as ptyalin and amylopsin; but it yields dextrose

[1] Stone, *Chemical News*, 1894, ii. 144.
[2] Wröblewski, *Zeit. für Physiol. Chem.*, 1898, xxiv. 173.
[3] Bourquelot, *Compt. Rend.*, 1893, cxvi. 30.
[4] *Bull. de la Soc. Chim. de Paris*, 1893, ix., No. 9.

when boiled with dilute acids, and is probably inverted by the hydrochloric acid of the gastric juice.

Glycogen $[n(C_6H_{10}O_5)$ or $6(C_6H_{10}O_5)+H_2O]$ is the principal carbohydrate stored up in liver, muscle, placenta, and the cells of nearly all animal tissues, whence it has been called "animal starch." It is an amorphous white powder, comparatively indiffusible. Its solution is dextro-rotatory, and turns wine-red on the addition of iodine. It is distinguished from starch by the property of swelling up and being apparently dissolved in cold water. This solution, however, is never clear, but is opalescent and indiffusible. In this respect it resembles the gummy colloid carbohydrates, such as dextrin, arabin, and bassorin. It is, however, more complex than dextrin, as the latter is obtainable by the decomposition of glycogen. It yields products similar to those of starch when it is broken up, and its molecule is probably of a very complicated character.[1]

Dextrin, or starch-gum $[n(C_6H_{10}O_5).H_2O]$: Pure dextrin is a yellowish-white powder which is readily soluble in water, but is insoluble in ether and alcohol. The solution is dextro-gyrate; it is not directly fermentable by yeast, but must first be inverted to sugar. Concentrated watery solutions are sticky or viscid—whence it is often called "British gum."

Dextrin is obtained commercially by one of the following methods: (*a*) The action of diastase on gelatinized starch; (*b*) the action of acids upon starch in the presence of water at a temperature of 100° C. or higher; (*c*) by heating dried starch to 200° or 210° C.; (*d*) by heating acidified dried starch; (*e*) by the digestion of starch with various alkalies—*e.g.*, lime.

The dextrins stand in close relationship to the starches, and are formed from them by the action of diastatic enzymes or dilute acids, as stated above. They are intermediate products in the conversion of starch to sugar, as shown under the head of Starch. There are two views of the mode of transformation of starch to sugar by enzymes or acids: (*a*) That successive dextrins are formed consecutively, which approach nearer and nearer to the hexoses, dextrose being formed by splitting the last dextrin. (*b*) That (1) soluble starch is first formed—iodine turns it blue; (2) this is transformed to a mixture of amylo-dextrin and erythro-dextrin, which gives a reddish-brown colour with iodine. (3) In the next stage the mixture contains iso-maltose and achroo-dextrin, but is not coloured with iodine. (4) The achroo-dextrin is further split into malto-dextrin, and iso-maltose. (5) Malto-dextrin is further split into maltose and a little dextrose. According to the latter view, the reaction is represented by the following formula:

$$\underset{\text{Starch.}}{10(C_6H_{10}O_5)n} + 4(H_2O)n = \underset{\text{Maltose.}}{4(C_{12}H_{22}O_{11})n} + \underset{\text{Achroo-dextrin.}}{(C_6H_{10}O_5)n} + \underset{\text{Erythro-dextrin.}}{(C_6H_{10}O_5)n}.$$

Malto-Dextrins (amyloïns) exist in malted cereals, and other foods and substances, being produced from starch by the action of *maltase*, an enzyme. Four-fifths of the complex starch molecule is successively reduced through a series of malto-dextrins or amyloïns into maltose, and one-fifth into dextrin, thus:

$$\underset{\text{Starch.}}{10(C_{12}H_{20}O_{10})n} + 8(H_2O)n = \underset{\text{Maltose.}}{8(C_{12}H_{22}O_{11})n} + \underset{\text{Dextrin.}}{2(C_{12}H_{20}O_{10})n}.$$

[1] Bunge, "Physiological and Pathological Chemistry," p. 343.

Malto-dextrins are more soluble in alcohol than dextrin, and they have an apparent composition of—Maltose 34·6 per cent., and dextrin 65·4 per cent. The latter is completely hydrolyzed to maltose by the continued action of the enzyme. The composition of malto-dextrin may be expressed as $[(C_{12}H_{22}O_{11})+2(C_{12}H_{20}O_{10})]$—that is, one molecule of maltose and two molecules of dextrin linked together.[1]

Brown and Morris consider that starch consists of five groups of $(C_{12}H_{20}O_{10})_3$; that by hydration one of these ternary groups becomes detached from the molecule thus, $(C_{12}H_{20}O_{10})_3 + H_2O = [(C_{12}H_{22}O_{11}) + 2(C_{12}H_{20}O_{10})]$, in which it is seen that only one of the amylin or dextrin, sub-groups is hydrated. But as the action of the enzyme continues, the malto-dextrin, or amyloïn, is subsequently converted into crystallizable and fermentable maltose:

$$\underset{\text{Malto-dextrin.}}{[(C_{12}H_{22}O_{11})+2(C_{12}H_{20}O_{10})]} + 2H_2O = \underset{\text{Maltose.}}{3C_{12}H_{22}O_{11}}.$$

This is of great importance in brewing, because malto-dextrin is not fermentable by ordinary yeast, but it is slowly fermented by *S. pastorianus* and *S. ellipticus*.

Malto-dextrins are of different types:

(*a*) Higher types contain more dextrin and less maltose—*e.g.*, one group of maltose and four of dextrin, or one of maltose and two of dextrin, in the molecule.

(*b*) Lower types contain less dextrin and more maltose—*e.g.*, one group of maltose and two of the dextrin group, or two of the maltose and one of the dextrin group.

Malto-dextrin is very slowly diffusible, but passes through a septum *unaltered*. A simple mixture of maltose and dextrin, on the other hand, is separated by dialysis. During fermentation by yeast the higher types of malto-dextrin are first converted into lower types, then into maltose, which is finally split into dextrose, alcohol, carbon dioxide, etc. The lowering of the type of malto-dextrin is believed to be due to an irregular yeast (*Saccharomyces pastorianus II.*). In the processes of malting and brewing, the temperature influences the type of malto-dextrin which is produced by the enzymes. As the temperature rises, the starch is not so completely transformed, and malto-dextrins of a high type are produced, which ferment with exceeding slowness; therefore, as the heat of the malt-kiln rises from 145° to 160° F., the type of malto-dextrins rises also, and is therefore less easily fermented.

The term "malto-dextrin" was formerly applied by Herzfield to a substance *intermediate between* achroo-dextrin and maltose; but the latter is fermentable by ordinary yeast, while the malto-dextrins are not fermented by it.

Gums.—The vegetable gums are amorphous carbohydrates which take up water and form mucilage. Most of them dissolve in water, but are insoluble in alcohol. They are generally converted into sugars, especially arabinose, galactose, and xylose, by heating them with dilute acids. Examples: gum-arabic, the gum of

[1] Brown and Morris, *Chemical News*, 1885, ii. 308.

cherry and plum trees, bassorin, etc. Gum-arabic, or *arabin*, is a compound of arabic or gummic acid with calcium and potassium. Cherry-tree gum, or *cerasin*, is also composed chiefly of arabic acid and calcium. *Bassorin* is the mucilaginous principle in linseed, quince-seed, and many roots; tragacanth contains a large proportion. These gums are soluble and form viscid solutions; mucilages, on the other hand, are varieties of gum which do not readily dissolve, but only swell up with water. They all yield pentoses (arabinose, xylose, etc.) and hexoses (*e.g.*, dextrose) abundantly under the influence of acids and certain enzymes.

An animal gum was discovered by Landwehr as a constituent of mucin. This body is of physiological importance in mucin, chondrin, and collagen.

Cellulose [$n(C_6H_{10}O_5)$].—Cellulose is a carbohydrate or group of carbohydrates of a complex character. It is the main product of plant life, as it composes the cell walls and vegetable fibres, and is therefore the preponderating constituent of all vegetable tissues, and essential to the structural unit. While the synthetizing activity of the cell is identical with its protoplasmic contents, its main function is the building up of non-nitrogenous substances, of which cellulose is the chief. In fact, elaboration of cellulose is synonymous with growth of the plant.

As understood by the analyst, cellulose is the residue from the exhaustive treatment of vegetable tissues, alternately with alcoholic solvents and weak oxidants. Typical cellulose is the substance of bleached cotton—$n(C_6H_{10}O_5)$. It is insoluble in water, ether, alcohol, dilute acids and alkalies, but dissolves in an ammoniacal solution of cupric oxide. In the alimentary canal it resists the action of ptyalin and amylopsin, but undergoes partial decomposition under the influence of bacterial enzymes, with the production of methane and carbon dioxide. They are variously classified:

(*a*) *True celluloses:* converted by acids—*e.g.*, H_2SO_4—into dextrose and dextrin.

(*b*) *Hemicelluloses:* converted by dilute acids into arabinose, xylose, galactose, and mannose, but not into dextrose.

A genetic series, however, is recognized by some authorities:[1]

(*a*) *Ligno-celluloses:* easily soluble in mild reagents.
(*b*) *Oxy-celluloses:* more resistant.
(*c*) *Cellulose proper*, α and β: very resistant.

Ligno-celluloses form the group of woody tissues. Jute fibre is the simplest example; it has the composition C 47·0, H 5·9, O 47·1, per cent. Sachasse considers it is a compound of lignin ($C_{18}H_{24}O_{10}$) and cellulose ($C_{18}H_{30}O_{15}.H_2O$ or $3C_6H_{10}O_5 + H_2O$). Lignin is probably an aromatic body, non-cellulose, which encrusts the cellulose in older plant cells; the process is called "lignification." Although various woods differ in their physical structure, their composition is similar in all. Lignin is coloured by methylene blue, and the stain is not removed by acids. Other sub-classes

[1] Cross and Bevan, *Chemical News*, lxviii. 225-235.

have also been recognized ; thus, *adipo-cellulose*, which forms the protective substance on plants, as cork and the skin of fruits—*e.g.*, the skin of apples—when purified from wax, etc. It has the composition C 73·66, H 11·37, O 14·97, per cent. *Pecto-cellulose* is a compound of cellulose and pectose substances. It is more complicated than cellulose, and generally yields gelatinous hydrates. Under hydrolyzing agents the pectose substances are converted into their derivative acids. Flax fibre is a typical pecto-cellulose, and, according to Kolb, has the following composition : C 43·7, H 5·9, O 50·4, per cent.

Pectose Bodies.—Most fruits and roots, and some vegetables, contain a substance or substances which, under certain conditions, cause their juices to gelatinize. These are the *pectose bodies*. Their constitution and composition cannot very well be ascertained, because they cannot be separated from the associated cellulose without disorganizing them or changing their substance. But they consist of a mixture of carbohydrates.

Pectose is insoluble in water, alcohol, and ether ; but it is converted by enzymes and acids into *pectin*, which is soluble in water. Pectin is the chief substance in fruit and vegetable jellies. Pectin and pectic acid are complex, jelly-like compounds, allied to the carbohydrates, and obtained from the juice of unripe fruits and roots such as carrots. Pectin is precipitated by alcohol after removal of the albuminoids. The pectose bodies are converted into cellulose, and cellulose is probably converted into pectose bodies (Johnson). Changes are constantly going on in vegetables.

As pectose bodies are converted into pectin by ferments or acids, so pectin is converted by an enzyme—*pectase*, normally present in plant juices—into pectic and pectosic acids. These acids are also normally present in plants, fruits, and roots. Their formulæ are as follows :

Pectin, $C_{32}H_{48}O_{32}$.
Pectosic acid, $C_{32}H_{46}O_{31}$.
Pectic acid, $C_{16}H_{22}O_{15}$.

According to Bertrand and Mallèvre,[1] *pectase* will not coagulate pectin when alone ; the transformation is only effected in the presence of a soluble salt of calcium, barium, or strontium. The coagulum, therefore, does not consist of pectic acid alone, but is an alkaline, earthy pectate—*i.e.*, a combination of pectic acid with an alkaline earth. By long boiling in water the coagulum yields parapectin or parapectic acid ($C_{24}H_{30}O_{23}$) ; and treated with alkalies, the latter yields metapectin or metapectic acid ($C_8H_{14}O_9$), which in turn yields pectin-sugar ($C_6H_{12}O_6$)—a glucose—and an organic acid. A solution of parapectin, unlike that of pectin, gives a precipitate with lead acetate ; and metapectin gives a precipitate with barium chloride. Pectin is converted into music acid by the action of nitric acid, and pectic acid yields arabic acid. Pectose bodies like cellulose are stained with methylene blue, but the coloration is destroyed by acids.

The nutritive value of pectin and pectose bodies is probably about the same as that of starch. But these bodies have not all the same constitution ; some of them are closely connected with

[1] *Bull. de la Soc. de Chim. de Paris*, 1892, xiii. 2.

dextrin, and others with starch. Pectins are considered by some authorities to bear the same relation to pentoses as dextrins do to hexoses. The pectose bodies are converted in the body into *pentoses* (see Hemicelluloses), sugars which are not easily assimilated by the human organism ; but they are absorbed to some extent, and when taken in excess (that is, above the amount which the body is capable of dealing with) they are apt to cause pentosanuria or pentosuria.[1]

The Fats.

The fatty bodies are widely distributed through both the animal and vegetable kingdoms, but originate for the most part in the vegetable world. They occur in seeds, fruits, and sometimes the leaves and roots of plants ; in all animal tissues and organs, especially in bone-marrow, subcutaneous and intermuscular tissues, around various organs, and in the omentum of the abdominal cavity.

All fats consist almost entirely of neutral fats with small quantities of fatty acids. The neutral fats are *esters*, or compound ethers of the triatomic alcohol, glycerine [$C_3H_5.(OH)_3$], with monobasic fatty acids. The three hydroxyls (OH) of the alcohol are replaced by the acid radicals, thereby forming tri-glycerides. The fatty acids have already been named (see the Fatty Acid or Aliphatic Series, p. 14). The principal acids are—

Stearic acid : $C_{18}H_{36}O_2$, or $CH_3.(CH_2)_{16}.COOH$.
Oleic acid : $C_{18}H_{34}O_2$, or $CH_3.(CH_2)_7.CH.CH.(CH_2)_7.COOH$.
Palmitic acid : $C_{16}H_{32}O_2$, or $CH_3.(CH_2)_{14}.COOH$.
Capric acid : $C_{10}H_{20}O_2$, or $CH_3.(CH_2)_8.COOH$.
Caprylic acid : $C_8H_{16}O_2$, or $CH_3.(CH_2)_6.COOH$.
Caproic acid : $C_6H_{12}O_2$, or $CH_3.(CH_2)_4.COOH$.
Butyric acid : $C_4H_8O_2$, or $CH_3.(CH_2)_2.COOH$.

The fatty acid radical replaces the OH in the alcohol molecule (glycerine), and joins the alcohol radical, C_3H_5, or allyl, which is a trivalent ion, whereby the fats are formed—*e.g.* :

Stearin, or tri-stearin ($C_{57}H_{110}O_6$) $= \begin{cases} CH_2.O.C_{18}H_{35}O \\ CH.O.C_{18}H_{35}O \\ CH_2.O.C_{18}H_{35}O \end{cases}$

Olein, or tri-olein ($C_{57}H_{104}O_6$) $= \begin{cases} CH_2.O.C_{18}H_{33}O \\ CH.O.C_{18}H_{33}O \\ CH_2.O.C_{18}H_{33}O \end{cases}$

Palmitin, or tri-palmitin ($C_{51}H_{98}O_6$) $= \begin{cases} CH_2.O.C_{16}H_{31}O \\ CH.O.C_{16}H_{31}O \\ CH_2.O.C_{16}H_{31}O \end{cases}$

Stearin is abundant in hard or solid fats. It is a stearoptene or oil which is solid at ordinary temperature. It is the hardest and most insoluble of the fats. Pure stearin melts twice on heating, first at 55° C. ; on further heating it solidifies, and melts again at 71° C. The stearin of fatty tissues is not quite pure, and melts at 63° C. It nearly always occurs in company with palmitin. It is

[1] Hutchison, "Food and Dietetics," p. 158.

soluble in ether and alcohol. It separates from solution in warm alcohol in the form of rectangular or rhombic plates. Boiling it in alcohol splits off the stearic acid, which crystallizes out in rhombic plates.

Olein is present in all animal fats, but exists in greater abundance in vegetable fats and oils. It is an oleoptene, or nearly colourless liquid, at ordinary temperatures, and is without odour or taste. It solidifies in fine crystalline needles at −6° C. It is a solvent of other fats, especially palmitin and stearin. Oleic acid is also, at ordinary temperatures, a colourless oily fluid, without taste or odour, insoluble in water, soluble in ether, alcohol, and chloroform, and solidifies at 4° C. in crystals, which dissolve again at 14° C.

Palmitin also occurs in all animal and many vegetable fats, but especially in palm-oil. It is a stearoptene, or fat solid at ordinary temperatures—*i.e.*, 10° to 30° C. Ordinary palmitin melts at 62° C. ; pure palmitin melts at 50·5° C., but solidifies on further heating, and melts again at 66·5° C.—a rather remarkable and uncommon characteristic which it shares with pure stearin. It is soluble in ether and alcohol ; it crystallizes out of the latter in tufts or starry rosettes of fine needle-shaped crystals.

Margarine, a mixture of palmitin and stearin, crystallizes on cooling from warm alcohol into balls or round masses, which consist of long or short needles or thin plates which look like blades of grass.

The **vegetable fats** consist of oleic, palmitic, and stearic acids in varying proportions ; but they also contain small quantities of erucic, linoleic, behenic, myristic, lauric, and other acids, which give characteristic properties to specific fats.

Animal fats are also mixtures of stearin, olein, and palmitin, in varying proportions. As a rule, the proportion of olein to stearin is enough to insure the fluidity of the fat at the ordinary temperature of the body. In solid fats, however, such as suet, stearin and palmitin predominate ; in less solid fats there is a greater abundance of olein.

Certain fats, such as butter, contain glycerides of fatty acids of a low molecular constitution ; they are **volatile fatty acids,** the chief of which are propionic, butyric, succinic, valeric, caprylic, and caproic acids. The **non-volatile fatty acids** include stearic ($C_{18}H_{36}O_2$), oleic ($C_{18}H_{34}O_2$), margaric ($C_{17}H_{34}O_2$), palmitic ($C_{16}H_{32}O_2$), myristic ($C_{14}H_{28}O_2$), lauric ($C_{12}H_{24}O_2$), and a few others (see Fatty Acids).

The characteristics of neutral fats are that they are yellowish or colourless, odourless and tasteless, when pure. They are lighter than water, insoluble in water, soluble in ether, benzene, chloroform, and boiling alcohol. They are split into the corresponding acids by the *lipase* or lipolytic enzyme of the pancreas, by some other enzymes, and by superheated steam. They become rancid on exposure to the air, especially olein. In this change part of

the fat is split into glycerine and fatty acid, and some of the acid becomes oxidized and forms various volatile bodies of unpleasant odour.

In the decomposition of fat there may be formed propionic, acetic, and formic acids, which are absent from fat in its fresh condition. These occur when a fat becomes rancid, and are doubtless produced in the alimentary canal under the influence of putrefactive organisms. The process is an oxidation, and the following table shows how such acids may be reduced to a lower one, and finally to carbon dioxide and water:

$$\underset{\text{Propionic acid.}}{C_3H_6O_2} + O_3 = \underset{\text{Acetic acid.}}{C_2H_4O_2} + CO_2 + H_2O.$$

$$\underset{\text{Acetic acid.}}{C_2H_4O_2} + O_3 = \underset{\text{Formic acid.}}{CH_2O_2} + CO_2 + H_2O,$$

$$\text{and } CH_2O_2 + O = CO_2 + H_2O.$$

In the analysis of foods, the entire amount of *ether-extract* is usually classed as fat. But this is only a rough calculation; for the ether-extract includes not only true neutral fats, but fatty acids, lecithins or nitrogenous fats, and chlorophyll. Unless a definite statement is given, therefore, all these bodies may be included under the head of "fats."

The fat of the animal body consists chiefly of fat absorbed from the food, but fat is also formed from the carbohydrates and proteins of the food. These are considered to be the mother-substances of fat, and there are many proofs that animals fed solely upon them accumulate fat in their body. Liebig showed that cows give more fat in their milk than is contained in their food—a statement which has since been confirmed by many experiments. Men at work in the fields during the sugar-cane season are known to become fatter than before the season began, from their consuming the raw cane. Persons who live largely on a carbohydrate diet are frequently fat and bulky.

The formation of fat from carbohydrate is considered proved by experimental evidence, although the stages are not clearly shown. Magnus considers that the carbohydrate is first reduced to an aldehyde or aldehydes, and that fatty acids are constructed from the latter, thus—

$$(a)\ \underset{\text{Dextrose.}}{C_6H_{12}O_6} = 2\underset{\text{Glycollic aldehyde.}}{C_2H_4O} + 2H_2 + 2CO_2,$$

$$\text{and } (b)\ 9C_2H_4O + 7H_2 = 7H_2O + C_{18}H_{36}O_2 \text{ (stearic acid).}$$

This is in accordance with the ionic theory, or theory of the evolution of organic matter.

Protein foods split into a fatty moiety and a nitrogenous moiety. The fatty moiety may be used as a source of energy, or stored up as fat in the body. The formation of fat from protein necessarily occurs in fatty degeneration. Experiments by Pettenkofer and Voit demonstrated that animals fed entirely on proteins formed

fat in their body. Gautier, Kaufmann, and Chaveau, also consider the formation of fat from protein is positively proved. But this well-supported theory is not accepted by all physiologists. Pflüger, for instance, does not accept the conclusions indicated, but considers the assumption that fat is formed from protein as *not proven.*

The immediate destination of fat is equally as important as its origin. It appears to be undoubted that the immediate destination of alimentary fats is the maintenance of the *potential* of the organism, the surplus going to the reservoirs of fat in the adipose tissues. Chaveau[1] concludes, however, from evidence supplied by the respiratory exchanges, that fat never constitutes the *potential* directly utilized by the muscles when a man is working, even in a state of abstinence from food, but that the energetic potential supplied to muscular activity is in the form of a carbohydrate borrowed from the reserves of glycogen in the organism, or from the transformation of fat immediately absorbed, or from the fatty reserves of the body. *Fat is transformed into potential carbohydrates.* We cannot otherwise explain the fixation of oxygen which occurs during the winter sleep of hibernating animals, with the gradual disappearance of fat and the reconstruction of glycogen and glucose. Nor is there anything to warrant us in concluding that this process is confined to hibernating animals. The work of the muscles tends to exhaust the reserves of glycogen and glucose; nevertheless these reserves tend to reconstitute themselves in proportion to their consumption, in spite of abstinence from food.

Lipoids.

Although proteins, fats, and carbohydrates, are the chief, as they are the best known, foodstuffs of man and animals, they probably do not include the whole of the essential organic foodstuffs of the animal kingdom. Certain organized compounds of phosphorus are present in all the tissues of animals and plants, and their universal presence leads to the supposition that they must be included among the essential foodstuffs. They are **nucleins, lecithins,** and **cholesterins.** The nucleins are highly phosphorized materials among the organic phosphorus compounds, which form a class apart from the lipoids (see Nucleins). Lecithins and cholesterins are present in all cells; they are rich in phosphorus, and, owing to their relationship to the fats, are called *lipoids*, and sometimes "nitrogenous fats."

The **Lecithins** are esters or neutral compound ethers of fatty acids and glycero-phosphoric acid. They are compound molecules consisting of—

One molecule of glycerine,
Two molecules of fatty acid,
One molecule of phosphoric acid, and
One molecule of cholin.

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[1] *Compt. Rend.*, cxxii. 21, 22.

These several substances are linked together, each molecule losing ions of H or OH, which results in formation of water. Concerning the fatty acids, it may be said that one molecule always consists of oleic acid ; the other may consist of oleic, stearic, palmitic, or margaric acid. Thus we have oleyl-, stearyl-, or palmityl-lecithin—*e.g.*, di-stearyl-lecithin ($C_{44}H_{90}NPO_6$). The molecule is very complex, and readily decomposes into glycero-phosphoric acid, fatty acid, and cholin ; and the latter is further decomposed into trimethylamine, NH_3, CH_4, and CO_2.

Waldemar Kock proposed calling the group of substances containing lecithin as **lecithans.** They all are composed of the same bodies ; they closely resemble each other in their physical appearance, being waxy, non-crystalline, and very hygroscopic. They all show the same behaviour towards water, but they vary in solubility or solubility of their salts in water. The group includes—

Egg-lecithin,
Brain-lecithin,
Cephalin,
Myelin,
Paramyelin,
Amido-myelin, etc.

Their behaviour towards water can be observed under the microscope. A piece of brain-lecithin placed in water first swells up and becomes slimy, then gives off long filaments, called "myelins," which sometimes form a twisted skein.

Like the fats, lecithins are soluble in alcohol and ether, from which they can be recovered as waxy crystalline needles. Their behaviour shows them to be particularly adapted to aid in the interaction of substances not soluble in water, as well as watery solutions, for which reasons they take part in various chemical processes in the body.

Lecithins are very widely distributed, being a constant constituent of every animal and plant cell, but especially obtainable from the yolk of eggs, fish roe, brain of man, sheep, and fowl, bile, blood, yeast, maize, peas, beans, wheat, and beetroot. According to Stocklasa,[1] seeds which are rich in albumin contain a greater proportion of lecithin than seeds which are oily. The latter are comparatively poor in lecithin. It appears to arise as a product of assimilation. Being primary cell constituents, lecithins are important materials in the building of many tissues, and especially in the construction of the nucleins of the cell and of its nucleus. We, however, know scarcely anything at all of the meaning of their constant presence, or of their importance in the vital functions. Bunge[2] remarks : "Our ignorance about them is very great ; but that they are indispensable to man follows from the fact that they are a constant constituent of milk. One thing only is clear, and that is, that the milk of various animals contains more lecithin in proportion to the greater relative weight and size of the brain of the species."

Lecithins originate in the vegetable kingdom, being abundant

[1] *Year-Book of Pharm.*, 1897, 74.
[2] Bunge's "Organic Chemistry," p. 105.

in the seeds of many plants,[1] but it is probable that they are also formed in animal cells, as they are found almost everywhere, and form the chief connecting link between inorganic and organic phosphorus. What is the precise value of lecithin as a foodstuff is not known. Hoppe-Seyler and Bokay found that lipase splits egg-lecithin into neurin, fatty acid, and glycero-phosphoric acid. The same happens when lecithins are submitted to artificial digestion by pancreatin, cholin being produced. It is not known whether such a complete decomposition occurs in normal digestion, or whether some of the lecithin is absorbed by the cells in an unchanged condition. The latter suggestion has been offered, and attempts have been made to establish it by injecting lecithin into the circulation, but the reports on the metabolism after such injection are too unsatisfactory to be discussed. On the other hand, it may be observed that, according to Halliburton, neurin has a decided effect on the blood-pressure; that neither lecithin nor glycero-phosphoric acid are found in the fæces or urine. It is therefore probable that the products of the decomposition of lecithins in the alimentary canal are immediately absorbed and resynthetized or used in the formation of lecithins in the body, for a meal containing lecithin has never been known to produce a bad effect. The same remark cannot be made respecting neurin and cholin, the absorption of which is often followed by unpleasant symptoms.

Cholin [$C_5H_{15}NO_2$ or $C_2H_4.N(CH_3)_3.(OH)_2$] is one of the constituents in the complex molecule of lecithin. As an animal constituent, it only occurs normally as one of the components of lecithin, and its presence as a free substance in animal tissues or secretions is construed as evidence of decomposition.

Cholin is, however, found in plants, especially in hops. Heckel and Schlagdenhauffen,[2] moreover, have detected the decomposition products of lecithin in quite a number of vegetable preparations. This fact establishes another link between the animal and vegetable worlds, and confirms the truth of vital unity proclaimed by Claude Bernard, to which is now added the unity of chemical composition and of evolution. Cholin is a derivative of a quarternary ammonium base, and is really hydroxy-ethyl-trimethyl-ammonium hydroxide. When a molecule of water is split off from the hydroxy-ethyl group, it forms **neurin** ($C_5H_{13}NO$), a very poisonous body. When cholin is exposed to the influence of oxidizing agents, such as hydroxyl, it loses two atoms of hydrogen, and becomes **muscarin** ($C_5H_{13}NO_2$), or with water of crystallization ($C_5H_{15}NO_3$), as it occurs in *Agaricus muscarius*. Cholin may also be oxidized in a third way, by which it is reduced to **betaïn** ($C_5H_{11}NO_2$), also called "oxy-neurin" or "trimethyl glycocoll," a non-poisonous crystalline substance, occurring in molluscs, beetroot, and other plants.

Protagon, or brain-lecithin, cephalin, and jecorin, are the special lecithins of the brain; while myelin, paramyelin, etc., are the

[1] Schultze and Stieger, *Zeit. f. Physiol. Chem.*, xiii. 365.
[2] *Compt. Rend.*, August 9, 1886.

lecithins of the nerves. Protagon has the following composition : C 66·39, H 10·69, N 2·39, P 1·068, per cent. There are several varieties of it, and their constitution is very complex—probably a combination of lecithin and cerebrin, the latter being a nitrogenous glucoside ; and they yield on decomposition lecithin, cerebrin, cholin, neurin, and glycero-phosphoric acid. Jecorin is similar to protagon, and occurs in the brain and liver. Cerebrin is a phosphorus-free substance containing C 69·08, H 11·47, N 2·13, O 17·32, per cent.

Cholesterin ($C_{27}H_{46}O + H_2O$) is constantly present in animal and vegetable cells, being apparently a normal constituent. It is always present in milk, where the proportion averages 0·0318 per cent. ; and it is probably one of the essential foodstuffs of man. It is obtainable from bile, gall-stones, blood, yolk of egg, spleen, nerve tissues, and wool-fat. Like lecithin, which is also everywhere present in living cells, we do not know exactly what rôle is played by cholesterin in the vital functions.

We do know, however, that the constituents of our food are not all assimilable by the proteoidal constituents of protoplasm, for there are some which will not dissolve in water ; but these substances, like the lipoids lecithin, cerebrin, protagon, and cholesterin, are soluble in ether ; they are, in fact, related to the lipoids, whence it is inferred that the use of lipoids in the body is to render these materials absorbable by the protoplasm of the cells. The substances referred to are various *esters ;* they are combinations of an alcohol and an acid, but are scarcely dissociable into ions in aqueous solutions, whence there is a wide difference between the entrance of these bodies into the cells of an organism and those of ionizable salts. Overton, however, has shown that all esters readily enter the cells because they are soluble in the lipoids of the cell. Salts, on the other hand, enter the protoplasm with difficulty because of its comparative impermeability to them. The ester enters the cell and becomes saponified by union with the lipoids. This is of importance in therapeutics as well as dietetics, for many non-ionizable agents—narcotics, sedatives, bactericides — have an ester-like constitution which brings them into intimate relation with the lipoids of the cells with which they enter into combination ; and just as ionizable compounds find their point of attack in the proteins of the cell, so the non-ionizable compounds find their selective point in the lipoids.[1]

Cholesterin is a monatomic alcohol, belonging to a class having the general formula $C_nH_{2n-8}O$. Its structure is not known, although chemists have been acquainted with it since 1788. As stated above, it has the empirical formula $C_{27}H_{46}O$ or $C_{27}H_{45}.OH$; but there are various homologues : $C_{26}H_{39}.OH$, $C_{26}H_{40}.OH$, $C_{26}H_{41}.OH$, $C_{26}H_{43}.OH$, $C_{27}H_{45}.OH$, $C_{28}H_{47}.OH$, which have been obtained from various substances. Wool-fat is almost exclusively composed of cholesterins, either in a free state or combined with stearic or other acids. Cholesterins are soluble in ether and alcohol. They are insoluble in water, but *absorb* 100 per cent. of water. They cannot be saponified. They are probably related to the terpenes and camphors, and also to taurocholic and glycocholic acids. By treatment with sulphuric or phosphoric acid they yield hydrocarbons of the ethylene or olefine (C_nH_{2n}) group.

[1] Pauli's " Physical Chemistry in the Service of Medicine," p. 86.

Cholesterin originates in the vegetable kingdom, and several different kinds, called **phytosterins** ($C_{26}H_{39}.OH + H_2O$) have been recognized—thus : *phytosterin* in peas, beans, vetches, rape-seed, wheat-gluten, barley-fat, lentils, almond, earthnut or peanut, and other seeds ; *daucosterin* in carrots and beetroot ; *caulosterin* in yellow lupin ; *paracholesterin* in a fungus ; etc. Whether cholesterin is formed in the animal body, or whether animals are directly or indirectly dependent upon the vegetable kingdom for their supply of the cholesterin necessary to them, is, for certain, unknown. It is considered by some authorities that cholesterin appears in the cells as a cleavage product during life processes. But, again, it is not known whether it had been previously assimilated in a combined form. That cholesterin is normally excreted from the body in the alimentary canal, especially in the bile, in daily quantities which are measurable and fairly regular, is pretty certain. The fæces always contain it. But whether this material was absorbed from the alimentary canal in a preformed condition in the food, or has originated in the body, and what function it has performed before or after it left the cells, is at present unknown to us.

The **Waxes** are esters of fatty acids of the higher series. They differ from fats in the fact that they are not compounds of fatty acid and *glycerin*. Beeswax, for instance, is an ester composed of palmitic acid, cerotic acid, and myricyl alcohol. Waxes form the beautiful bloom upon fruit, from which it was formerly supposed the bees gathered it ; but beeswax is really secreted by bees, for they continue to produce it when fed upon sugar or honey.

Hydrocarbons.

Hydrocarbons of various kinds occur in the foodstuffs. They contain carbon and hydrogen, but no nitrogen. They are derived from the paraffin series CH_n. When one of the H atoms of the hydrocarbon molecule is replaced by an OH ion, we have an alcohol, and thus is formed the whole series of alcohols. A table of the hydrocarbons and corresponding monatomic alcohols is given on p. . *Methyl alcohol* [$CH_3.OH$ or (CH_4O)] is a colourless liquid, having S.G. 0·796, and boils at 65° or 66° C. It burns with a pale, non-luminous flame, has a peculiar odour, with properties and physiological action similar to those of ethyl alcohol. *Ethyl alcohol* [$C_2H_5.OH$ or (C_2H_6O)] is also a colourless, transparent, mobile liquid, having a characteristic odour and S.G. 0·795. It boils at 78·5° C., and when pure burns with a white flame. In the animal organism it is oxidized to acetic acid, acetaldehyde being formed as an intermediate product. *Amyl alcohol* [$C_5H_{11}.OH$ or $(C_5H_{12}O)$], butyl, propyl, hexyl, and heptyl alcohols, are also members of the series, and are among the secondary products of the distillation of fermented substances. They occur in many spirits, and are commercially grouped together as " fusel-oil." *Allyl alcohol* (C_3H_6O) is a primary alcohol derived from propylene. It is present in various

essential oils, especially as a compound in oil of mustard, horse-radish, etc.

Glycerin [$C_3H_8O_3$ or $C_3H_5.(OH)_3$] is a triatomic alcohol which, being joined to fatty acids, forms neutral fats, such as stearin, olein, and palmitin. It is therefore a constant constituent of our food. It is a clear, colourless, hygroscopic liquid, of syrupy consistence and sweet taste, but without odour. It has S.G. 1·260, is miscible with water, but insoluble in ether and chloroform. There is no satisfactory evidence of the value of glycerin *per se* as a foodstuff; opinions differ about it. But there is evidence to show that any excess of glycerin, which is consumed for therapeutic purposes, is not utilized in the system, but decomposed into propionic, succinic, and formic acids. The urine of persons taking glycerin in sufficient proportion to be of any value as a food sometimes contains a reducing agent which gives the tests for sugar, but is not sugar (dextrose). The continued use of glycerin in this manner may be injurious by causing a diffusion of hæmoglobin from red corpuscles into the plasma, thereby resulting in hæmoglobinæmia. When glycerin is heated, whether it be free or in the form of fat, it undergoes decomposition, with loss of water, resulting in the production of *acrolein*, a substance of unpleasant odour. This occurs when frying foods in fat, and when milk is burnt during cooking:

$$\underset{\text{Glycerine.}}{C_3H_8O_3} - 2H_2O = \underset{\text{Acrolein.}}{C_3H_4O}.$$

Volatile or Essential Oils are the odorous substances of vegetables, flowers, fruit, and seeds. They are not chemical individuals, but consist of substances of several types in combination:

1. Ethers or esters—*e.g.*, ethyl acetate.
2. Aromatic aldehydes—*e.g.*, cinnamic aldehyde.
3. Terpenes and similar hydrocarbons.

Terpenes have the general formula $C_{10}H_{16}$ or $(C_{10}H_{16})_n$, and by oxidation they are transformed into camphors and resins. They are not identical substances, but isomers called "terpene," "camphene," and "citrene." There is a difference in the structure of the molecules of terpene and camphene, or camphene and citrene. The following terpenes are distinguishable from each other: Pinene, limonene, dipentene, terpinoline, terpinene, sylvestrene, and phellandrene. The chief representative of the series is that which is most abundant in oil of turpentine—viz., *pinene*, a colourless, mobile liquid having an odour of turpentine, S.G. 0·858, and boiling-point 155° C. It also occurs in lemon, sage, juniper, thyme, anise, rosemary, and other oils. Its oxidized products are: myristicol ($C_{10}H_{15}.OH$), an alcohol in oil of nutmeg; absinthol, an alcohol in oil of wormwood; and pinol ($C_{10}H_{16}O$), a ketone or aldehyde.

Cymene arises from various terpenes by the loss of two atoms of hydrogen:

$$\underset{\text{Terpene.}}{C_{10}H_{16}} + 2OH = 2H_2O + \underset{\text{Cymene.}}{C_{10}H_{14}}.$$

It occurs in cumin-seed and other seeds. Its aldehyde is *carvol*, or carvone ($C_{10}H_{14}O$), and its alcohol is $C_{10}H_{15}.OH$. Carvol occurs in caraway, mint, and dill.

Thymol ($C_{10}H_{13}.OH$) occurs in the oil of thyme (*Thymus serpyllum*). It differs from cymene by having a hydroxyl group; therefore it is oxy-cymene. It is a crystalline substance, soluble in 1,100 parts of water.

Limonene ($C_{10}H_{16}$) occurs in oil of sweet oranges, lemons, dill, lavender, caraway and other seeds. It is a colourless liquid, of pleasant odour, having a boiling-point of 175° C. It yields cymene when acted on by H_2SO_4.

Sylvestrene ($C_{10}H_{16}$) occurs in various kinds of turpentine.

Phellandrene ($C_{10}H_{16}$) occurs in seeds of *Phellandrium aquaticum*, oil of fennel, oil of eucalyptus, etc.

Dipentene, or terpilene, is the same as cinene, di-isoprene, etc. They give several alcohols—cineol, terpineol, eucalyptol, and cajeputol, all having the formula $C_{10}H_{17}.OH$—and a glycol called terpin [$C_{10}H_{18}(OH)_2$].

Terpinene and terpinolene arise from pinene, terpine, etc. They occur in oil of cardamoms.

Fenchene ($C_{10}H_{16}$) occurs in oil of fennel. Its alcohol is fencheol ($C_{10}H_{17}.OH$); and its aldehyde is fenchone ($C_{10}H_{16}O$), and occurs in fennel.

The isoterpenes ($C_{10}H_{16}$) are closely related to terpenes. The chief ones are—

1. *Camphene* ($C_{10}H_{16}$), a solid hydrocarbon which occurs in a number of oils—*e.g.*, ginger, spike, valerian, citronella, etc. It melts at 48° C., boils at 160° C., and is practically insoluble in water. It closely resembles cymene, for Japanese camphor can be converted by dehydration into cymene :

$$\underset{\text{Camphor.}}{C_{10}H_{16}O} = H_2O + \underset{\text{Cymene.}}{C_{10}H_{14}}.$$

The oxidation products of camphene are the alcohols called "borneol," "geraniol," and "linolool," all of which = $C_{10}H_{17}.OH$; camphene-glycol [$C_{10}H_{16}.(OH)_2$]; and the ketone camphor ($C_{10}H_{16}O$).

2. *Menthene* ($C_{10}H_{18}$) is of importance because of its derivatives, including the alcohol **menthol** ($C_{10}H_{20}O$), obtained from oil of peppermint; and menthone ($C_{10}H_{18}O$), a ketone.

Camphors.—The most important are—

1. Peppermint camphor (menthol), $C_{10}H_{20}O$.
2. Borneo camphor (borneol), $C_{10}H_{18}O$.
3. Laurel camphor (common camphor), $C_{10}H_{16}O$.
4. Thyme camphor (thymol), $C_{10}H_{14}O$.

Thymol, or metacymophenol, occurs in *Thymus serpyllum*, *Monarda punctata*, *Carum-ajowan* (an Indian plant), *Origanum hirtum*, *Saturja hortensis*, etc.

Carvacrol ($C_{10}H_{14}O$) is an isomer of thymol, and is a cymophenol.

It is a thick oil closely related to thymol, and occurs in *Origanum hirtum*, *Saturja hortensis*, *S. montana*, and *Thymus serpyllum*.

Resins are natural exudations from trees, and are produced by the oxidation of terpenes. They are either balsams—*i.e.*, mixed with terpenes—or essential oils, or gum-resins—*i.e.*, mixed with vegetable gums.

Sesquiterpenes ($C_{15}H_{24}$) occur in the oils of cloves, calamus, cascarilla, etc.

The Organic Acids.

The organic acids in various foodstuffs are such as were being used by the living plants in their synthetic processes, or, as in the case of acids in animals, arise from analytic or retrograde processes. In the evolution of organic matter, organic acids arise from the oxidation of hydrocarbons.

Fundamental monobasic acids have only one carboxyl (COOH) in their chain—*e.g.*, formic, acetic, propionic, butyric, and other acids. Fundamental dibasic acids have two carboxyls, and are derived from the former by hydroxyl (OH) being removed from the group; thus, oxalic acid arises from acetic, and succinic from propionic acid. Malic acid also arises from succinic acid by oxidation—*i.e.*, by OH replacing H in the chain; by still further oxidation succinic acid is transformed into tartaric acid; the latter therefore may arise from malic or succinic acid. Glycollic acid, which occurs in unripe fruit, likewise arises from the oxidation of acetic acid.

In the ripening of fruit, some of these acids are progressively utilized in the formation of ethers, aldehydes, and carbohydrates. Others are combined to form salts of potassium, sodium, calcium, etc., and are mingled with the phosphates, sulphates, carbonates, etc., of such bases in greater or lesser quantities.

The combined organic acids or salts consumed in the food are most of them transformed in animal bodies into alkaline carbonates, which thereby increase the alkalinity of the blood and secretions; the uncombined acids either form alkaline carbonates or they are oxidized into carbon dioxide and water.

Formic Acid (CH_2O_2) occurs in small proportions in honey (where it acts as a preservative), in nettles, ants, etc. It is a colourless, mobile, hygroscopic liquid of S.G. 1·24 at 0° C.; boiling-point, 101° C. It is miscible with water and alcohol, has a pungent odour, somewhat like sulphur dioxide, an acid reaction, decomposes carbonates, and forms salts called *formates*.

Acetic Acid ($C_2H_4O_2$ or $CH_3.COOH$) occurs in Nature in combination with alcohols in the ethers or essential oils of many plants, and is formed in the fermentation of many substances by the enzyme of *Mycoderma aceti*, as in the manufacture of vinegar. It is a clear, colourless, pungent liquid, miscible in water, ether, and alcohol in all proportions, having S.G. 1·044, a pungent, penetrating odour, a sharp sour taste, and a strong acid reaction. It forms salts or *acetates* with sodium, potassium, ammonium, and other metals and alkaline earths. Acetates normally occur in certain vegetable juices, and a minute proportion in some animal fluids.

In the animal body acetic acid and acetates are oxidized, and transformed into alkaline carbonates, in which form they are excreted in the urine.

Glycollic Acid, or hydroxyacetic acid ($C_2H_4O_3$ or O.H.CH_2.COOH), occurs in unripe fruit as the result of the oxidation of acetic acid or glycol. It is in turn converted to glycollic aldehyde, which forms carbohydrates by polymerization.

Oxalic Acid ($C_2H_2O_4$ or COOH.HOOC) is a dibasic acid widely distributed through the vegetable kingdom either as oxalic acid or oxalates. It especially occurs in rhubarb, tomatoes, spinach, cabbage, sorrel, beet, celery, plums, apples, grapes, gooseberries, strawberries, raspberries, pepper, black tea, etc. As an oxalate it occurs as an acid potassium salt in *Rumex acetosa* and *Oxalis acetellosa;* as a sodium salt in *salsola* and *salicorna;* and a calcium salt in lichens and the leaves and roots of many plants. Oxalic acid is formed from the oxidation of many substances, such as glycol, glucose, sucrose, alcohol, and fats. It can be prepared by gently warming cane-sugar with six times its weight of pure nitric acid, and is prepared on a large scale from sawdust (containing cellulose, lignin, and other compounds allied to the carbohydrates) by heating it with alkalies. The following equation probably represents the transformation of glucose into oxalic acid:

$$2C_6H_{12}O_6 + 9O_2 = 6C_2H_2O_4 + 6H_2O.$$

Oxalic acid is of considerable physiological interest, in view of its origin and destination. When taken in food, it circulates through the animal tissues and fluids, either as the free acid or a salt—usually the acid or alkaline calcium salt. It undergoes oxidation to carbon dioxide and water. This is fortunate, because of its toxic nature. But, owing to defective metabolism, some of it may be excreted unchanged; hence arises the danger of the formation of calcium oxalate stones in the kidneys or bladder. Some neutral calcium oxalate may also be deposited in the tissues. It is an unsettled point as to whether the oxalic acid taken in the food is all excreted as carbon dioxide and water, or whether any of it is normally excreted unchanged. But, considering its poisonous nature, it is satisfactory to know that the amount consumed with ordinary food is usually small.

Propionic Acid ($C_3H_6O_2$ or CH_3.CH_2.COOH) occurs in pyroligneous acid. It closely resembles acetic acid in its chemical properties. Its salts, called "propionates," are soluble in water, and are of little importance.

Butyric Acid ($C_4H_8O_2$) occurs in milk-fat in combination with glycerin; as a free acid in rancid butter, crude wood vinegar, perspiration, muscle-juice, contents of large intestine, and Limburger cheese; as hexyl-butyrate in the oil from the fruit of *Heraclum giganteum;* as octyl-butyrate in seeds of parsnips, etc. There are two forms: *Normal butyric acid* ($C_4H_8O_2$ or CH_3.CH_2.CH_2.COOH), a thick, sour liquid, boiling at 163° C., which has a nauseous smell,

and is that substance which renders rancid butter unpalatable. It is formed from the decay of nitrogeneous animal matter and the butyric fermentation of lactic acid. *Isobutyric acid* [$C_4H_8O_2$ or $(CH_3)_2.CH.COOH$], which has a boiling-point of 164° C., and occurs in carob beans and Roman camomile-oil.

Oxybutyric acid, or rather hydroxybutyric acid ($C_4H_8O_3$), occurs abundantly during the fermentation of carbohydrates in the alimentary canal. This is the result of bacterial action. It also occurs in the urine in diabetes and other metabolic disorders as the result of the incomplete oxidation of the food. There are three isomers :

α-oxybutyric acid = $CH_3.CH_2.CH(OH).COOH$.
β-oxybutyric acid = $CH_3.CH(OH).CH_2.COOH$.
γ-oxybutyric acid = $CH_2(OH).CH_2.CH_2.COOH$.

The acid of physiological and dietetic importance, however, is the β-oxybutyric acid. It contains an asymmetric carbon atom—

$$\begin{array}{l} CH_3 \\ | \\ H—C—OH \\ | \\ CH_2.COOH. \end{array}$$

Succinic acid ($C_4H_6O_4$) occurs normally in unripe fruits, especially grapes, lettuce and other vegetables, and some animal secretions. It likewise occurs in the bacterial decomposition of carbohydrates and proteins, and as one of the metabolic products of yeast during alcoholic fermentation of sugar.

Malic Acid ($C_4H_6O_5$) is a hydroxy-derivative of succinic acid. It occurs in a free state and in the form of salts (*malates*) in many plants and fruits. As a free acid it exists in apples, pears, quinces, morello cherries, pineapples, grapes, currants, blackberries, mountain-ash berries. In combination with bases—*i.e.*, as malates—it occurs in sweet cherries, apples, rhubarb, gooseberries, grapes, and strawberries. In these fruits, however, it is usually a compound of malic acid and a malate of potash, calcium, or magnesium. Malic acid is accompanied by citric acid in unripe apples, grapes, pineapples, gooseberries, cherries, bilberries, strawberries, etc. Malic acid or malates also occur in potatoes, carrots, thyme, the seeds of anise, cumin, parsley, and caraway.

Tartaric Acid ($C_4H_6O_6$) is one of the most common acids in the vegetable kingdom, especially in grapes, mountain-ash berries, and other fruits. During the latter stages of the fermentation of grape-juice a considerable quantity of " argol," or cream of tartar (potassium-hydrogen tartrate) is deposited.

There are four optical isomers : dextro-tartaric acid, which turns the plane of polarized light to the right ; levo-tartaric, which turns it equally to the left ; racemic acid, which is optically inactive, and appears to be a mixture of about equal parts of the former two ; and meso-tartaric, which is also optically inactive.

The tartaric acid in fruit appears to be successively reduced to malic and succinic acids. The gradual disappearance of organic acids as the fruit ripens, and the concurrent increase of sugar and other carbohydrates, agrees with the idea of their transformation into aldehydes, and thence into sugar or starch.

Citric Acid ($C_6H_8O_7$) occurs in the free state in many fruits—*e.g.*, lemons and tomatoes—and also as citrates in lemons, limes, oranges, quinces, currants, gooseberries, strawberries, raspberries, cherries, cranberries, and other sour fruits. Citric acid is also constantly present in the milk of man and other mammals, and it is assumed that it arises in the animal body from the decomposition of carbohydrates. The origin of citric acid from carbohydrates also occurs from the action of two moulds—*Citromyces pfeifferianus* and *C. glaber*. But the part played by citric acid in the milk is not quite understood. It is always present in a proportion which is definitively relative to that of the calcium salts ; wherefore it is supposed that it is concerned in the solution of calcium salt.[1] Citric acid is absorbed from the alimentary canal and partly decomposed and excreted by the kidneys as sodium carbonate. It is neutralized by all alkaline carbonates.

Lactic Acid ($C_3H_6O_3$).—There are three isomers of this acid, two at least of which are of importance in dietetics.

1. *Lactic Acid*, or *Fermentation Lactic Acid*, is α-hydroxypropionic acid [$CH_3.CH(OH).COOH$]. It arises in consequence of the fermentation of lactose by *B. acidi lactici*, as in the souring of milk, cheese-making, and ripening of cream ; from the fermentation of various sugars, starch, and other substances, in the presence of nitrogenous animal matter. It is a thick, sour, hygroscopic liquid, miscible with water, ether, and alcohol, in all proportions. It is inactive—*i.e.*, has no influence on polarized light. It forms metallic and ethereal salts—*e.g.*, calcium lactate [$(C_3H_5O_3)_2Ca + 5H_2O$] and ethyl lactate [$CH_3.CH(OH).COOC_2H_5$].

2. *Levolactic Acid* arises from the fermentation of cane-sugar by a special bacillus. It turns the plane of polarized light to the left.

3. *Paralactic or Sarcolactic Acid.*—This is probably the most important lactic acid. It occurs in muscle-juice, lean meat, spleen, thymus, thyroid, meat-extracts, etc. It is an isomer of lactic acid, but differs from it by being optically active. Its origin is unsettled. During muscular activity the chemical reaction changes, an acid reaction arising and increasing in proportion to the work, which is considered to be due to the formation of sarcolactic acid. According to Araki, it arises from the decomposition of protein ; but this theory is opposed by the fact that nitrogen excretion is very little increased by work, whereas the development of sarcolactic acid varies as the work done. It probably arises from the consumption or destruction of carbohydrates. This theory received the support of Hoppe-Seyler. When there is sufficient oxygen in the body,

[1] Vaudin, *Annal de l'Institut Pasteur*, 1894, 503.

sugar is completely reduced to carbon dioxide and water. But, according to Hoppe-Seyler, if there is an insufficiency of oxygen, a portion of the dextrose or glycogen is transformed into lactic acid by the protoplasm of the muscle. That protoplasm possesses such a function is held by Stoklasa, who considers that the transformation of glycogen or dextrose to lactic acid is the work of an enzyme in the muscle cells. Respecting the use of lactic acid in muscular work, Hermann formulated the theory that the muscular force was derived from a complex protein molecule called **inogen,** which breaks down during contraction into myosin, sarcolactic acid, carbon dioxide, and water. The myosin is not completely formed during life, but a myosin antecedent, *myosinogen,* combines with glycogen and sarcolactic acid to form the complex inogen, which is present in resting muscle. This theory agrees with that which assumes the destruction of a carbohydrate molecule during work, and gives a reason for the formation of sarcolactic acid, without regarding it as a waste product.

Gallic Acid ($C_7H_6O_5$) is widely distributed in vegetables, especially in the form of compounds bearing the common name of **tannins,** which are glucosides (*q.v.*). It occurs in tea-leaves, nut-galls, claret, etc.

It is a trihydroxybenozic or pyrogallolcarboxylic acid ($C_6H_2(OH)_3.COOH$). It crystallizes in needles, melts at 220° C., and is decomposed by continued heating into pyrogallol and carbon dioxide. It is soluble in water, and an aqueous solution gives a bluish-black precipitate on the addition of ferric chloride. It is a strong reducing agent, and precipitates gold, silver, and platinum from solutions of their salts.

Tannic Acid, or digallic acid ($C_{14}H_{10}O_9$), occurs in gallnuts and all kinds of bark. It is readily soluble in water, but is colourless and almost amorphous. When boiled with dilute sulphuric acid, it is converted by hydration into gallic acid ($C_{14}H_{10}O_9 + H_2O = 2C_7H_6O_5$).

Salicylic Acid ($C_7H_6O_3$) occurs probably as a methyl-ester in currants, 0·5 milligramme per kilo ; cherries, 0·4 ; plums, 0·28 ; grapes, 0·32 ; crab-apples, 0·22 ; also in strawberries, blackberries, raspberries, mulberries, peaches, apricots, pineapples, and oranges.

Boric Acid [H_3BO_3 or $B(OH)_3$] has been found in oranges and lemons. Lemon-juice may contain as much as 0·5 per cent.

The Inorganic Acids and their Salts.

The inorganic acids of foodstuffs exist chiefly in the form of salts or their ions. These together form the inorganic compounds of the food, and in chemical analysis the salts are usually expressed as *mineral substances or ash.* The figures usually given as representing the percentage of mineral substance, or salts, is the amount of ash resulting from the incineration of the material under consideration. In particular instances the amount of each salt actually present in the food is ascertained, and stated accordingly.

The salts, or combined acids and bases, taken in our food are numerous and of great importance. They are essential for the proper constitution of cells and the performance of their function. In the human body such inorganic substances are partly combined with the organic substances of the tissues, and partly in solution in the tissue fluids. Most of the salts, their acids and bases, are electrolytes, and exist in the body to some extent in the form of ions or dissociated particles. The importance of ions in the body has been ascertained by many investigators. It is through them that electrical conductivity exists. By means of them certain proteins—*e.g.*, globulins—are kept in solution, and many physical and chemical changes are brought about. The maintenance of a proper balance of the mineral substances in the body is therefore essential to its well-being. An excess of salts may be remedied by speedy elimination, but a deficiency results in grave consequences, and Forster[1] says : " Their entire removal from the food of animals causes death more rapidly than complete starvation."

The salts of the body are derived from the food. They consist of carbonates, sulphates, phosphates, and chlorides of sodium, calcium, potassium, magnesium, etc. The average amount of salts in the fluids and tissues of the body is 10 per 1,000, in the muscles 100 per 1,000, and in the bones 220 per 1,000. The food of adults very probably contains more of these substances than the body uses, and the excess is speedily eliminated.

[1] *Zeit. f. Biol.*, ix.

LEEDS & WEST RIDING
MEDICO-CHIRURGICAL SOCIETY.

PART II

THE MATERIA ALIMENTARIA DERIVED FROM THE ANIMAL KINGDOM

CHAPTER III

THE MAMMALIA

THE term **meat** is sometimes used to indicate food in general, but it particularly denotes the flesh of animals which live upon the surface of the earth and are used for the food of man. **Game**, on the other hand, is a term used to denote four-footed and winged creatures used as food for man, which afford sport to him in catching or killing. The flesh of all ruminant animals is used for food and is esteemed good; but nearly all meat is derived from the flesh of cattle, sheep, and swine; goat-flesh is eaten in some countries, but not in the large centres of civilization; horse-flesh is not usually consumed by those who can afford beef or mutton, but in some countries it is used to a considerable extent. Many wild animals are used for food, such as rabbits, hares, deer, bear, squirrel, and cavy, and are highly esteemed. The quantity of animal food used per person per annum, according to Mulhall, is as follows: United States, 120; Great Britain, 105; France, 74; Germany, Belgium, and Holland, 69; Scandinavia, 67; Austria, 64; Spain, 49; Russia, 48; Italy, 43—pounds.

Beef.

Beef is the flesh of oxen, genus *Bos*, family *Bovidæ*, a sub-family of the Cavicornia, or hollow-horned quadrupeds, gregarious and ruminant herbivorous animals. There are native species in Europe, Asia, Africa, and America, including *Bos primigenius*, the wild-ox; *Bos taurus*, the common ox; *Bos urus* or *aurochs*, the ancient wild-ox of Europe, and an ancestor of the common or domestic ox; *Bos bison*, the buffalo of America; *Bos grummius*, the yak of Thibet; *Bos bubalus* or *Bubalus buffelus*, the buffalo of India; *Bos caffer*, the Cape buffalo; *Bos moschatus*, the musk buffalo; etc.

The common ox, *Bos taurus*, has been domesticated from ancestors which it is now almost impossible to trace. The domestic ox of England is descended from cattle brought to Britain by the Romans, which in turn were probably derived from Egyptian or Indian cattle. There seems, however, to be the closest relationship between the present species of oxen and *Bos longifrons* (*primigenius*), whose fossilized remains are obtained from post-pliocene strata, and also

with the stunted Galloway and Highland Kyloe oxen, of which this was possibly an ancestor. This connection is supported by the fact that the latter breed freely with English oxen. There have, however, been found fossilized remains of oxen in England which are not represented by any cattle now existing there. The wild-oxen of Chillingham Park show no connection with these pre-existing types, but are supposed to be descendants of Roman feral cattle. Whatever the origin of the domestic ox, the wild-ox appears to have been formerly an inhabitant of many forest districts in Britain, particularly in the North of England and South of Scotland.

There are existing several other native species of the Bovidæ in various parts of the world. The **Zebu** (*Bos indicus*) is the domestic ox of India and China. It is characterized by having a hump on the shoulder. It varies in size, but is usually smaller than European oxen. Its flesh is used for food ; the hump is baked and considered a great delicacy. The sacred bulls of India belong to this stock. The **Yak** (*Bos poephagus* or *grummius*) is a small species of ox, inhabiting Thibet and the higher plateaux of the Himalayas, which can be crossed with various domestic breeds of cattle. The term "buffalo" is incorrectly applied to wild cattle generally. There are several genuine species of buffalo belonging to the genus Bovidæ. The Indian buffalo (*Bubalus buffelus*) is larger and less docile than the common ox. It is found all over the East of Asia, and is used for many purposes. The female gives more milk than the cow, and from it the Indian *ghee*, or clarified butter, is made. The flesh nearly resembles ox-beef, but is of finer flavour. It is the support of many Indian tribes. The **Arnee** is a variety of Indian buffalo, native in the forests at the base of the Himalayas. The **Cape Buffalo** (*Bubalus caffer*) is another species, and a variety of the latter is the Egyptian gamoose. It is of the size of an ox, and its flesh used for food, but is not esteemed so highly as that of European domestic cattle. There are several species of **Bison** (*Bos bison*). The European bison, or aurochs (*Bos urus*), is a species of wild cattle once abundant and roaming in herds over many parts of Europe, especially in large forests. It has been reduced by the spread of the human population to a few herds in the forest of Lithuania, which would become extinct if unprotected. The American bison (*Bison americanus*), or so-called "buffalo," inhabits the interior of the American continent, and, like other undomesticated animals, is becoming rapidly reduced in numbers. In some parts of the continent the animal is now protected to prevent its extinction. The flesh is eaten by the American Indians, Sumatrans, and islanders of Savu. According to Catlin, about 250,000 North American Indians formerly subsisted upon its flesh almost exclusively. The beef is tough, dark-coloured, and occasionally of a musky odour. The chine, however, is good.

The Domestic Ox.—The ox, having been domesticated, has become an essential item in the domestic economy of the human race. Many permanent varieties and breeds have been evolved by natural or artificial selection, which is fostered by civilized man wherever he locates. Some of these are valuable for their flesh, others for their milk, hides, or motor-power. It is not, however, the purpose of this work to discuss the breeds most suitable for the butcher, dairyman, tanner, or for draught purposes. It will suffice to say that the breeds include such well-known cattle as the Shorthorn, Longhorn, Devon, Hereford, Sussex, Red-Poll, Ayrshire, Aberdeen-Angus, Shetland, Galloway, Kerry, Dexter, Welsh, Jersey, Guernsey breeds, etc.

AVERAGE WEIGHT OF CATTLE AT SMITHFIELD.

Breed.	Steers.		Heifers, 2 to 3 Years.
	2 Years and under.	2 to 3 Years.	
	lb.	lb.	lb.
Shorthorn	1,450	1,860	1,770
Hereford	1,365	1,662	1,601
Devon	1,229	1,678	1,375
Aberdeen-Angus	1,334	1,788	1,676
Sussex	1,459	1,831	1,685
Red-Poll	1,560	1,596	1,399
Galloway	1,205	1,562	1,390
Welsh	1,432	1,787	1,511
Highland	1,505	1,854	1,466
Cross-bred	1,496	1,884	1,655

The Shorthorn stands first among the meat-producing breeds, followed by the Devon and Red-Poll. The richest milk is said to be produced by the South Devon cows, but among the Shorthorns are many which produce milk equal in quality to that of the Jersey and Guernsey cattle, and the latter are the best butter-producers. None are superior to the dairy Shorthorn and Ayrshire cattle for cheese-making. But many tests at cattle-shows and on farms have resulted in the exclusion of the Hereford, Sussex, Aberdeen, West Highland, and Galloway cattle from lists of first-class milk, butter, and cheese-producing stock.

The Supply of Beef.—The greater part of the beef we consume is raised in the United Kingdom. Nevertheless our imports are very large. The following is a careful estimate of British beef supplies by Mr. R. H. Hooker, of the Board of Agriculture :

BEEF-SUPPLY OF THE UNITED KINGDOM.

Year.	Home Supply.	Imported.	Total Supply.	Percentage of Home to Total Supply.
	Million Cwt.	Million Cwt.	Million Cwt.	
1900-1901 ..	13·4	8·3	21·7	61·7
1902-1903 ..	13·3	7·2	20·5	64·8
1904-1905 ..	13·4	8·8	22·2	60·3
1906-1907 ..	14·3	9·3	23·6	60·5
1907-1908 ..	13·9	8·9	22·8	60·8

We produce far more beef than we import.

Our beef imports are drawn chiefly from the United States and Argentina. The third largest supplier is Canada.

Horse-flesh.

The horse family, genus *Equidæ*, consists of two groups of ruminant herbivorous animals: (1) genus *Asinus*, including asses and zebras; (2) genus *Equus*, consisting of the true horses.

The **Asses** (*Equus asinus*) are supposed to be natives of Central Asia. The wild-ass is accounted the noblest of game in Persia, where its flesh is prized as venison. The flesh of zebra (*Equus v. Asinus zebra*) and quagga (*E. quagga*) is also eaten. The Romans, according to Pliny, ate the flesh of the ass, which is considered delicious and far superior to beef; roast mule is said to be an exquisite dish. According to Payen, ass's flesh originally formed the basis of the renowned Bologna sausage.

The **Horse** (*Equus equinus*) is everywhere used for human food in times of scarcity, and is regularly eaten by the people of various countries. The domesticated animal exists everywhere in places inhabited by civilized man. It is not known whether it exists in its natural condition. It is exclusively an Old World animal. The wild-horses of Tartary and other places are probably descendants of animals which have escaped from domestication; those of America (*mustangs*) are descendants of horses imported into that country by the Spaniards.

Horse-flesh is largely consumed in France. It is stated that in Paris and its environs more than 80,000 horses are annually killed, or about 200,000 in the whole of France, and consumed as food. Bicknell[1] mentions fifteen other European States where horse-flesh is eaten. The Russians have always consumed it. The Danes of old did so, and in 1807 the modern inhabitants of Denmark returned to the custom of their forefathers. In Germany the practice was begun in 1841 in Würtemberg, and spread to Bavaria, Hanover, Bohemia, Prussia, and Austria, and the consumption has now reached 150,000 horses, or 45,000,000 pounds of horse-flesh, per annum.[2] The Icelanders have eaten it since the eighth century, the Tartars and Siberians for a longer period, while Indian horsemen of the pampas live entirely upon it. There is no objection to the consumption of horse-flesh, providing the animals are first submitted to inspection by a veterinary surgeon, who certifies that they are sound or free from disease. The flesh is like coarse beef, and its toughness or otherwise depends upon the age of the animal, mode of feeding, and other circumstances. It has the following average composition:

Composition of Horse-flesh.

	Per Cent.
Water	69·81
Protein	19·47
Meat bases	1·23
Fat	9·61
Glycogen	1·70
Ash	1·00

[1] *Jour. Soc. Arts*, xvi. 349.
[2] *Berliner Morgenpost*, January 18, 1910.

Owing to the fact that horse-flesh may be sold as beef, it is necessary to give the points of distinction. These were admirably summed up by Dr. James Bell :[1] (1) Horse-flesh is reddish-brown in colour, more or less dark, and becomes darker on exposure to the air. (2) It has an odour which is peculiar to itself. (3) It is soft, but slightly tenacious. The finger sinks easily into it. On working up the fibres a bit, they break and become pulpy. (4) The muscular fibres are long and fine, and united by a very compact cellular tissue. (5) On cooking the flesh, it becomes more dense and compact than beef. (6) The fibres and striæ of the muscular tissue appear finer under the microscope than in the flesh of the ox.

The following table is from Baillet's treatise on the inspection of meat :

Characters of the Flesh.	Ox.	Cow.	Horse.
Colour	Bright red.	Bright red.	Dark red.
Cut	Resistant ; large grain ; not mottled.	Easy ; fine grain ; mottled.	Resistant ; large grain ; not mottled.
Odour	Fresh : that of beef.	Fresh : aromatic.	Musk-like.
Fat	No covering fat ; interior fat is white.	Covering fat is white or yellow.	No covering fat ; interior fat is firm and white.
Articular surfaces	Rosy-white.	Rosy-white.	Deep rose.
Muscular tissue	The bundles have long, smooth fibres, united by a loose connective tissue easily penetrated by fat.	More compact and resistant ; the connective tissue is loose or compact, according to the quality.	The fibres are short, crowded into long thin bundles.

Mutton.

Mutton is the flesh of sheep, which are ruminant animals of the genus *Ovis*, family *Capridæ*. The domestic varieties, *Ovis aries*, are numerous. It is not possible to tell exactly from what wild or native species they have descended.

They have many points of affinity with the argali (*Ovis ammon vel Caprovis argali*) and with the moufflon (*Ovis musmon*). The latter is wild and inhabits the mountainous parts of Corsica, Sardinia, Greece, and North Africa, where it was formerly very abundant. It now affords sport and food for man. The argali is also a wild-sheep inhabiting the mountains of North Africa, Central Asia, and Siberia. The same name is applied to the Rocky Mountain sheep, or bighorn (*Ovis montana vel Caprovis canadensis*), which is the only

[1] "Horse-flesh," James Bell, D.Sc., F.R.S., *Chemical News*, 1887, i. 15.

native species of sheep on the American continent. Most authorities incline to the opinion that the argali is most probably the progenitor of all the present varieties of sheep.

The **Domestic Sheep** (*O. aries*) is now distributed over the entire world, as the result of the migrations of civilized man. The antiquity of the domestic species is very great, and many breeds have been originated from it, the efforts of the patriarch Jacob to breed sheep of a particular colour being evidence of the care which has been exercised by man over the species from very early times. The domesticated sheep does not represent any particular species of *Ovis*, but a series of races of the animal which have been bred by man for thousands of years—certainly from before the time of Abraham and the Shepherd Kings of Egypt. The various breeds of domesticated sheep are thus classified by Professor James Long :

1. **Short-Wooled Sheep.**—Southdown, Hampshire Down, Suffolk, Shropshire, Dorset, Oxford, and Ryeland.

2. **Long-Wooled Sheep.**—Lincoln, Leicester, Cotswold, Kent, Devon Long-wool, Wensleydale, and Roscommon.

3. **Hill Sheep.**—The Cheviot, Lonk, Limestone, Herdwick, Welsh, Exmoor and Dartmoor, and the Clun or Radnor Forest.

It is unnecessary here to go into their respective value for the butcher and clothier, etc., but the following table of their respective weights may be of interest :

AVERAGE WEIGHT OF FAT SHEEP AT SMITHFIELD (PROFESSOR J. LONG).

Class.	Lambs.	Whethers.
	lb.	lb.
Lincoln	216	334
Cotswold	192	307
Leicester	153	273
Suffolk	184	290
Hampshire Down	188	284
Oxford Down	191	294
Kentish	158	267
Devon Long-wool	183	—
South Devon	228	—
Dorset and other Short-wooled ..	195	—
Ryeland	—	208
Shropshire	157	—
Southdown	146	194
Mountain-bred	127	195

The Supply of Mutton.—At the present time we raise in the United Kingdom 5,500,000 hundredweights of mutton and lamb, and import 4,500,000, chiefly from Australia and Argentina.

The Goat.

The **Goat** (*Capra*) consists of many species of Capridæ found from Spain to the Caucasus, whence they extend through Armenia and Persia to the Himalayas and China, and in lesser numbers in most

parts of the world. Typical examples: The wild-goat (*C. hircus agragrus*); the Persian goat (*C. agragrus*), also called the Paseng or Bezoar goat, which is believed to be the parent of the common or domestic goat; the ibex (*C. sinaitica*) of Arabia, the Alps, and Himalayas; the Spanish goat or ibex; and the "tur" of the Caucasus. Goats are closely allied to sheep, and probably have a common origin. It is not known definitely from what species the domestic animal has descended, although opinion favours the *C. agragrus*. The term "common goat" generally means any kind of goat which is domesticated, of whatever size, colour, or conformation, in contradistinction to the Angora goat, which is a special breed. Goats exist upon the coarse and scanty food of rocky or mountainous regions, their natural home, the inhabitants of which keep them for their milk, an exceedingly nourishing and sweet fluid, and for their flesh, which is a valuable article of food.

There are many varieties—*e.g.*, the English, which is a short-haired animal, horned, of a white, grey or black colour. The Irish or long-haired goat is a long-horned animal, usually of a red colour, but may be pied. The Maltese goat, which is exceedingly valuable to the inhabitants of that island, is hornless. The Syrian goat is long-eared, and has its horns erect and spiral. The Nubian goat has short twisted horns; the Nepaul goat is a sub-variety. The Angora and Kashmir goats are two distinct species with long silky hairs. In America great numbers of goats exist in the islands off the Californian coast, where they were introduced by man. The hunting of the wild animals affords diversion to the tourist who visits these islands. There are also a considerable number of goats in the Southern States, where they are kept on farms tenanted by coloured people or poor whites, for whom they serve as a supply of meat. They are mostly of the long-haired Mexican variety.

The raising of kids for their skins is a leading industry in some countries, but the long-haired variety is useless for this purpose, because the skin is thinner in proportion to the length of hair. To obtain skins in prime quality for gloves, shoes, and Morocco leather, the animal must be killed before it is old enough to eat grass or coarser vegetation. However, if not eaten too young, the flesh of the kid is a great delicacy. It is, perhaps, often unconsciously eaten as lamb, and such lamb is never complained of. Goat's flesh is eaten as mutton wherever the animals are bred, but it is not so palatable, being only of the quality of poor mutton. It has a stronger taste, and is to some extent more tough, perhaps owing to the greater activity of the animal. These points, however, are mitigated when proper care is taken in breeding, feeding, and herding, the animals; in killing them at an age when they are suitable for food; and in dressing and cooking the flesh. These points are naturally most carefully attended to in those countries where goat's flesh is most commonly used for food. The flesh of the Angora goat, contrary to that of the common goat, is most excellent, being both nutritious and palatable.

The milk of the goat is everywhere acknowledged by those who have investigated it as nutritious and healthy. When hardy and well cared for, goats have a lactation period of four to six months,

during which time they give from 3 to 6 or even 8 pints of milk a day. This milk is thoroughly relied on in some districts, especially in the island of Malta, where goats supply all the milk.

Venison.

Venison is the flesh of deer, which is dark, wholesome, and nutritious ; but the flesh of antelopes is also eaten as venison wherever they appear.

The **Antelopes**[1] (*Antilopidæ*) belong to the Cavicornia, or hollow-horned ruminant animals. They are a large and numerous family, spread over a great part of the earth, particularly in warm countries. They appear to be most abundant where the deer family is absent or scantily represented, as in Africa. Their flesh is highly esteemed, and is eaten roasted, boiled, or in soup.

There are two chief species in Europe : The **Chamois** (*Antilocarpa rupricarpa*), which is structurally near to the goats, and inhabits the high grounds and inaccessible mountains of Europe and Western Asia ; and the **Saiga** (*Antilocarpa saiga vel Colus saiga*), which dwells upon the Russian steppes and hills on the borders of Asia. In Asia the antelopes are represented by the **Saisin,** or common antelope of India, the **Chikara,** and the **Nylghau** (the latter having a cow-like form), which extend into China, Japan, Formosa, and the Malay Archipelago. In America there is the **Prongbuck** (*Antilocarpa americana*), called by Canadian hunters the " cabrit." It occupies the western portion of the continent, living in the plains in summer and the mountains in winter. The African antelopes (genus *Alcephalus*) are much more numerous. There are many closely related species, some of which are known by the names of eland, gazelle, impoon, kob, kevel, blesbok, blue-bok, gnu, spring-bok, bush-bok, harte-beste, etc. The eland was introduced into England as a food, but the experiment failed because of the cost.

The deer family, or *Cervidæ*, belong to the Ceraticornia, or solid-horned ruminants. They are widely distributed over the whole world, but none are native in Australia. Africa has only two species —the fallow-deer and stag—and they are only represented to a limited extent in America. True deer, although found in every quarter of the globe except Australia, are particularly abundant in Oriental regions, where they vary in size from the giant rusa to the diminutive muntjac. The principal species are as follows :

The **Red Deer** or **Stag** (*Cervus elephas*) is a native of Britain and the North of Europe and Asia. In the British Isles it is now only abundant in the Highlands of Scotland, although some are found in Devon, Somerset, and Ireland. It is represented in America by the wapiti (*C. canadensis*), often misnamed the " elk." Its flesh is coarse and dry, and not much prized for food.

The **Fallow-Deer** (*C. dama*) is a native of the countries surrounding the Mediterranean, and was introduced into Europe at an unknown date. They are more numerous than the former, being kept in the parks of aristocratic houses. There are two chief

[1] See " The Book of Antelopes," Sclater and Thomas.

varieties: the dappled deer, which was brought from Southern Europe; and the deep brown deer, brought from Norway. The species, however, extends through Europe, the West of Africa, and Asia.

The **Roebuck** (*C. capreolus vel Capreolus capræa*) is one of the smallest species of deer. It is essentially a forest animal, and is a native of the British Islands, especially Scotland, where it is still found wild. It extends throughout Europe, Northern Asia, and as far as China. It is highly esteemed for food.

The **Reindeer** (*C. tarandus vel Rangifer tarandus*) and the caribou, of America are usually considered to belong to the same species. Its habitat is northern latitudes. In America it extends from the Arctic Ocean to the United States on the west, and to Newfoundland on the east, but does not extend so far down the inlands. It formerly extended over the whole of Europe, but now reaches only as far down as 52° latitude in Norway, Sweden, and Russia. The domestic reindeer is a most important animal in Norway, Iceland, Lapland, and Siberia, where they serve the purposes of the horse, cow, and sheep, their flesh being used for food and their milk made into cheese and butter. Within recent years the reindeer has been introduced into Alaska, where the herds are increasing, and the people are beginning to appreciate their value, the caribou, or native animal, which is larger than the Eastern variety, being chiefly an object of the chase. Reindeer flesh is the favourite food of the Esquimaux and the principal food of the Laplanders. The tongue is excellent when salted, and the milk is sweet and nutritious.

The **Elk** (*Cervus alces*), found in Northern Europe, Asia, and America, is the largest species of the deer family. It is called the *moose* in America. The flesh is eaten in Norway, Sweden, and Lapland, where it is much esteemed. The flesh of the young animal is particularly delicious. The tongue and nose are delicacies.

The Camel Tribe.

The *Camelina* are ruminant animals. The camel is eaten with relish in Africa. The flesh is said to taste like veal. The hump is written of as a savoury dish, and is said to be procurable in a preserved state at some London restaurants. Tennent[1] says the flesh of the camel is alleged to produce serious gastric derangements in the Arabs. Several members of the camel tribe are native in America.

The **Guanaco** (*Auchenia huanaca*, genus *Auchenia*); the **Alpaca** (*A. paco*), native of the Andes of Chili and Peru; the **Llama** (*A. lama*); and **Vicuna** (*A. vicugna*), inhabit Southern and Central America in a wild state, and have become domesticated. The guanaco is believed to be the progenitor of the domesticated alpaca and llama, the former of which is about the size of a sheep. Their flesh is wholesome and agreeable, and said to resemble mutton.

[1] "Ceylon," by Sir E. Tennent.

The Carnivora.

As a general rule the flesh of carnivorous animals is tough, coarse, and ill-flavoured, therefore unsuitable for the food of man. It is only eaten by uncivilized people and by others in great need. But notable exceptions occur among the *Plantigrada*, which include the bears, badgers, raccoons, etc.

The **Badger** (*Meles vulgaris*, family *Melidæ*), although classed with the carnivora, only eats small animals and vegetables. The flesh, which is very fat, is eaten as pork, and makes good bacon. It lives in Central Europe, Asia as far as Japan, and America. The American variety is *M. labradorica*, and is also called the "groundhog."

The **Raccoon** (*Procyon lotor*) is another plantigrade animal which feeds on small animals and vegetables. There are several species whose flesh is palatable food, inhabiting the American continent from Canada to the tropics.

The **Aswail,** or sloth-bear (*Ursus labiatus*), is another carnivorous and frugivorous animal whose flesh is highly esteemed for food. It belongs to the family of bears, and inhabits the mountains of India.

The **Bear** supplies food to several nations of Europe, and its hams are considered excellent. The flesh of the brown or black bear is commonly eaten in Norway, Russia, and Poland, where it is salted and dried before being used. It is difficult of digestion. The polar bear was considered by Ross to be unwholesome, but the Esquimaux feed upon it without apparent inconvenience. The Indian tribes of the interior of Oregon also eat bears. The flesh of bears was eaten during the siege of Paris, and was considered to have the flavour of pork.

Pork.

The **Hog** family (*Suidæ*) are omnivorous. The domestic pigs consist of varieties which have descended from the **Wild-Boar** (*Sus scrofa*), which formerly inhabited the forests of Britain, and is still to be found in most parts of the continent of Europe, the greater part of Asia, and the Barbary coast of Africa. Ordinary swine are now bred from the domesticated species in most parts of the civilized world. The breeds most used in Britain, according to Professor James Long,[1] are—(1) The **Large White Pig,** whose home is Yorkshire and Lancashire. It reaches an enormous size and great weight. (2) **Middle Whites,** a cross-breed between the "large" and "small" whites, bred in all parts of the country. (3) **Small Whites,** a fancy variety, of slow growth. Like the two former, it is of Yorkshire origin. (4) The **Large Black Pig,** bred chiefly in Cornwall, Devon, and Suffolk, is a pig of great size and weight. (5) The **Small Black Pig,** of Essex, Suffolk, and Dorset. (6) The **Berkshire,** also of a dead black to a plum colour. (7) The **Tamworth,** of a bright sandy colour, usually described as "red." It is of great length, one of the best pigs for the butcher, bred chiefly in the counties of Warwick and Stafford. **Porkers** do not usually exceed 100 to 120 pounds weight when killed, but **bacon** pigs attain a great size, increasing in weight at the rate of 1 or 2 pounds daily.

[1] "The Book of the Pig," James Long.

AVERAGE WEIGHT OF PIGS AT SMITHFIELD.

Breed.	Age.	
	Under 9 Months.	9 to 12 Months.
	lb.	lb.
Small White	206	243
Middle White	287	372
Large White	369	428
Large Black	334	467
Berkshire	313	414
Tamworth	290	413

The quality of pork, and especially of bacon, depends very much upon the feeding of the pigs. The Government of New South Wales paid considerable attention to the investigation of this matter, and the following conclusions were arrived at : During the cold season the flesh of pigs becomes " oily," but when the animals are kept warm and comfortable their flesh is firmer and the bacon of better quality. The bacon is also " soft " when maize forms the principal food. Softness of the flesh also results from the too free use in feeding of oil-seeds, such as rape, linseed, or cottonseed, rice-meal, brewers' grains, and the waste from distilleries. It is recommended, therefore, that not more than one-third of the ration should consist of these foods, especially in the last stage of fattening. The too free use of roots, such as mangolds, turnips, potatoes, and green vegetables, causes the production of flesh which is devoid of good keeping qualities. The investigators recommend that the aforementioned foods should be used only during the growing stage, if at all, and that they be fattened or " finished off " in the last month or so with foods that will counteract the softness of the flesh, and make it more suitable for curing purposes, and that peameal and skim milk is the best ration for this purpose. Barleymeal and milk is a favourite ration with many feeders, but the tendency of all grain foods to form soft flesh, according to the authorities quoted, should be counteracted by the addition of peameal.

Native species or varieties of pigs having peculiar forms occur in some countries—*e.g.*, the babyrussa (*Sus babyrussa*), or horned hog, of the Indian Archipelago and continents of Asia and Africa. The wart-hogs of East and South Africa are also special genera of the *Suidæ*, having well-flavoured flesh which is eaten for food.

The **Peccary** (genus *Dicotyles*) is a native pachydermatous animal of the American continent, nearly related to, and representing, the hog family of the Old World. Several species exist. The tajacu, or collared peccary, (*Dicotyles torquatus*), is considered good eating in South America, and the white-lipped peccary (*D. labiatus*) in Paraguay.

The **Hippopotamus,** of which two species inhabit the eastern and central districts of Africa, and a third in Madagascar, may be considered essentially a magnified hog, although they are not true *Suidæ*. The flesh is comparable

to pork, and is eaten with great relish by the natives. When young the flesh is very delicate, but when old it is coarse and strong, and inferior to beef or pork.

The **Rhinoceros,** of which there are five species in Africa and Asia, is also nearly related to the hog family, and has flesh which is not despised as food.

The Rodents : Hares, etc.

The family of *Rodentia* includes numerous animals which are consumed for food and afford excellent sport to man.

The **Hares** belong to the genus *Leporidæ*. The common hare (*L. timidus*), the Irish hare (*L. hibernicus*), the Scotch or Alpine hare (*L. variabilis*), which becomes white in winter, are the British species. About thirty species exist in Europe, Asia, and Africa. In Russia and Siberia some of the species are pure white. Hares are found in nearly all regions from the tropic of Capricorn to the Arctic regions. The common English hare is not indigenous to Ireland or the Highlands of Scotland, where they are replaced by the species mentioned above. The American hare (*L. americanus*) is little larger than a rabbit. In South America hares are replaced by cavies.

The **Rabbit** (*L. cuniculus*) is nearly related to the hare, and has almost the same habitat. It is believed that its original home was on the shores of the Mediterranean, whence it spread over Europe at a comparatively recent period after the extermination of its natural enemies. It is not indigenous to Australia, but, having been introduced by man in 1864, it has spread over that continent so as to become a pest. The flesh of the rabbit is white and juicy, loose in texture, without a well-defined flavour, although delicate and easy of digestion. That of the hare is dark and dry in comparison, and less digestible, and the animal should be hung to improve the flavour and render the flesh more easy of mastication and digestion.

The **Squirrel** (family *Sciuridæ*). There are the true squirrel (*Sciurus*), ground-squirrel (*Tamias*), and flying-squirrel (*Pteromys*). The British species (*S. vulgaris*) feeds upon nuts, acorns, and other seeds, which they store for winter use. Squirrels have a tender flesh which resembles that of the barn-door fowl. It is a favourite dish in Norway and Sweden, and is eaten by the natives in America, and sometimes by those of England. It is said to make excellent pies, the flesh being dense, gelatinous, but highly agreeable and nutritious.

The **Marmot,** genus *Arctomys*, family *Sciuridæ*, is eaten in the Tyrol, Savoy, the Pyrenees, and also in Asia and America. There are several species. The Alpine marmot is as big as a rabbt. *A. monax* is the American ground-hog, or woodchuck.

The **Jerboa** (family *Dipodidæ*) are little animals of the size of a rat, in Northern Africa, Syria, Siberia, etc. There are several species, but *Dipus ægypticus* is the most common. Its flesh is considered by the Arabs one of the greatest dainties. The alagtaga (*D. jaculus*) is larger than the common jerboa, and is called by the Arabs the "lamb of the Israelities." Other authorities consider it the coney of the Scriptures.

The **Beaver** (genus *Castor*). The common beaver (*C. fiber*) was formerly common in the North of Europe and America ; it is still common in America,

where it forms colonies. Chiefly valuable for its fur, this animal is much prized as food by the Indian and Canadian hunters, who roast it in the skin after singeing off the hair. The animal is a vegetarian.

The **Rat**, genus *Mus*, is nearly ubiquitous, although it is not intentionally introduced by man. The brown rat (*M. decumanus*), commonly called the "Norway rat," was originally a native of China. The black or house rat (*M. rattus*) was also originally a native of Asia, but spread over Europe some centuries earlier than the former. Where the brown rat is now common the black rat was formerly abundant. Rats and mice (other species of *Mus*) are considered delicate morsels in Asia, Africa, Australia, and New Zealand. To the Chinese and Esquimaux the mouse is a real *bonne bouche*. The flesh of rats tastes somewhat like that of poultry. They are cooked in various ways. The **Bandicoot** (*M. giganteus*) is the largest known rat. It has delicate flesh, resembling pork, which is a favourite article of diet among the natives of India and Ceylon, where they are abundant, and the aborigines of Australia.

The **Hedgehog,** genus *Erinaceus*, family *Erinaceidæ*, belongs to the order of Insectivoræ. They live in Europe (*E. europæus*), parts of Africa, Asia, and the Malay Archipelago. There are various species. Their flesh is sometimes eaten in England, Spain, and Germany. It is considered a princely dish in Barbary.

The **Porcupine** (*Hystrix*), family *Hystricidæ*, of the natural order Rodentia, was formerly considered a delicacy in Europe, and is mentioned in old cookery-books. It is now occasionally eaten. There are various species in Europe, Africa, and America.

Amongst the Edentata, the **Armadillo** is esteemed good food, roasted in its shell, in Central and Southern America, and the **Aard-Vark,** or earth-pig, in South Africa.

The Marsupials, including the kangaroo, kangaroo-rat, opossum, and wombat, are eaten in Australia and New Guinea, where they are indigenous, and represent the ruminant omnivora of the Old World. **Kangaroo** (*Macropus giganteus*) has excellent flesh which eats like venison, and was formerly an important article of food among the natives. Soup made from the tail is far superior to ox-tail soup. It is imported into England preserved in tins. The **Wallaby** (*Halmaturus ualabatus*) is eaten in the same way. The **Wombat** (*Phascolomys wombat*) has red, coarse flesh, which is fat and resembles pork, and is said to be preferable to that of all other Australian quadrupeds. The **Kangaroo-rat,** or bettong (*Hypsiprymnus*), is a separate species, about the size of a hare. It makes highly nourishing and stimulating soup. Although there is an animal called the **Opossum** in Australia, the true opossum (*Didelphys virginiana*) only exists in America. Its flesh is said to be pleasant and nutritious.

Amongst Oceanic Mammalia, the **Porpoise** (*Phocæna communis*), genus Cetacea, which lives almost entirely on fish, is welcomed by sailors as fresh food, boiled, roasted, or fried. It was formerly a delicacy in Europe, and is mentioned in old cookery-books. The Greenlander still esteems it a dainty. Its habitat is the north Atlantic Ocean. The **Whale** is eaten by the natives of various countries. Its flesh is said to be tender and palatable as veal, and endeavours have been made to introduce canned whale into the fashionable restaurants of Europe and America. The flesh is consumed especially upon the shores of Northern Europe, Asia, and America, Western Australia, and New Zealand. The blubber is used as food by the Esquimaux. The **Narwhal,** or sea-unicorn, is eaten in Greenland. The **Dugong** (*Halicore*

dugong), a herbivorous mammal of the order Sirenia, and an inhabitant of the Indian Ocean, has flesh which is tender and considered to be not unlike beef. The **Walrus** is eaten by the Esquimaux, and appreciated by Arctic explorers. The **Seal** is a very important article of food to the Greenlanders and Esquimaux. It is also eaten in Labrador and Kamschatka. Its flesh is coarse and oily. It was formerly served on great occasions at feasts in England. Seals consumed during the siege of Paris were said to taste like lamb. The **Manatee,** sea-woman or sea-cow (*Manatus* of the order Sirenia), which lives on the American and African coasts, is similar to the dugong. Its flesh is whitish, having a flavour between veal and pork, and is said to be excellent eating.

CHAPTER IV

MEAT: GENERAL CONSIDERATIONS

Meat consists of fat and lean, bone and gristle. But the skin, bones, tendon, nerves, etc., of an animal are spoken of collectively as **refuse.** They are not valueless, but uneatable. Bone, for instance, contains a considerable amount of nutriment, which may be obtained by making soup. These materials, therefore, are only "waste" when they are not converted into food. The total amount varies up to 25 or 30 per cent.

Lean meat is practically muscular tissue, but meat is never so lean as to contain no fat. The fat is in various parts of the flesh—in the subcutaneous tissues, between the muscular planes, about the tendons, etc. Besides visible fat, there is always more or less invisible fat present in particles interspersed with the muscular fibres, and apparently indistinguishable from them. First-class meat cannot be obtained from animals that are "poor" in flesh. A reasonable amount of fat must be present to give juiciness and flavour to the meat, and, within reasonable limits, the fatter the animal the better is the meat. The amount of fat in meat varies with the age and condition of the animal. It may be as low as 3 per cent. and invisible, or it may be as much as 25 per cent. in fat beef or mutton, and from 50 to 90 per cent. in fat pork.

The presence of a large amount of fat, however, is not necessary to the wholesomeness of the meat. It is far more important that the animal should be in good health. "Never kill an animal which is losing flesh" is a maxim of importance. When an animal is failing in flesh, the fibres shrink in volume and contain correspondingly less water, and the meat is correspondingly drier and tougher. On the other hand, when an animal is gaining flesh the opposite condition obtains, and the meat is of better quality. It is therefore better to kill an animal while in medium flesh, but still gaining, rather than when it is at a standstill or losing flesh.

The distribution of the fat is an important guide to the age of the animal. In young animals the fat is interspersed among the muscular fibres, and gives the flesh that marbled appearance which is always a desirable quality of butcher's meat. In old animals the fat is chiefly collected in masses or layers external to the muscles—in the subcutaneous tissues and around the internal organs. In pork the fat is everywhere abundant, more or less fatty infiltration or degeneration occurring in the muscular fibres. The abundance

of fat and the saturation of the muscular fibres by it, even during cooking, is a cause of the relative indigestibility of pork. In contrariety of this, the flesh of rabbits, chicken, pheasant, etc., contains very little fat ; and this characteristic, together with the shortness of the muscular fibres, renders their flesh more easy of digestion.

Although the quality of meat depends so much upon the health and condition or plumpness of the animal, the " breed " must also be taken into account. The best quality of meat cannot be obtained from poorly-bred stock. The admixture of fat and lean, or marbling of the meat, " is never got from scrub or native animals, neither do the ' gaudy ' fellows, with rolls of fat on their ribs, furnish the ideal quality of meat. There seems to be a connection between the smooth, even, and deeply fleshed animal and nicely marbled meat which is not easily explained, but the two usually go together. Fine bones, soft luxuriant hair, and mellow flesh, are always desirable in an animal to be used for meat, as they are the indications of small waste and good quality of meat."[1]

The age at which animals are killed naturally influences the quality of the meat, and especially its flavour and texture. The flesh of old animals, however fat it may be, is likely to be more tough than that of young ones. The flesh of young ones, on the other hand, is very watery, and has not attained the flavour natural to the species. For this reason an old animal in good condition affords a better quality of meat than a young one in poor condition or imperfectly developed. A calf should not be killed for **veal** under six weeks of age, and, when nourished by its mother, is probably best at about ten weeks old. The fat in the carcase should then be abundant, white, and brittle. If killed too young, the flesh is not wholesome. It wants firmness, which can only be obtained by the development of muscular fibre. It also lacks those animal juices on which flavour and an important part of the nutritive qualities depend. Cattle are fit for **beef** at eighteen or twenty months old, if properly fed, but even this flesh lacks the flavour of good beef. The best beef is obtained from animals at two and a half to three and a half years old, although the animal may be killed for food at any age if it is in good condition. Small-breed oxen are in their best condition at three years; large oxen are in their prime at four to five years of age. Cow-beef cannot be eaten too young. **Lambs** are killed when two to three months old, and any time after. Sheep are usually at their best for providing **mutton** at about a year old, and in their prime for eating at one and a half to two years of age. **Wedder-mutton,** the flesh of the castrated animal, is said to be in perfection at three years of age. Ewe-mutton is best eaten young, not more than two years old, but many come into the market at a more advanced age. Pigs are killed at any age after six weeks, and make good **pork** up to twelve months old.

[1] Twentieth Report, Bureau of Animal Industry, U.S. Department of Agriculture, p. 339.

Choice of Meat.—Mutton is more digestible than beef. When young, well conditioned, and not eaten too soon after killing, its fibres appear to possess that degree of consistence which permits of easy mastication and is most congenial to the stomach. Beef is not quite so easily digested. Its texture is a little firmer, and its muscular fibres longer, but it is equally nutritive. The tenderness and flavour of meat depend upon the sex, age, breeding, and feeding, of the animal, the length of time since it was killed, and the mode of cooking it. Sex greatly influences the quality of the flesh, that of the female being more delicate and finely grained than that of the entire male—ram, bull, or buck—which, during the time the sexual organs are functional, may be so coarse and rank as to render it almost uneatable. Castration deprives the meat of this strong flavour, and improves it altogether for edible purposes. Spaying the females also improves the quality of their flesh.

In season and *out of season* are common domestic terms. They imply that at some period of the year the flesh of an animal provides us with a better quality of food than at another. Beef and mutton are never out of season, but they are at their best during early autumn and winter—that is, just after they have been out of doors and had an abundant supply of pasture food, with the advantages of fresh air. Their highest perfection is, therefore, in September and October. Stall feeding, on the other hand, causes the meat to lose its choiceness of flavour, even though the animal gains in fat by eating dry and artificial food. Pork is out of season in summer. Buck venison is at its best from June to the beginning of September, when the rutting season begins. Doe venison is in season during winter.

Good meat ought to be firm and elastic, the lean being intermingled with fat (*marbled*) in young, healthy, and well-fed animals. The lean should be of a deepish red colour, not dark, greenish, pale, nor soft and flabby. It should have the odour characteristic of meat. The lean of animals killed while in a state of inflammation or fever is dark or otherwise discoloured. It is more moist than usual, and there may be localized areas containing pus or other fluid, and it soon undergoes putrefaction. Meat which has begun to putrefy is soft, pale, flabby, and has an unnatural odour, perceptible on a knife pushed deeply into it, and which becomes apparent when the meat is warmed by cooking. When meat is good, the flesh adheres to the bone ; the fat is firm, somewhat yellow, has no red points (blood), is not particularly greasy nor friable to the touch, but is moderately unctuous. When the animal is emaciated, the flesh adheres but slightly to the bone, its fibres are contracted and dry, and the fat is friable and shrunk. When meat is stale or game is too " high," the decomposition has proceeded too far, and bacterial action has taken place, whereby certain poisonous substances of the nature of ptomaines and leucomaines are produced.

With regard to the choice of beef, it should be pointed out that the qualities of the meat vary with the sex, and are perceptible to an observer. **Bull-beef** is very dark red, requires long cooking, is generally dry, tough, and not very agreeable. **Ox-beef** is the best. It is of a bright red colour, highly nutritious, agreeable to the palate, and digestible. **Cow-beef** is paler, and not so agreeable to eat nor so good for making beef-tea. **Heifer** is held in high estimation by epicures. The flesh of small-breed animals is always sweeter and better flavoured than that of large ones. The fat of beef should be white or pale yellow. When it is of a decided yellow tint, it indicates that the animal was largely fed on oilcake, cottonseed-cake, etc., and the flesh is not so good for invalids as that fed on roots or pasture.

As regards mutton, the smaller the frame and the better the breed of the animal, so much the more delicate will be the flesh ; on the other hand, the larger the sheep and its bones, so, correspondingly, the coarser will be the flesh. The difference in the quality of the meat, shown by its flavour and tenderness, depends very largely upon the variety of the animal ; but equally important are the pastures and breeding-ground. Turnips give a flavour to mutton which is distinctly recognizable by the epicure. The peculiar flavour of mountain sheep is easily appreciable. The fragrant herbs belonging to different pastures produce their influence upon the taste of the meat—witness the fine flavour of the mutton grown upon the thymy heaths of Sussex.

Animals intended for slaughter are made to fast for twenty-four or thirty-six hours before their death. Water is given to them freely; this helps to keep their temperature normal, and washes effete material out of their system. If they are killed when the system is full of food, the meat is too red in colour and has not such good quality. The meat of fasted animals is also believed to keep better than that of animals not fasted. It is obvious that the fasting must not be prolonged sufficiently to produce an unhealthy state of the body.

Meat which is known to be the flesh of an unsound animal would naturally be rejected by all persons of refined taste and sensibility, although, as is well known, proper cooking would destroy the disease germs which may be contained in it. Nevertheless, the flesh of animals which have died a natural death, or have been slaughtered during a condition of ill-health, sometimes finds its way into the market and on the table.

Lamb and veal are prone to be become tainted more readily than the flesh of mature animals. This arises from the large amount of moisture in the tissues of all young animals, which is a very suitable medium for the development of bacteria. It consists chiefly of lymph and serum, which exudes from the interstices of the tissues when the animal is cut into joints, thereby causing a loss of nutritive material and drying the meat. The object of the cook in sprinkling such joints with flour is to

prevent that loss, and is partially effective. The freshness of lamb can be told by the dilated pupils and brightness of the cornea, by the muscular rigidity, firmness of the kidneys, etc., which indicate wholesomeness, freshness, and death by the hands of the butcher.

If any animal is killed while suffering from fever or any serious derangement of health, its flesh will not be wholesome food. The diseases most affecting cattle are anthrax, black-leg, pneumonia, pleuropneumonia, milk-fever ("drop"), catarrh, influenza, foot and mouth disease; those most affecting sheep are pneumonia, braxy, liver-fluke (*Fasciola hepatica*), and other parasites, such as husk (*Strongylus filaria* in the respiratory organs) and staggers (*Cœnurus cerebralis*, in the nervous system); pigs are also affected by swine-fever, pneumonia, measles, husk, and trichinosis. Animals are often killed while suffering from **actinomycosis,** tuberculosis, cholera, swine-fever, and other diseases. There is little evidence of danger arising from the consumption of the flesh of such animals when killed in the early stages of the disease. But it is almost impossible to distinguish the flesh of an animal in the incipient from one in the fully-developed disease. It would be manifestly improper to encourage the consumption of the flesh of any animal in imperfect health. Comment has already been made on the effects of emaciation upon the quality of the meat. It is also known that the flesh of animals who have recovered from a disease before slaughtering does not "cure" well, and possesses bad keeping qualities. "Bruises, fractures, and the like accidents, have the same ill-effect upon the flesh, and, unless the animal be bled and dressed immediately after such accident, it is better not to use the meat for food. This rule should always hold good if there has been a rise of 2° F. or more in the animal's temperature. A rise of temperature before slaughtering is almost sure to lead to stringy, gluey meat, and to create a tendency to *souring* in curing."[1]

The **flavour** of meat depends upon various things. It is generally admitted that the flesh of animals which have lived out of doors and roamed about the land in search of their food is of finer flavour than that of stall-fed animals or those confined in enclosed areas. The dark flesh of beef, mutton, venison, hare, and game birds has more flavour than the white flesh of lamb, veal, chicken, pheasant, or rabbit. This flavour depends entirely upon the amount of nitrogenous extractives, or "meat bases"—creatin, creatinin, xanthin, hypoxanthin, etc. The amount of these substances in mutton and pork and the flesh of young animals is comparatively small, and they depend largely upon the fat for their flavour. Thus, Walker Hall showed that pork-neck contained 3·97 grains of "meat bases" per pound; tripe, 4·00; rabbit, 6·31; mutton, 6·75; beef-ribs, 7·96; fat ham, 8·08; veal, 8·14; pork-loin, 8·49; turkey, 8·82; chicken, 9·06; beef-sirloin, 9·16; beef-

[1] Twentieth Report, Bureau of Animal Industry, U.S. Department of Agriculture, p. 340.

steak, 14·45 ; liver, 19·26 ; and sweetbread, 70·00 grains per pound.[1] The flesh of mature animals contains more meat bases than that of the young, that of the male more than the female, and that of well-fed more than poorly-fed animals. We have mentioned the influence of the genital organs upon the quality of the flesh. Castration as a rule improves its flavour ; it also becomes fatter and more tender. Every day the testes are allowed to remain injures the quality, delicacy, and flavour, of the flesh of a male animal. The flesh of a male animal which is not castrated until puberty retains the flavour and coarseness of that of the entire animal. Even the flesh of the female is improved by spaying. Birds afford a notable example of the effects of castration in the capon, which retains the tenderness and juiciness of the chicken even at adult age.

The flavour of meat is improved by allowing it to hang for some time after being slaughtered. It becomes more tender and softer owing to the action of lactic acid upon the sarcolemma and connective tissues, and the flavour is improved by the development of extractives and aromatic bodies. Game is allowed to hang until the changes of decomposition are well marked, which is necessary for the development of the *high* flavour so much relished by epicures.

The texture or toughness of the flesh depends upon the character of the sarcolemma and the connnective tissues which bind the muscular fibres into muscle or which surround the muscles. In young and well-nourished animals the sarcolemma is thin and delicate, and the connective tissue small in quantity; therefore the flesh is tender and easy of mastication. In animals which have arrived at adult age, are poorly nourished, or have been hard-worked. the sarcolemma, connective tissues, and fasciæ, become thick and hard ; their flesh therefore is tough, and is not readily softened by roasting nor by long boiling.

Post-mortem Changes.—When killed, the flesh of an animal undergoes several changes. The variations in its texture depend upon them. The first stage is the condition of the flesh immediately after it is slaughtered. In young and well-nourished animals it is juicy and quite tender ; in others it is more or less tough. The second stage is the condition of *rigor mortis*, which succeeds to the former state at periods which vary with the condition of the animal prior to death, and lasts for a period of from one to seven days. The flesh is stiff, the meat hard and more or less tough. It passes sooner or later into a third stage. Meat is seldom eaten in the first stage in cold climates, except when the need for it is urgent ; but it is usually consumed in the second or beginning of the third stage. As the rigor mortis passes off, the meat loses its toughness and becomes softer and more tender, owing in part to the action of lactic acid upon the sarcolemma and connective tissues, and it acquires additional flavour from the development of aromatic bodies.

[1] *British Medical Journal*, 1902, i. 1461.

The **third stage** may be divided into an early and a late stage. (*a*) In the *early stage* the flesh is edible. This is the period when the flesh softens, becomes tender, juicy, and develops a game flavour, especially in wild animals. It is not quite clear whether this change is due to commencing decomposition or to **self-digestion.** According to Cossar Ewart, it is due to putrefaction, the rigor mortis continues indefinitely if the entrance of bacteria is prevented, especially in fishes. On the other hand, the rigor mortis often disappears before putrefaction commences ; but it may continue after decomposition is well started (Hill). According to Halliburton, the change is due to autodigestion. The muscle contains pepsin, and, if it is kept at the ordinary body temperature, the rigidity soon passes away, and proteoses and peptones appear in abundance. In addition to these proteoses and peptones, there arise various amino-acids, diamines or hexon bases, tryptophan (skatol-amino-acid), tyrosin, a little ammonia, and aromatic bodies. So far the changes are those which occur in the development of the game flavour and the softening of the tissues which, in the flesh of animals killed for human food, is considered desirable by connoisseurs. (*b*) The *late stage* is undeniably the period of **putrefaction.** In this stage the proteins are still further decomposed, and result in the production of a large number of substances belonging to the aliphatic and aromatic series, which, according to Hammarsten,[1] are as follows : (1) The aliphatic series, including ammonium salts of the volatile fatty acids, caproic, valerianic, butyric, and succinic acids, with carbon dioxide, methane, hydrogen, hydrogen sulphide, methyl-mercaptan, and other gases. (2) The aromatic and heterocyclic products of putrefaction, including phenol, cresol, tyrosin, and aromatic oxy-acids ; phenyl-acetic and phenyl-propionic acids ; indol, skatol, skatol-acetic and skatol-carbonic acids.

Curing and Preserving Meat.

The preservation of food has been the means of enormously increasing our supply of food from foreign and colonial sources. There are many ways in which meat is preserved, such as by salting, smoking, canning, the use of chemicals, and cold. Beef and mutton are stored in refrigerators and sent long journeys in a frozen condition, to be eaten as fresh meat. Beef is also dried.

Biltong is dried beef. The meat is cut into thin strips and suspended in the sunshine, by which means it is dried until the substance does not contain enough moisture to support the life of the ordinary putrefactive germs. In consequence these bacteria, as well as the meat, are desiccated, and the meat is no longer a suitable medium for the development of other germs which light upon it. The meat becomes hard, and will keep indefinitely in a dry atmosphere. It retains most of its nutrient qualities, and is palatable, but not attractive in appearance. It is sometimes smoked as well as dried. This mode of preservation of meat is open to no objection from a sanitary point of view. Biltong also consists of the sun-dried flesh of the deer, koodoo,

[1] " Physiological Chemistry."

spring-bok, etc., the prepared article having the appearance of strips of leather. The Boers scrape it with a knife or a nutmeg-grater, and it is by no means unpalatable, and is a staple article of food. Halliburton[1] found it has the following composition : Water, 19·41 ; solids, 80·59 ; inorganic matters, 6·59 ; organic, 73·94 ; proteins, 65·86 ; fat, 5·14 ; glycogen, 0·13 ; sugar, 0·09 ; extractives, 2·76—per cent.

Jerked beef, or the **tasajo** of Uruguay, is another form of dried meat much used in that country, and exported to the West Indies and Cuba, where it is largely consumed. The slaughtered animal is cut into four quarters, and the bones at once removed from each. After being exposed to the air to cool for about an hour, they are put into strong salt-brine for half an hour. The pieces are then stacked one upon another, with a layer of salt between them, until it has thoroughly penetrated into the flesh. They are then dried by exposure to the air and sun. This is a useful food, especially when fresh meat cannot be obtained. But it is not so nourishing as fresh meat, because it loses half its soluble albumin by the mode of preparation. Other names are applied to dried meat in Brazil and Chili, where dried beef is called **charque,** and mutton **chalona** ; in the Eastern Archipelago it is called **dendang,** and may consist of pork. The North American Indians call their special preparation **pemmican** (see Meat-Powder).

The **preservatives** most commonly used are—salt, saltpetre, sugar, and molasses. Borax, boracic acid, sulphite of soda, salicylic acid, formalin, etc., are also used ; but, as they are considered by many authorities to be harmful, their use should be avoided. **Salt** is astringent, and, when applied alone to meat, renders the fibres very dry and hard ; it draws out the meat juices (serum, lymph, globulin, and albumin), and in a few days the fibres contract and harden, so that the volume of the meat is diminished. Salt is not entirely germicidal, but it prevents the development of putrefactive germs and the eggs of various flies and other insects ; moreover, it does not altogether prevent the action of the enzymes of the meat. **Saltpetre** is even more astringent than common salt. Its chief use lies in preserving the natural colour of the meat ; but its use in excessive quantities is injurious to the health of the consumer. **Sugar,** on the contrary, is not astringent. When used alone, it maintains the original softness of the meat ; when added to a salt pickle, it prevents the hardening and shrinking of the fibres which result from the use of salt and saltpetre, and it manifestly improves the flavour of the meat. Sometimes the meat is preserved by first using **vinegar.** This liquid can be injected into the arteries and veins before cutting up the meat ; it then permeates rapidly into all the tissues, and acts as a preservative, which is not objectionable if an acid taste is desired. Meat so treated requires less salt in pickling than when this process is not adopted.

When meat is **smoked,** it is first pickled in brine, and a day or two after its removal it is exposed to the smoke arising from the slow combustion of green, hard wood in a smoking-house. This exposure is continued for two or three weeks. The creosote arising from the wood during combustion closes the pores of the meat to some extent, thereby excluding air containing bacteria, and is objectionable to insects. Juniper berries and fragrant woods are

[1] *British Medical Journal*, 1902, i. 880.

sometimes added to the fire to give additional flavour. In the Wiltshire method of curing bacon or hams, a pickling solution is *injected* all over the fleshy parts of the meat, so that it is at once permeated by the solution. Immediately this is done, a powder consisting of salt, saltpetre, and an antiseptic, is rubbed well into the flesh, which is also thickly sprinkled with it, and laid on a bench for two weeks. By this means it is **mild-cured,** being afterwards washed and dried. If, however, it is designed to keep it any length of time, the meat is rubbed again with the powder at intervals for another period of seven to fourteen days, after which it is washed and hung up to dry. If it is to be **smoked,** it is now exposed to the fumes in a smoking-house for a period of three or four days only (see Ham and Bacon).

Sausages.—(*a*) Pork sausages consist of fresh pork in the proportion of three parts of lean and one of fat, seasoned with salt, pepper, sage, or other seasoning, and frequently mixed with bread reduced to an even consistency in a machine. This mixture is put into *casings* consisting of the intestines of hog, sheep, or cattle, which have been properly cleansed, soaked in lime-water or lye, then washed again, and salted or soaked in brine. (*b*) Bologna sausage consists of beef or beef and fat pork, bacon, or tongue, in the proportion of 10 to 1, flavoured with pepper, salt. and a little coriander. This is also put into casings, boiled, smoked, and dried. It is said that horse-flesh is sometimes used in the manufacture of German sausages. The **detection** of various kinds of flesh used in the manufacture of sausage and other forms of minced meat is a matter of difficulty. The muscular fibres of flesh are much alike. But a skilled microscopist may be able to tell the differences, unless the meat is very finely minced. Moreover, the fibres of animals of the same species vary as much in size, texture, and coarseness, as fibres of the flesh from different animals. A chemical examination, however, may be of some assistance. Thus it has been ascertained that the presence of more than 1 per cent. of glycogen is characteristic of horse-flesh. But even this test could not be depended on unless the meat is comparatively fresh, because the glycogen undergoes various changes by which it is transformed into other substances. Further assistance may be gained from an examination of the fat. Fats have a different melting-point, they absorb different proportions of bromine and iodine, and their fatty acids crystallize differently.

Saveloy originally consisted of pig's brains, but now is largely formed of pork, pig's cheek, etc., minced with bread or biscuit, and seasoned similarly to sausage. **Polonies** are usually put into coloured skins; the interior is similar to sausage. **Black puddings** are a variety of sausage made of boiled groats and various spices, mingled with pork, fat, and pig's blood, put into skins and boiled. **Pork pies** consist of pork cut into small pieces, mingled with spices, and baked in a paste-crust.

Ham and Bacon.—There are various methods of preserving them.

(*a*) *Salt-cured Ham and Bacon.*—" Home-curing " is done in a simple manner. The sides and legs are put upon a stone slab or table in a cool cellar, and a mixture of salt and saltpetre is rubbed in at frequent intervals, and sprinkled upon them for three or four weeks ; they are afterwards hung up to dry.

The *modern method*[1] is as follows : After the animals are slaughtered, the head, feet, and vertebral column, are removed, the sides and legs disconnected, and they are hung up for six to twelve hours. They are then transferred to the " cooling-room," where the atmospheric temperature is about 37° F. for twelve hours. In this period the temperature of the meat is reduced to about 40° F., as shown by a meat thermometer. They are then transferred to the " curing-room," where they are injected in numerous places with the following solution, at a pressure of 40 pounds per square inch :

Common salt	55 pounds.
Saltpetre	5 ,,
Boric acid	5 ,,
Cane-sugar	5 ,,
Water	20 gallons.

The sugar is only added in the winter season. The solution is sterilized by boiling, skimmed to remove rising material, and allowed to stand in order to deposit refuse. It is injected into the flesh at the same temperature as the atmosphere in the cellar. After injection the *sides* are piled into stacks, with the skin downwards, and a layer of salt, saltpetre, and boric acid, thickly laid on. They are left for twelve or fourteen days, during which the saline mixture and powder diffuses through the flesh, and they are cured. They are afterwards washed, drained, and trimmed, and are then ready for the market. The hams are chilled and *placed in* the *pickle* for twenty-four hours, after which they are pressed to " purge " them of blood, and the saline solution is injected into the principal vein. They are then " salted " in the same way as bacon, for fifteen days, and slowly dried in an atmosphere at 80° F.

Many hams and bacon are more quickly dried by being hung in a " smoke-chamber " for three days, where the temperature is about 85° F., and the smoke is produced from oak or elm sawdust. The glossy appearance of smoked ham or bacon is sometimes produced by rubbing *vaseline* into the rind.

(*b*) *The Wiltshire Method* of producing **smoked bacon** is as follows : The animals are killed, and at once hung over a furnace for half a minute to burn off the hair. This is a peculiarity of the Wiltshire method, and replaces scalding. They are then decapitated, devertebrated, the sides and hams cut out, branded, and sent to the " cooling-house," where they are reduced to 40° or 45° F., by the ammonia process of refrigeration. They are afterwards injected with brine, similar to the solution given above, and salted for three weeks. Finally they are transferred to the " smoke-chamber," where they

[1] Douglas, *Journal of the Royal Agricultural Society of Great Britain*, 1898.

are hung for three days to dry in smoke derived from elm sawdust.

(*c*) *The Method of Injection through the Circulatory System.*—The animals are *shot* through the brain, and *cured* by pumping the brine through the heart, arteries, and veins, by great pressure, so that it reaches the smallest capillaries and interstices of the tissues, This method is practised to some extent in Denmark.

(*d*) *The Auto-Cure.*—This method is also practised in Denmark. The bacon being cut and cooled, brine is injected into the tissues in the ordinary way. The sides are then placed in a large chamber or cylinder capable of holding 200 to 250 sides, and the chamber is closed and the air extracted. By this means a partial vacuum is created, and the interstices of the tissues opened up, so that they are more susceptible to the influence of the brine. After this semi-vacuum has been maintained for one hour, the valves of the chamber are opened, and it is filled with brine and a pressure equivalent to eight or ten atmospheres exerted upon the surface of the liquid. The brine is thus driven into all the interstices of the flesh. Finally it is removed from the cylinder, strewn with salt, and placed in a cooling chamber for a few days, after which it is dried.

(*e*) *Sugar-Curing.*—The fresh meat is rubbed over with salt for four days in succession, and left on a stone slab to drain. On the last day some saltpetre is mixed with the salt. During the next fourteen days the meat is rubbed over daily with a mixture of equal parts of sugar and treacle. Finally it is smoke-dried. Or the fresh meat is rubbed with fine sugar, and finally put into a tub containing equal quantities of treacle and sugar, where it is left for several weeks. By this means a protective crust is formed around the meat. Very little moisture is drawn out, and therefore the meat is not so dry as when salt-cured. The crust is removed by washing the meat before cooking it. Ham cured in this way resembles pork in appearance, but has the flavour of ham, although it is sweeter than when cured in the ordinary way.

Sugar versus Salt-Curing.—Salt absorbs a portion of the nutritive substance of meat, and extracts some of the nutritive constituents, etc. A solution of salt which has been rubbed into ham or bacon contains albuminoid and extractive matters, phosphoric acid, and salts of potash, more being extracted in proportion to the duration of the application. Sugar is better as a preservative than salt, because it withdraws less moisture, and therefore less albuminoid and extractive matters, and less of the salines. It forms a solid crust around the flesh which protects it, and prevents it drying It does not alter the taste like salt. The chief objections are that it is more expensive, and the sugar requires to be washed off before the meat is cooked.

Preservation of Meat by Cold Storage.—The packing of salt pork and barrelled beef has been in vogue from time immemorial, but the introduction of modern methods of cold storage and refrigera-

tion has revolutionized the trade. Meat frozen by Harrison's method, introduced in 1873, was a failure, but the invention of the Bell-Colman refrigerating process in Scotland in 1878, and other methods since that date, enable cargoes of meat to be brought from the antipodes none the worse for the voyage through equatorial regions. This enables mariners and passengers to have fresh meat throughout the longest voyage. Perhaps, however, the most important point is that the poorest person is now enabled to buy meat at a reasonable cost. Slaughtering and refrigeration goes on all the year round at the great meat centres, and Europe is supplied constantly with beef, mutton, lamb, rabbits, etc., from Australia and Argentina; with beef and mutton from America; hares from Argentina, Russia, and Norway; salmon from Canada; poultry and game from various sources.

Putrefaction is the result of bacterial activity, whereby changes are wrought in the constitution and composition of the substance. It is, however, a well-known fact that the action of bacteria can be restrained by keeping the substance under consideration at a temperature below that which is favourable for their development. In this way many foods besides meat—namely, fish, eggs, butter, fruit, and vegetables—can be kept fresh for an indefinite period, and the growth of the practice of cold storage has materially increased the world's stock of provisions. The agent primarily used was **natural ice.** This was followed by the invention of various freezing machines, which, however, proved inadequate, and have given place to more recent methods. It is unnecessary to go fully into details, but an outline of these methods is essential knowledge to the dietist.

(*a*) **Refrigeration by Direct Expansion.**—In 1845 Gorrie invented a machine for producing refrigeration on the principle that when compressed air, gas, or a volatile liquid, expands, it abstracts heat from the neighbouring substances. When a gas or liquid is compressed, it loses its latent heat in proportion to the degree of compression. When such a gas or liquid again expands, it acquires heat from the surroundings, and the latter are proportionately cooled. Gorrie used compressed air; in 1876 Linde of Munich used anhydrous ammonia; and in 1881 Raydt used carbonic anhydride (CO_2). The gas is derived from a generator and pumped through a coil of pipes, where it is kept cool by water, to a cylinder where it is compressed under very high pressure. Refrigeration is produced by the subsequent expansion. In **direct expansion** the gas or air, when liberated, passes into pipes along the walls or ceilings of the cooling-room or refrigerator. Ammonia expands 1,500 times, and absorbs a considerable amount of heat from the surrounding air, thereby producing a very low temperature. The gas passes through the pipes of the refrigerator, and is pumped back into the condenser to be compressed and used again. The compression can be carried to any degree in proportion to the reduction of temperature which is desired, but usually the pressure

of the condensed gas varies from 100 to 200 pounds to the square inch.

(*b*) **Refrigeration by Indirect Expansion.**—In this method the gas is used to cool a liquid brine in a tank ; the refrigerated brine is afterwards circulated in pipes around the cooling-room, and absorbs heat from the air and contents of the chamber. The circulating brine returns to the tank to be cooled afresh and sent through the pipes again, the current moving at about 60 feet per minute. The gas which cools the brine is also collected and again compressed.

(*c*) **Refrigeration by Air Circulation.**—Air is cooled by passing it over pipes conveying cold brine, carbonic anhydride, or ammonia. It is then circulated by fans through the cooling or storing rooms, and thus keeps them at a sufficiently low temperature. Such stores can be divided into compartments or chambers, which may be kept at the different temperatures which experience has shown to be desirable for the cold storage of various substances.

Chilled or Frozen Meat.—The practice is carried out more or less on the Bell-Colman method. After being dressed, the carcases are allowed to hang in a cooling-room, exposed to a current of air for twelve to twenty-four hours. The cold thus penetrates through the substance, and the entire carcase is chilled. Care has to be taken that the action throughout the tissues is uniform, and the temperature reduced stage by stage until the whole substance is chilled or frozen. The object is to preserve the meat, so that when it is **defrosted** the flesh is sweet and fresh and retains its nutritive qualities. If a carcase be plunged, before the animal heat has disappeared, into a chamber of low temperature—say freezing-point or below it—the external parts are frozen before the internal, and the latter is thus cut off by the frozen zone from receiving the same intensity of cold as the external part. The external frozen zone, contracting on the internal portion, causes many of the cells, whose limiting membranes are stretched to their utmost capacity, to be ruptured, and the cell contents to escape ; and on cutting into carcases so frozen, a pulpy, or even decayed, condition of the meat is found adjacent to the bones. The carcases are therefore first put into a chamber where the temperature is from 37° to 45° F. for fifteen to twenty-four hours.

A cold blast is then turned on, or they are transferred to a refrigerator, where the temperature is gradually reduced to 15° or 17° F. (that is, to 15° or 16° below freezing-point). The carcases require from twenty-four to thirty-six hours to become frozen throughout, sides of beef naturally requiring a longer exposure than sheep, hares, or poultry. They are afterwards transferred to store-rooms, or chambers on the transport vessel, where the temperature is maintained equally low (or even as low as 5° F.) during the voyage. American and Canadian meat sent to Europe is not frozen hard ; it has not to pass through the equatorial regions. Experience has shown that, if kept at a temperature just above freezing-point, meat, fish, poultry, game, eggs, etc., will keep

good for a length of time. Enormous quantities of beef are sent annually from huge stockyards and slaughtering centres at Chicago, St. Louis, St. Joseph, Omaha, and Kansas City.

On its arrival in Europe, frozen meat is " defrosted " by placing it in a chamber of *dry* air, where the temperature is allowed to rise gradually. Just as much care is required in defrosting as in refrigerating the meat, if it is to retain the proper consistence, flavour, and freshness, of meat. When properly treated, meat cannot suffer deterioration ; no rupturing of the cells occurs ; all the properties of the flesh are retained. Neither the proteins nor the fats are chemically affected by the cold. There is no impairment of the nutritive properties when it is thawed, excepting a slight loss of myosin from the cut surfaces. Indeed, when properly frozen, thawed, and cooled, it is much tenderer than meat which has not been so treated.

Cold Storage.—An enormous quantity of food materials are now kept for an indefinite time in cold storage ; that is to say, they are stored in chambers cooled by air which has passed over pipes conveying cold brine, carbonic anhydride, or ammonia gas. The circulation of such air is a sufficient protection against the processes of putrefaction by keeping the substance at a temperature below that necessary for the development of putrefactive germs. Experience has shown that the best temperature for the preservation of materials by cold storage is as follows : Brined meat, 35° to 40° F.; fresh beef, 37° to 39° F. ; mutton, 32° to 36° F. ; pork, 30° to 33° F. ; veal, 32° to 36° F. ; ham, 30° to 35° F. ; lard, 34° to 35° F. ; fish, 25° F. ; oysters, 40° F. ; poultry (frozen), 5° to 10° F. ; ditto, cold storage, 29° F. ; fresh fruit, 33° to 40° F. ; vegetables, 33° to 35° F. Rabbits and hares are packed and refrigerated in Australia under Government supervision ; they are chilled in Russia and Norway, and sent from these countries in cold-storage chambers. Careful inspection and carrying out of routine insures that only fresh, sound, and wholesome animals are exported.

Canned or Tinned Meat.—The various forms of tinned meat are corned beef, braised beef, mutton, tongue, rabbit, poultry, and game. It is elsewhere explained that the putrefactive changes which occur in meat can be effectually prevented by sterilizing the meat, and keeping it hermetically sealed from the air. The products of decomposition of meat include albumoses, amino-acids, ptomaines, hydrogen, carbon dioxide, and marsh gas. The principles of canning therefore include the destruction of the organism which produce these changes, and afterwards hermetically sealing the tins to prevent the access of more bacteria. If the destruction of the micro-organisms is not complete, the bacteria still produce changes in the meat, and the gases accumulate in the tin. When the pressure is great enough, the tin becomes " blown "—*i.e.*, the flat parts bulge—and the contents are unfit for food.

Corned Beef.—The meat is cured for several days in a mixture of salt, saltpetre, and sugar, after which it is washed and put into

a brine of the same materials *plus* spices. The latter consist of thyme, sage, bay-leaf, coriander, allspice, mace, nutmeg, pepper, etc., in a combination which varies with the maker. The beef is then boiled *slowly* for one hour, packed into tins, sealed, and sterilized by boiling or subjection to superheated steam under pressure.

Canned Tongue is similarly prepared. The tongues are cured for a few days in salt, saltpetre, and sugar, and *dried*. They are afterwards *soaked* in water, then boiled in water containing spices such as the foregoing, put into tins, sealed, and sterilized. They are sterilized either in a retort or a calcium bath. (*a*) *Sterilization in a Retort :* The cans are put into a " process kettle " or retort before they are finally sealed down ; the exhaust valve is closed and the cans *processed* for seventy-five minutes, with steam at 3 pounds pressure ; they are then taken out of the retort, sealed up, and put in again, being now submitted to the action of steam at 4 pounds pressure for one hundred minutes, with the exhaust valve *open*. Finally they are taken out and rapidly cooled in water. (*b*) *The Calcium Bath :* Water containing chloride of calcium can be raised to a much higher temperature than plain water. Advantage is taken of this fact in sterilizing canned foods of various kinds. Thus canned tongue is lowered into the bath until the tins are nearly covered. They are then " processed " or boiled at a temperature of 230° F. for forty minutes from the time steam begins to issue from the vents in the tins. They are hermetically sealed before they are removed from the bath, afterwards being transferred to a retort where they are boiled for one hundred minutes by steam at a pressure of 4 pounds per square inch, and finally removed and cooled by immersion in water.

Diseased Meat.

All slaughter-houses and establishments for the sale of meat and its preservation by salting, smoking, drying, canning, or the manufacture of meat products, should be regularly inspected by officials properly qualified to certify the soundness of the material and the sanitary condition under which such foods are prepared, stored, and sold. The entire carcases, parts of carcases or meat, and meat products from cattle, sheep, goats, swine, and horses, which are intended for human food, ought to be inspected by such officers before they are exposed for sale.

The establishments in which the animals are slaughtered, the meat cut, prepared, packed, stored, cured, or otherwise handled, should be well lighted, ventilated, and drained. The walls, ceilings, pillars, and partitions, of stables, hovels, pigsties, fasting-pens, should be frequently whitewashed, limewashed, or painted with such material as can be readily washed. Lime- or white-washed walls, etc., should be frequently scraped. Floors and other parts of the buildings which are in a very insanitary condition ought to be replaced. The apparatus of all slaughtering-houses, dressing-

rooms, canning and packing rooms, should be cleaned every day. The employés should only be allowed to work with clean hands ; they should wear washable aprons and smocks ; there should be lavatories fitted with hot and cold water for their use ; and the employés should be under the supervision of a foreman responsible for their cleanliness and good health. The rooms in which meat and meat products are stored should have no direct communication with the slaughtering-house, pens, lavatories, etc. The drainage and ventilation should be so arranged that no odours from hides, tanks, manure, or other refuse, can penetrate.

Inspection of the Animals—(*a*) *Before Slaughtering.*—All cattle, sheep, goats, swine, or horses about to be slaughtered for human food, whether for meat or meat products, should be examined in the establishment of the butcher before they are slaughtered. Any animal suspected of being unsound should have an official tag attached, or be so marked upon the ear that it can be easily recognized by some responsible person before removal of the skin or evisceration. If disease of a feverish character be suspected, the exact temperature should be taken, and may reveal such a condition as will lead to its condemnation. It should, of course, be remembered that a rise of temperature may occur from the removal of the animal from place to place, from excitement, etc. Crippled animals should also be marked for further examination.

(*b*) *Post-Mortem Examination.*—Any medical officer of health or inspector of nuisances may at all times inspect and examine meat exposed for sale or in preparation for sale, and intended for the food of man, and deal with the same under the Public Health Act, 1875, sections 116 to 119, and other Acts. All carcases and all viscera should be examined at the time of slaughtering. Carcases and viscera found healthy should be marked as such by the inspector. When any diseased or other condition is observed that would render the flesh unfit for human consumption, the carcase or viscera should be marked for further examination. Actually diseased carcases or parts of carcases and organs must then be dealt with as the law directs. All this tends to the necessity for public abattoirs in all large centres of population, as a means of carrying out the work of inspection in a ready and systematic manner.

Good meat should have a marbled appearance, due to streaks of fat between the muscular fasciculi ; the surface should have a bright, florid colour, neither too dark nor too pale. The colour of meat, however, depends on various things : if it is very dark, it is the flesh of an old or diseased animal ; a magenta hue indicates the existence of some acute disease at the time of death. A very pale or yellow colour, sometimes called " white flesh," in an adult animal, is due to fatty infiltration or degeneration or fibroid infiltration. The flesh of all young animals is paler than that of older ones. The colour of mutton, pork, and veal, is paler than that of beef, but this is exaggerated by the fact that sheep, pigs,

and calves, are well bled at the time of killing. On cutting into the meat, it should show a *uniform* colour, although the interior is a little paler than the exterior. The muscular fasciculi should not be too large ; the connective tissue should glisten ; and it should have the peculiar odour of meat known to all. Any departure from the normal odour should excite suspicion at once. To test this more particularly, a clean knife should be plunged deeply into it, in the direction of the bone, and the knife should be smelt, or some of the meat may be finely minced and mixed with water. The touch of meat should be firm and slightly elastic, which implies freshness and a due rigor mortis. The surface should not be absolutely dry, but should give a slight moisture to the finger when passed over it. This moisture or meat juice should be of a clear red colour and *acid reaction*. The *fat* of meat has a firm, greasy feel, and a pale yellow colour which deepens with age, and becomes distinctly yellow when the animal has been fed on oil-cakes. *There should be no hæmorrhagic points*. According to Gamgee, some butchers rub melted fat over the surface of diseased meat, to give it the glossy appearance which sound meat shows. The *lymphatic glands* should be firm, slightly moist, and of a pale yellowish-grey appearance on section. The *marrow* should be light red. That of the hind-quarters should set firmly in twenty-four hours, but in the fore-quarters it requires a longer period. The *ash* of meat should be alkaline. It consists almost entirely of phosphates and chlorides. The *moisture :* Meat dried over a water-bath should not lose more than 74 per cent. of its weight, the loss representing the amount of water in its composition. On cooking meat, the loss of weight should not exceed 30 per cent., nor its fibres become hard, and it should give off a savoury odour. Unsound meat may lose 40 per cent. of its weight on cooking, and the odour may be unsavoury. *If the meat is putrefied*, the flesh softens and tears readily ; it loses its elasticity ; some parts become softer than others ; it becomes paler ; the marrow turns brown and softens, and later on the flesh becomes greenish ; the juice has an alkaline reaction, and the odour is characteristic of putrefaction. Diseased meat is frequently of a dark or purple colour, which shows that the animal has not been killed or properly bled, but died with the blood in it, probably of some febrile complaint, or from some mechanical obstruction to the respiration. Well-defined dark-coloured areas full of blood are either due to hypostatic congestion or post-mortem staining. A yellowish or mahogany colour is due to staining with bile. The animal may be emaciated, as shown by a disproportion between the fat and lean. The meat juice may be dark or otherwise discoloured, and *alkaline*. There may be tumours or *pus* between muscular fibres. The flesh may be soft, sodden, flabby, or dropsical. The fat may be soft, flabby, or gelatinous ; or the marrow of bones sets badly. The odour may indicate putrefaction ; a sweet odour will indicate uræmia, a urinous odour suggests extravasation of urine. Other odours may

indicate that the carcase has been hung near to odoriferous substances—*e.g.*, tar or carbolic acid—or that some drug, such as turpentine, camphor, or creosote, was administered to the animal, or that it fed on odoriferous plants, such as garlic.

The organs may show signs of some special disease. The *lungs* and *pleura* may show signs of hepatization, œdema, suppuration, cavities, nodules, or adhesion, in tuberculosis, pleuro-pneumonia, pneumo-enteritis, anthrax, and actinomycosis. The thoracic lymphatic glands may be enlarged, caseous, or purulent. Tuberculosis is often called the " grapes " or " pearl disease " by farmers, because the tubercular deposits may hang from the surface of the lungs like grapes. The *liver* may exhibit hydatids, liver-fluke, abscesses, or tubercle; it may be enlarged, softened, hyperæmic, or bile-stained, in tubercle, anthrax, etc. The *spleen* may be enlarged, with rounded edges, and show nodules or ulcers, in tubercle, anthrax, parasitic infections, etc. The *kidneys* may be hyperæmic or inflamed in tubercle, swine-fever, etc. The *abdominal lymphatic glands* may be inflamed or enlarged in tuberculosis, glanders, pneumo-enteritis (pig-typhoid), swine-fever, or plague, small-pox of sheep, etc. The *stomach* and *intestines* and peritoneum may be hyperæmic, inflamed, or ulcerated, in swine-plague, cattle-plague, anthrax. The existence of such hyperæmia may be due to poisoning by tartar emetic, *Rhus toxicodendron*, bryony, meadow-saffron. In any case of suspected poisoning by these things, or by arsenic, antimony, strychnine, etc., a piece of meat should be given to a cat or dog. The *skin* of the animal may show papules or pustules; the *udder* may show blisters, ulcers, or nodules, in foot and mouth disease. The *head* may be enlarged and inflamed; there may be blisters and ulcers on the tongue and mouth in foot and mouth disease; swellings under lower jaw in actinomycosis; the nose may be ulcerated in glanders, farcy, and smallpox; the brain may show tuberculosis and parasites.

Condemned Meat.—All animals suffering from anthrax, blackleg, pyæmia, septicæmia, tetanus, rabies, malignant epizootic catarrh, should be condemned without reserve. **Actinomycosis**, or " lumpy jaw " : (*a*) When the carcase is well nourished, and the disease has not spread beyond the mouth or tongue, it is considered to be sufficient to condemn the head; the rest of the carcase may be eaten. (*b*) But when the disease has spread beyond the primary infection of the tongue or mouth, the carcase should receive the same consideration as in tuberculosis. **Tuberculosis :** (*a*) All carcases which show marked emaciation should be condemned. (*b*) But when the signs of the disease are slight, or the lesions are calcified or encapsuled, the carcase is not usually condemned *in toto*, but the diseased organs or glands and surrounding parts only. (*c*) *Carcases in which the cervical glands and one organ and serous membrane of one cavity are affected should be condemned as unfit for human food—e.g.*, cervical glands and one lung and pleura, or the liver, peritoneum, and glands; excepting that, after removing

the diseased parts, the carcase may be rendered for the manufacture of lard or stearin by cooking it with steam at a temperature of 220° F. for not less than four hours. (*d*) When the disease is limited to the superficial lymphatic glands (*caseous lymphadenitis*), or a few nodules upon one organ and adjacent glands in an animal which is otherwise well nourished, the meat is usually passed after removal of those parts. **Swine fever and hog-cholera :** (*a*) If the signs of fever or cholera are slight, being confined to the lymphatic glands and kidneys, the carcases are as a rule passed ; (*b*) where there are well-marked signs in more than two organs—skin, bones, kidneys, and lymphatic glands—it is usual to condemn the whole carcase. (*c*) If the lesions are more severe than in the first, but less so than in the second case, the carcase may be rendered into lard or stearin, provided it is cooked in steam of a temperature of not less than 220° F. for four hours. **Pneumonia, pleurisy, enteritis, etc. :** When the carcase shows marked signs of acute or chronic disease in the lungs, pleura, peritoneum, intestines, or uterus, it is usually condemned. **Fluke, abscesses, bruises, etc. :** The particular organ or part of the animal affected by liver-flukes, abscesses, suppurating sores, tumours, or malignant tumours, should be condemned. If the lesions are extensive, the entire carcase should be condemned. **Emaciation and anæmia :** The carcases of emaciated or very anæmic animals, and those which show a slimy degeneration of the fat or serous infiltration into the muscles, are unfit for human food, and should be condemned. **Tapeworm cysts :** Carcases affected slightly with tapeworm cysts may be rendered into lard or stearin. If the cysts are numerous, the body should be condemned. **Skin affections :** If only slightly affected by mange, scab, urticaria, tinea tonsurans, erythema, etc., the carcase may be passed if it is otherwise sound. The skin of swine afflicted with skin diseases should be condemned. **Icterus :** Carcases showing an intense yellow or yellowish discoloration after cooling should be condemned. If the yellowish tint disappears on cooling the carcase, it may generally be passed, providing it is otherwise in good condition. Carcases afflicted with parasitic ictero-hæmaturia should be condemned. Those having a strong sexual or urinous odour should be condemned. **Immaturity :** The carcases of calves, pigs, kids, or lambs, under three weeks of age should be condemned ; and all stillborn or unborn animals should also be condemned as unfit for human food. **Pregnancy and parturition :** Animals in an advanced stage of pregnancy, and animals delivered within the previous ten days, are unfit for human food—they should be condemned ; but the carcase may be rendered into lard or stearin. **Dead or dying animals :** All animals that die a natural death or are in a dying condition when slaughtered are unfit for human food. A few other notes may usefully be added upon some of these diseases.

The common **fluke** in the liver of sheep and cattle is *Fasciola hepatica*, one of the Trematoda. It resembles a sole in shape, is 1 to 1½ inches long and ½ inch wide, and infests the bile-ducts.

Tapeworms belong to the Cestoda. The beef tapeworm (*Tænia mediocanellata*) occurs in beef and veal, where the larvæ (*cysticerci*) are found in the voluntary and involuntary muscles. They are destroyed by a temperature of 135° to 140° F. (60° C.) for a few minutes; therefore, thoroughly cooking the meat is a sure preventative against them. Human beings are usually infected by eating raw or underdone meat, sausages, etc. Mutton is not so often measly as beef or pork; indeed, the existence of cysticerci is denied by some authorities, but Cobbold says there is a small tapeworm, which he named *Tænia tenella*, and that he has seen the cysticerci in both sheep and lambs. The pork tapeworm (*Tænia solium*), formerly considered the common tapeworm, is not nearly so common as that of beef. The cysticerci are small, round, or oval cysts $\frac{1}{25}$ to $\frac{3}{4}$ inch in size, situated in spaces between muscular fasciculi. Human beings are usually infected from eating raw or underdone pork or sausages, also from salads, raw vegetables, fallen fruit, etc. It is destroyed easily by thoroughly cooking the meat or vegetables. *Bothriocephalus latus* is indigenous to Ireland, and not common in England. It particularly infests fresh-water fish, such as trout and bleak, and human beings become infested by eating underdone fish. A similar worm infests the dog, but Cobbold considers there is very little relation between the two. On the other hand, the **common hydatid** (*Echinococcus hominis*) is commonly obtained from dogs, being the larval stage of the tapeworm *Tænia echinococcus*. Sheep, oxen, and man, become affected by association with the dog, and by partaking of food and filthy water upon which the eggs abound. They occur in the lungs, liver, brain, and elsewhere. *Trichina spiralis* is common in pork, ham, bacon, and sausages. It is the juvenile state of the little round worm *Trichina*, one of the Nematode worms. As commonly observed, the young Trichinæ appear as spirally coiled worms in the interior of small, globular, or lemon-shaped cysts, looking like minute specks, which are about $\frac{1}{70}$ inch in length and $\frac{1}{120}$ inch in breadth. They resemble little specks or particles of lime, and give a more or less *gritty feeling to the flesh*, according to the degree of calcareous degeneration they have undergone. The adults occupy small lemon-shaped cysts of about the size of a pin's head, the male worm being $\frac{1}{16}$ inch, the female $\frac{1}{8}$ inch, long. They are very numerous in measly pork. One ounce of ham may contain 100,000, and 1 pound about 400,000,000, parasites. As they migrate from the alimentary canal of the host, they reach first of all the liver, then the diaphragm, intercostal and abdominal muscles.

Psorospermiæ, or Rainey's capsules, which closely resemble Trichinæ in appearance and size, are small, oval, or elliptical bodies, formed by small hair-like fibres enclosing granular cells, and are embedded *in the sarcolemma*, whereas the Trichinæ are *between* the muscles fibres—*i.e.*, outside the sarcolemma. These bodies are obscure in their nature and origin, and may exist in the flesh of most animals consumed, and apparently do no harm to human beings.

Onchocerciasis.—Australian beef frequently presents superficial nodules on the forequarters due to the presence of Onchocerca or filaria-like entozoa. Although they are chiefly on the surface of the brisket and flanks, they are sometimes present in the intermuscular fat, even when there are none on the surface. They do not appear to be of clinical importance; and it has been suggested that, apart from the unsightliness of the meat, the parasitic nodules do not render the flesh unfit for food. It is possible, however, that the meat may be deteriorated by the production of a toxin by the parasite, of which there is at present no scientific evidence.

Anthrax.—In acute cases the disease runs a rapidly fatal course. the animal dying in one or two days, or even quite suddenly, as if struck with apoplexy. In less acute cases it is fatal in three to seven days. If it ends in recovery, it is hardly likely that the flesh would be used at once for human food. The bodies of animals which have died from anthrax lose their rigidity; if rigor mortis appears at all, it passes away quickly. The flesh is therefore soft and flabby, and decomposition speedily sets in. Various swellings occur, as œdemas or carbuncles. The œdemas are flattened doughy swellings in the subcutaneous fat, and gradually pass into the healthy tissues. The carbuncles are much firmer swellings. The best mode of diagnosis is that of examining the blood and tissues for the *B. anthracis.*

Anthrax is transmissible to man, but the largest percentage of inoculations occur during slaughtering, dressing, or skinning the affected animals, in which case a malignant pustule appears on the skin. Human beings are also subject to anthrax affecting the lungs or digestive organs, but such cases are rare. In the former case, the workman who dresses the wool, hide, etc., is most likely to be infected by inhaling the spores. It is then called the "wool-sorter's disease." When it affects the digestive organs, the infection arises through eating the flesh of a diseased animal which has not been thoroughly cooked. Both cases are, however, comparatively uncommon, but more fatal than when the disease affects the skin.

Blackleg, formerly considered to be identical with anthrax, is a rapidly fatal disease of young animals from six months to two years of age; it affects young cattle, sheep, and goats, but man appears to be immune. It would not, however, be proper to eat the flesh of animals affected by it. This disease is due to a distinct bacillus, which causes a characteristic tumour or swelling upon the neck, breast, shoulder, or rump. It causes a temperature which ranges up to 107° F., and the animal usually succumbs in a few days.

Actinomycosis is commonly known as "lumpy jaw," "big jaw," "wooden tongue," etc. It is a chronic disease, characterized by the formation of peculiar tumours in various parts of the body, more particularly the head, and is due to a fungus, *Actinomyces.* This fungus appears in the tissues in the form of rosettes—hence the name "ray fungus." The disease is not transmissible directly from animal to animal, but is conveyed into the tissues by various foodstuffs, and gets entrance through slight wounds or abrasions of the

mucous membrane of the mouth, decayed teeth, or the shedding of the deciduous teeth. The fungus grows naturally upon vegetables, such as grasses, the ears of barley, wheat, and other grain. Quantities of the fungi have been obtained from between the vegetable fibres of barley which had become embedded in the gums or tongue of cattle. Having penetrated into the tissues, the fungus gives rise to various tumours or abscesses, in which the fungi are visible as pale yellow or sulphur-coloured bodies, about 0·5 millimetre, or $\frac{1}{50}$ inch, in size, which consists of club-shaped bodies radiating from the centre like a rosette. The seat of preference appears to be the tongue, bones of the jaw, parotid gland, and region of the throat ; later on it may cause extensive disease in the lungs, liver, spleen, muscular tissues, and brain. Whether an animal affected with actinomycosis should be used for human food after removal of the diseased organs depends on several things, including the carefulness of inspection, the extent of the disease, and the general condition of the carcase. If the tumours are small and the disease is not generalized, it is usually considered that if the affected parts are removed the remainder may be used for food. But when the disease is sufficiently developed to cause large swellings and abscesses which discharge into the alimentary canal, and the general health of the animal is affected, the carcase should be condemned, as the flesh is not fit for human food. The carcase should also be destroyed when the lungs or internal lymphatic glands are affected, or when a large number of foci are scattered throughout the body. The vitality of the fungus is very low *when exposed to heat*, and there is no clear evidence that the flesh can communicate the disease to man.

Tuberculosis.—The close relationship between human and animal tuberculosis, combined with the extraordinarily high mortality of human beings when affected by the disease, has raised the question in all civilized countries as to how far animal, and especially bovine, tuberculosis is responsible for the spread of the disease among human beings. The medical and veterinary professions have prosecuted this subject with ardent zeal, and much knowledge has been gained. If the disease is transmitted from animals to man, how does the transmission take place ? Comparatively few people come into contact with tuberculous cattle ; it must therefore be through meat, milk, butter, or cheese, that the virus enters the body—that is, it is a food disease.

It hence becomes a question as to whether all flesh from tuberculous animals is unfit for human food. It has been argued that, if it can be shown that the muscles and bones are free from the disease, there is no reason why the meat should not be exposed for sale. Two questions may therefore be asked : (1) How often does the disease affect such parts as are used for food ? (2) When the disease is only apparent in the internal organs, do the bacilli circulate in the blood and lymph, and can they be detected in the muscles ? Tubercular disease of the bones is not unknown, but it is rare. According to Walley, the disease sometimes affects the spongy

bones of the head, the vertebræ, and heads of long bones, and the synovial membrane of the joints is sometimes dotted with tubercular deposit. Respecting the muscular tissues, it may be said that tubercular deposits therein are exceedingly rare; but the lymphatic glands in and near to the muscles are often diseased. Whether tubercle bacilli occur in the fluids of the muscular tissue, independently of tubercular deposits, is a matter which can be settled experimentally in any particular case. Such experiments have shown that only in rare cases do the muscular tissues of tuberculous cattle contain *B. tuberculosis*, and then only in small numbers. Opinions therefore differ about the consumption of the flesh. Some authorities consider that all the flesh of tuberculous animals is unfit for food; others hold a contrary view. In Germany, the flesh of animals in which the disease is just beginning, or in which it is restricted to one or more related organs, is not condemned; but when the disease has affected the bones, muscles, or glands situated upon or between them, the carcase is condemned as unfit for human food. In cases of generalized tuberculosis—that is, when the bacilli have been distributed by the blood throughout the organs—the muscular tissues are liable to be infected, and the carcase is then rejected by all authorities.

A discussion arose a few years ago as to the identity of bovine and human tuberculosis, and whether the tuberculosis of animals can be transmitted to man and *vice versa*. Many experimenters worked to ascertain their identity or otherwise. Experiments on animals with the products of human tuberculosis have often failed to produce any marked disease in animals. Theobald Smith (1898) noticed certain morphological and cultural differences in the bacilli from man and animals, and obtained two types of bacilli from the mesenteric glands of children, one of which was the bovine bacillus. He, however, did not conclude that bovine tubercle bacilli could not produce the disease in man, but he said: "It seems to me that, accepting the clinical evidence, bovine tuberculosis may be transmitted to children when the body is overpowered by large numbers of bacilli, as in udder tuberculosis, or when unknown favourable conditions exist." Koch, however, went far beyond this. In his address on Tuberculosis at the British Congress (1906), he stated that he did not believe that bovine tuberculosis was transmissible to man. He maintained "human tuberculosis differs from bovine tuberculosis, and cannot be transmitted to cattle." As to the susceptibility of man to bovine tuberculosis, he said it had not been settled, but "one was at liberty to say that, if such a susceptibility really exists, the infection of human beings is but a very rare occurrence," and "I should estimate the extent of infection by the milk and flesh of tubercular cattle, and the butter made of their milk, is hardly greater than that of hereditary transmission, and I therefore do not deem it advisable to take any measures against it." This conclusion was so radically different from that of other observers that it at once roused great opposition,

and led to numerous investigations in most civilized countries. Koch's conclusions were based on his failure to produce tuberculosis in cattle by inoculating them with tubercular matter of human origin, and his success in causing progressive and fatal tuberculosis in the same animal when inoculated with tubercular material of bovine origin. The generally accepted view now is that human tuberculosis may be, and is, caused by bacilli of either bovine or human origin. Kossel in 1905 recorded finding bacilli of the bovine type six times out of fifty-six cases of tuberculosis in human beings. Ravenel in the same year pointed out that the bovine bacilli had a much greater virulence than human bacilli, and said it would be remarkable, seeing how susceptible man is to tuberculosis, if he were immune to the more powerful virus. Von Behring, in his Cassel Lecture, said he believed the chief source of human tuberculosis was the contraction of bovine tuberculosis in infancy through feeding on milk; that such tuberculosis often remained latent, and restarted in adult life. The Royal Commission, in its Second Interim Report, 1907, found that thirteen out of twenty-seven cases of tuberculosis in human beings observed by them were of bovine origin. The conclusion from these and other observations is that from 5 to 10 per cent. of the human mortality from tuberculosis in this country is due to infection from bovine sources. In the Final Report of the Royal Commission on Tuberculosis (1911), it is shown that although the two types of bacilli found in human and bovine tuberculosis present differences, and although certain animals are immune from attacks of the bovine type of the bacillus, man is not one of those animals ; in fact, man is notably susceptible to bovine tuberculosis ; and whether there are two kinds of tuberculosis or not, it is certain that much of the disease in man is caused by bovine bacilli.

It has been shown that when tuberculosis arises by ingestion of food materials it is not essential for the primary symptoms to appear in the abdominal organs. Calmette and Guerin showed that tuberculosis of the bronchial glands and lungs could result from feeding with tuberculous material without any intestinal or mesenteric lesions being found. The flesh of tuberculous animals is, however, not necessarily infectious, for the muscular tissue rarely contains deposits of tubercle. McFadyean and Nocard, who injected large numbers of tubercle bacilli into the circulation, were unable to find any in the muscles, and the circulation itself was free in three to six days. Even in pigs, in which generalization is very frequent, observations have failed to show the bacilli in the muscles, although positive results have more often followed the use of the muscles of tuberculous pigs, sheep, and fowls, than those of cattle. Tubercle bacilli, however, abound in the glands, and their presence makes the flesh dangerous ; it is impossible to remove all the glands before the meat comes into the market. Besides the muscular tissues, all the internal organs are a common form of diet among the poor, the lungs, udder, and mesentery, being consumed in one form or another. These organs are highly infective, and from them arises a source

of danger to man. The Royal Commission made the following recommendations: *The entire carcase and all the organs should be condemned when*—(1) there is miliary tuberculosis of both lungs; (2) tuberculous lesions are present in the pleura and peritoneum; (3) tuberculous lesions are present in the muscular tissues or in the lymphatic glands embedded therein; (4) the carcase is emaciated. *The carcase, if otherwise healthy, shall not be condemned, but every part of it containing tuberculous lesions shall be seized, when*—(1) the lesions are confined to the lungs and thoracic lymphatic glands; (2) the lesions are confined to the liver, (3) or to the pharyngeal glands, or (4) to any combination of the foregoing to a small extent.

The Effects of Cooking on Tubercle Bacilli.—Experiments have proved that the bacilli only show a moderate resistance to heat. Jersin found that their vitality was destroyed by exposure to 75° C. for ten minutes. Forster found an exposure of fifteen minutes at 65° C., ten minutes at 70° C., and one minute at 95° C., sufficient to destroy them. Woodhead, in his Report to the Royal Commission, working on the assumption that the flesh of tuberculous animals was rarely infective, unless soiled during the dressing of the carcase, injected tuberculous material into the flesh in some cases; in others he smeared pieces of meat with the tuberculous matter, and formed them into "rolls," such as are sold by butchers. The "rolls" of a butcher commonly contain minced lung, omentum, and other tissues, which in tuberculous animals are highly infectious. Having prepared his "joints," Woodhead submitted them to cooking in the ordinary manner, and noted the temperature attained in the process. He arrived at the following conclusions: The centre of a "joint" weighing six or more pounds never exceeded 60° C. (140° F.) during ordinary cooking. "Rolls" of meat weighing 3 or 4 pounds were never rendered sterile throughout, and ordinary cooking could not be relied on to render tuberculous meat innocuous. Ordinary cooking was sufficient to destroy tuberculous material "smeared" on the outside of the meat. Boiling the meat was the most trustworthy mode of cooking it, roasting in an oven the next, and roasting in front of a fire the least effective method of securing its innocuity. Forster found that salting and smoking the meat were not sufficient protection against tubercle; that tubercle bacilli could be found in the meat two months after such preservation.

Neither does the gastric juice destroy the tubercle bacilli. Falk and Wesener exposed tuberculous material to the action of gastric juice for several hours, but it was still virulent when injected into animals. Stern has also shown that the intestinal secretions have no effect on the bacilli.

We may conclude, therefore, that man can contract tuberculosis from cattle. But tuberculosis in man is probably not frequently caused by the ingestion of meat, since the swallowing of a large number of the bacilli is necessary for this mode to be effective. Furthermore, the

muscular tissue of animals is rarely infective, even in generalized tuberculosis, except by post-mortem contamination, and the ordinary methods of cooking the meat are more or less a safeguard against infection by this means. Finally, the Royal Commission found that during the period in which the consumption of meat as human food has greatly increased there has been a steady decline in the amount of human tuberculosis. The conclusion therefore must be arrived at that the risk to the community by eating the flesh of tuberculous animals is not so great as is generally assumed, and that this risk may be reduced by the more perfect and general inspection of meat and by efficient control of the market.

Sale of Unsound Meat.—There is no law in the United Kingdom enforcing the examination of flesh foods before they are sold. But no person can expose for sale any animal, carcase, meat, fish, game, poultry, rabbit, etc., which is unsound without rendering himself liable to fine or imprisonment (Public Health Act, 1875, section 117 ; Public Health (London) Act, 1891, section 47).

Seizure of Unsound Meat.—Any Medical Officer of Health or Inspector of Nuisances may at all reasonable times inspect and examine any animal, carcase, meat, game, poultry, rabbits, fish, etc., exposed for sale or in preparation for sale and intended for the food of man ; and, if it appears to be diseased, unsound, unwholesome, or unfit for the food of man, may seize the same and carry it away to be dealt with by a justice (Public Health Act, 1875, section 116 ; Public Health Amendment Act, 1890, section 28 (1) ; and Public Health (London) Act, 1891, section 47). Penalties may be imposed for obstructing the officer in the performance of his duty.

CHAPTER V

THE COMPOSITION OF BEEF, MUTTON, PORK, ETC.

Meat consists of muscle, fat, connective tissue, cartilage, bone, etc. The proportion of **water** is determined by drying the substance for three or four hours at a temperature of boiling water, in a current of dry hydrogen, but without allowing the containing vessel to be in contact with the boiling water. The **ash** is afterwards ascertained by charring the substance at a low red heat; the charred mass is then exhausted with water, the insoluble residue collected on a filter, burnt, and added to the residue obtained from the aqueous extract; finally the whole residue is heated at a low redness until the ash is white. The proportion is then ascertained. Fresh meat contains an average of 1 per cent. of mineral matters, but the proportion may be as low as 0·1 per cent. in fresh unsalted pork. The **fat** varies from 10 per cent. in some cuts of meat to 40 per cent. in side of pork, and even 80 per cent. in very fat bacon. Meat as a rule contains more fat than there is in fish; lean fish, such as cod and haddock, scarcely contain any, but shad, mackerel, and salmon, have as much as 5 to 10 per cent.

The proportion of fat is ascertained by extracting 2 or 3 grammes of the substance, dried for the determination of moisture, with anhydrous and alcohol-free ether for sixteen hours. The ether extract is then dried by exposure to the full heat of boiling water in a current of dry hydrogen until it attains a constant weight. The proportion is then determined.

The **proteins** of beef, mutton, and veal, vary in amount from 14 to 22 per cent. of the edible portion. The fatter the meat, the smaller the amount of protein. Protein is more abundant in meat than in fish, because the latter contains more water. Among vegetable foods, the legumes and some nuts are the only members which really approach meat in their protein content, although some fungi have improperly been considered equal to meat.

The mode of determining the proportion of protein is as follows: The nitrogen is determined by Kjeldahl's method, and the *crude protein* is found by the factor N × 6·25. The *albuminoids* are then determined by Stutzer's method, which is described thus:[1] 100 grammes of pure cupric sulphate is dissolved in 5 litres of water; 2·5 c.c. of glycerine is then added, and enough solution of sodium hydrate to make the solution alkaline. Filter. The precipitate so obtained is rubbed up with 10 per cent. of glycerine, thus preparing a uniform gelatinous mass which can be measured out with a pipette.

[1] *Chemical News*, 1892, ii. 18.

The quantity of cupric hydrate per c.c. of the mixture is then determined. One gramme of the substance to be analyzed is added to 100 c.c. of water in a beaker, heated to boiling-point, and a quantity of the cupric hydrate mixture, containing 0·7 to 0·8 gramme of hydrate, is added. It is filtered when cold, the precipitate washed, the filter and its contents put into the sulphuric acid, the nitrogen determined by Kjeldahl's method, and the protein reckoned from the usual factor.

Wiley[1] finds the following method to be better: Bromine precipitates all proteins, including the products of digestion of albumin by pepsin, and gelatin, but it does not precipitate solutions of meat bases—creatin, asparagin, aspartic acid, etc. He therefore recommends that dry, fat-free animal matter be first obtained by washing the substance in cold or lukewarm water, and afterwards in nearly boiling water. This method removes all the soluble nitrogenous substances. He then determines (1) the *total nitrogen* in the entire sample; (2) the insoluble nitrogen in the fat-free and washed sample when the factor N × 6·25 gives the **insoluble proteins;** (3) the solution is precipitated by bromine, and the nitrogen in the precipitate determined, and the same factor gives the **soluble proteins** (N × 6·25); finally the nitrogenous matters left in the solution are determined, and the factor N × 3·12 gives the amount of **meat bases.** Gelatin is determined by the factor N × 5·5.

The *carbohydrates* are almost absent from all animal foods, except milk. Glycogen is present in lean meat and liver to a variable extent, and some of the proteins (gluco-proteids) of meat have a carbohydrate complex.

The Composition of Meat.—König says that meat contains an average of 15 per cent. of refuse, including bone, cartilage, tendons, fasciæ, etc. The **edible portion** consists of water 75 to 77, muscle fibres 13 to 18, connective tissue 2 to 5, fatty tissue 0·5 to 3·0, ash 0·8 to 1·8, extractives 0·5, per cent. The dry or **water-free** substance is estimated by Rübner to consist of syntonin, myosin, and gelatin 70·1, hæmoglobin and serum albumin 8·57, muscle albumin 3·13, extractives 12·68, ash 5·50, per cent.

1. Muscle.—**Lean meat** consists of the muscular fibres, which contain many things. The proteins are myosin and paramyosin. *Myosin* is the chief substance of the sarcous elements or discs, and forms from 70 to 80 per cent. of the total proteins. It is a globulin, having the following composition—C 52·82, H 7·11, N 16·17, S 1·17, per cent.[2] The *paramyosinogen* of Halliburton, or *musculin* of Hammarsten is present in small quantities. Fürth says it is nothing but myosin. There are also small quantities of serum albumin and globulin from the blood and lymph; according to some observers, the latter are distinct bodies, called "myo-albumin" and "myoglobulin," similar to corresponding substances in the blood. There is also a slight trace of nucleo-protein in lean meat, arising from muscle cells, but the amount is insignificant, and few, if any, authorities take any note of it when considering a personal dietary. Lean meat also contains the sarcolemma of the muscle fibres, keratin and elastin from the bloodvessels, extractives or meat-bases, various non-nitrogenous extractives, fats such as lecithin, hæmoglobin or colouring matter, and mineral substances.

[1] *Chemical News*, 1899, ii. 89.
[2] Chittenden and Cummings, "Studies at Yale College," vol. iii., p. 115.

THE COMPOSITION OF MEAT.

(COMPILED FROM VARIOUS SOURCES.)

Substance.	Nutrients per Cent.					Calories per Pound.	Authority.
	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.		
RAW MEAT.							
Beef : Average of 478 samples	64·70	18·70	15·70	·5 [1]	·90	1,156	Atwater.
Very fat ox : Mean	55·42	17·19	26·38	—	1·08	—	König.
Moderately fat ox : Minimum	68·50	16·23	1·17	—	·71	—	
Maximum	78·00	25·35	9·50	—	1·95	—	
Average	73·25	20·78 [2]	5·33	—	1·33	—	
Lean ox : Mean	76·71	20·78	1·50	—	1·07	—	
Lean cow : Mean	76·35	20·54	1·78	—	1·32	—	
Beef, parts of : Lean beef or muscle, free from fat	73·80	22·40	2·90	—	1·20	540	
Beef fat—*e.g.*, suet	13·40	4·10	82·10	—	·40	3,540	
Edible portion of—							
Brisket	54·60	15·80	28·50	—	·90	1,495	
Chuck	68·30	19·60	11·90	—	·90	865	
,, rib	66·80	19·00	13·40	—	1·00	920	
Flank	59·30	19·60	21·10	—	·90	1,255	Atwater and Bryant (Bull. 28, U.S. Agricultural Department).
Loin	61·30	19·00	19·10	—	1·00	1,558	
Sirloin	42·20	13·80	43·70	—	·80	2,100	
Tenderloin	59·20	16·20	24·40	—	·80	1,330	
Ribs : Lean	70·90	25·00	3·50	—	1·20	615	
Fat	48·50	15·00	35·60	—	·70	1,780	
Average	57·00	17·80	24·60	—	·90	1,370	
Steak : Sirloin	61·90	18·90	18·50	—	1·00	1,130	
Porterhouse	60·00	21·90	20·40	—	·80	2,100	
Rump	57·90	18·70	23·10	—	·90	1,325	
Round	67·80	20·90	10·60	—	1·10	835	
Shank	69·60	21·70	8·70	—	1·00	770	

[1] In dry substance.

[2] Meat-bases 1·58.

THE COMPOSITION OF MEAT—*Continued.*

Substance.	Nutrients per Cent.					Calories per Pound.	Authority.
	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.		
RAW MEAT—*continued.*							
Beef, dried: salt or smoked	54·30	30·00	6·50	·4	9·10	840	
Veal: *Edible portion*—							
Fore-quarter	71·70	20·00	8·00	—	·90	710	Atwater and Bryant.
Hind-quarter	70·90	20·70	8·30	—	1·00	735	
Loin	69·50	19·90	10·00	—	1·10	790	
Leg	71·70	20·70	6·70	—	1·10	670	
Leg cutlets	70·70	20·30	7·70	—	1·10	705	
Mutton: Very fat	47·91	14·80	36·39	—	·85	—	König.
Moderately fat	75·49	17·11	5·77	—	1·33	—	
,, ,,	75·00	15·00	8·40	—	1·60	—	Parkes.
Average, 138 analyses	53·10	16·20	30·70	—	1·03	1,592	
Edible portion—							
Chuck	48·20	14·60	36·80	—	·80	1,825	
Flank	42·70	14·30	42·60	—	·70	2,065	Atwater and Bryant.
Leg	63·20	18·70	17·50	—	1·00	1,085	
Loin	47·80	15·50	36·20	—	·80	1,815	
Neck	56·60	16·70	26·30	—	1·00	1,420	
Shoulder	60·20	17·50	21·80	—	·90	1,245	
Lamb: *Edible portion*—							
Average	56·30	18·30	24·60	—	1·00	1,382	
Fore-quarter	55·10	18·30	25·80	—	1·00	1,430	
Hind-quarter	60·90	19·60	19·10	—	1·00	1,170	
Breast	56·20	19·10	23·60	—	1·00	1,350	Hutchison.
Leg	58·60	18·60	22·60	—	1·00	1,300	
Loin	53·10	18·70	28·30	—	1·00	1,540	
Shoulder	51·80	18·10	29·70	—	1·00	1,590	
Pork: Very fat	39·00	9·80	48·90	—	2·30	—	Parkes.

Pork: Fat	47·30	14·54	37·34	—	—	—	König.
Lean	72·57	19·91	6·81	—	—	—	
Average, 96 analyses	48·30	14·80	35·40	—	·80	1,790	
Edible portion—							
Leg	50·10	15·70	33·40	—	·90	1,700	
Loin: Tenderloin	66·50	15·90	13·00	—	1·00	900	
Middle cut	48·20	15·70	36·30	—	·70	1,825	
Chops	50·70	16·40	32·20	—	·90	1,655	
Shoulder	51·20	13·30	34·20	—	·80	1,690	
Head	45·30	13·40	41·30	—	·70	1,990	
Head cheese	43·30	19·50	33·80	—	3·30	1,790	
Ham: *Edible portion*—							
Smoked: Lean	53·50	19·80	20·80	—	5·50	1,245	Atwater and Bryant.
Medium fat	40·30	16·30	38·80	—	4·80	1,940	
Fat	27·90	14·80	52·30	—	3·70	2,485	
Bacon: *Edible portion*—							
Shoulder	37·60	15·50	41·00	—	6·10	2,020	
Side	34·40	9·10	55·30	—	3·90	2,505	
Salt pork: Fat end	7·90	1·90	86·20	—	3·90	3,670	
Lean end	19·90	8·40	67·10	—	5·70	2,985	
Smoked: Average	20·20	10·50	64·80	—	5·10	2,930	
Lean	31·80	15·50	42·60	—	11·00	2,085	
Medium fat	18·80	9·90	67·40	—	4·40	3,030	
Average, fat bacon	15·00	8·80	73·30	—	2·90	—	Parkes.
Various organs: Blood	80·80	18·10	·20	—	·85	—	
Brain	80·60	8·80	9·30	—	1·10	555	
Heart, ox	62·60	16·00	20·40	—	1·00	1,160	
,, sheep	69·50	17·00	12·60	—	·90	845	
Kidney, ox	76·70	16·90	4·80	·4	1·20	520	
,, sheep	78·70	16·80	3·20	—	1·30	440	
Liver, ox	71·20	20·40	4·50	1·7	1·60	606	Atwater and Bryant.
,, sheep	61·20	23·10	9·00	5·0	1·70	905	
,, calf	73·00	19·00	5·30	—	1·30	575	
Lung, ox	79·70	16·10	3·20	—	1·00	440	
,, sheep	75·90	20·20	2·80	—	1·20	495	
Marrow, ox	3·30	2·20	92·80	—	1·30	3,955	
Sweetbreads	70·90	16·80	12·10	—	1·60	825	

THE COMPOSITION OF MEAT—*Continued.*

Substance.	Nutrients per Cent.					Calories per Pound.	Authority.
	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.		
RAW MEAT—*continued.*							
Various organs: Suet, ox	13·70	4·70	81·80	—	·30	3,540	Atwater and Bryant.
Suet, sheep-kidney	3·40	1·80	95·40	—	·10	4,060	
Tongue, ox	70·80	18·90	9·20	—	1·00	740	
,, ,, pickled	62·30	12·80	20·50	—	4·70	1,105	
Tripe	86·50	11·70	1·20	·20	·30	270	
Sausages: *Edible part*—							
Arles ,, ...	17·20	26·80	50·60	—	7·30	2,635	
Banquet ,, ...	62·70	18·30	15·70	—	3·70	1,005	
Bologna ,, ...	60·00	18·70	17·60	·30	3·70	1,095	
Farmer's ,, ...	23·20	29·00	42·00	—	7·60	2,310	
Frankfort ,, ...	57·20	19·60	18·60	1·10	3·40	1,170	
Holsteiner ,, ...	25·60	29·40	37·30	3·40	4·30	2,220	
Lyons, ham	32·50	32·30	27·20	—	8·00	1,750	
Pork: Minimum	25·70	7·30	28·20	—	1·00	1,485	
Maximum	54·40	19·00	56·80	8·60	2·70	2,635	
Average	39·80	13·00	44·20	1·10	2·20	2,125	
,, sausage-meat	46·20	17·40	32·50	—	3·40	1,695	
,, and beef	55·40	19·40	24·10	—	1·00	1,380	
Salmi (bird's flesh)	30·50	24·10	39·90	—	7·00	2,130	
Pork	54·99	12·28	21·04	1·05	2·52	—	Hutchison.
,, Cambridge	51·54	9·45	29·72	2·20	3·47	—	
Polony	45·57	17·26	32·66	2·30	2·80	—	
Mutton	55·58	1·89	30·51	3·90	2·50	—	
German	46·54	16·58	17·87	15·00	4·47	—	
Horsemeat: Average	69·81	19·47	9·61	1·82	1·01	—	Bull. 13, Bureau of Chemistry, U.S. Agricultural Dept.
Maximum	76·91	22·50	33·66	4·83	1·27	—	
Minimum	52·16	13·31	1·24	·62	·63	—	

Horsemeat: Ribs	65·90	20·56	13·79	2·38	·98	—	Bull. 13, Bureau of Chemistry, U.S. Agricultural Dept.
Chuck	67·10	15·88	14·20	·92	·65	—	
Plate	52·16	8·31	33·65	·78	1·06	—	
Brisket	62·25	14·75	18·16	1·47	1·16	—	
Flank	57·62	16·69	24·68	2·37	1·11	—	
Round	73·36	21·44	3·19	·62	1·04	—	
Cooked Meat.							
Beef: Roast—Average	48·20	22·30	28·60	—	1·30	2,580	Atwater and Bryant.
Minimum	38·70	15·10	19·60	—	·70	1,660	
Maximum	59·50	29·00	41·40	—	2·70	3,500	
Boiled	38·10	26·20	34·90	—	·90	2,805	
Pressed	44·10	23·60	27·70	—	1·50	1,610	
Steak	63·00	27·60	7·70	—	1·80	840	
,, sirloin	63·70	23·90	10·20	—	1·40	875	
,, tenderloin	54·80	23·50	20·40	—	1·20	1,300	
Canned boiled beef	51·80	25·50	22·50	—	1·30	1,425	
,, corned beef	51·80	26·30	18·70	—	4·00	1,280	
,, tongue	51·30	19·50	23·20	—	4·00	1,340	
Canned beef: New Zealand Co.	57·35	29·06	10·33	—	·99	—	Warden & Bose, *Chem. News*, 1890, i. 303.
Queensland Co.	49·05	26·25	22·08	—	1·71	—	
Armour Co.	50·60	24·93	18·66	—	4·36	—	
Fairbank Co.	56·03	24·56	15·82	—	1·94	—	
Veal	51·88	32·19	11·39	—	1·57	—	Tankard.
Cutlets	57·59	29·00	11·95	—	1·43	—	König.
Pork	44·90	32·63	19·67	—	1·86	—	Tankard.
Lamb: Roast leg	67·10	19·70	12·70	—	·80	900	Atwater and Bryant.
Miscellaneous	47·10	23·70	29·40	—	1·40	1,680	
Chops, broiled	47·60	21·70	29·90	—	1·30	1,665	
Mutton: Roast leg	50·90	25·90	22·60	—	1·20	1,420	
Corned	45·80	28·80	22·80	—	4·20	1,500	
Tongue, canned	47·60	24·40	24·00	—	4·80	1,465	
Canned: Sydney Co.	54·70	27·50	15·03	—	1·53	—	Warden & Bose.
New Zealand Co.	55·00	26·27	14·00	—	·62	—	
Queensland Co.	52·60	28·18	14·39	—	1·60	—	
Potted meat: Beef	32·81	17·17	44·63	3·30	2·03	salt	König.
Ham	25·57	16·88	50·88	—	6·78	5·72	
Tongue	41·52	14·46	32·85	·46	6·71	5·98	
Foie-gras	46·04	14·59	33·59	2·67	3·11	·22	

COMPOSITION OF CANNED MEAT.[1]

NUTRIENTS PER CENT.

Substance.			Nitrogenous Substances.							
	Water.	Nitrogen.	Protein (N × 6·25).	Insoluble (Coagulated).	Soluble.	Meat-Bases.	Fat.	Glycogen.	Ash.	Salt.
Fresh beef:										
Average	68·19	3·02	18·89	15·08	1·21	1·29	12·60	—	·96	·080
Maximum	71·17	3·19	19·94	15·75	1·50	1·65	15·33	·38	1·13	·240
Minimum	65·81	2·83	17·69	14·50	·87	1·02	9·89	—	·78	trace
Canned roast and boiled beef:										
Average of ten packing companies	58·89	4·15	25·95	19·29	3·59	1·58	13·99	·50	1·28	·530
Maximum	66·39	5·51	34·44	27·94	7·25	3·21	31·78	·70	3·51	2·510
Minimum	45·35	3·31	20·69	12·38	1·50	·62	5·89	·36	·65	·040
Canned corned beef:										
Average	56·35	4·26	26·63	22·37	2·02	1·11	11·43	·25	4·69	3·370
Maximum	60·10	4·89	30·56	27·06	3·31	1·47	22·69	·42	7·39	4·680
Minimum	46·94	3·72	23·25	18·81	1·25	·62	6·33	·11	3·57	2·560
Canned dried & smoked beef:										
Average	47·42	5·21	32·59	26·41	·92	2·63	7·46	·36	12·51	9·670
Maximum	59·58	6·49	40·56	30·69	2·31	4·02	12·37	·54	17·30	11·330
Minimum	39·22	4·00	25·00	20·62	·38	1·59	4·59	·25	9·58	7·150
Horsemeat:										
Average	69·81	3·11	19·47	14·83	1·23	1·70	9·61	1·82	1·01	·009
Maximum	76·91	3·60	22·50	18·56	2·25	3·81	33·66	4·33	1·27	·090
Minimum	52·16	2·13	13·31	8·31	·75	·47	1·24	·62	·63	trace

Horsemeat and beef, equal parts	66·38	3·84	24·00	21·94	·44	·81	7·76	·39	1·38	·050
Horsemeat, two parts, and beef, one part	67·91	3·44	21·50	17·94	·81	1·37	8·54	·33	1·01	trace
Horsemeat and pork, equal parts	59·64	2·75	17·19	12·44	1·31	1·72	21·80	·32	·92	trace
Horsemeat, two parts, and pork, one part	65·24	2·18	13·63	11·31	·50	·90	20·00	·30	·71	trace
Horsemeat, beef, and pork, equal parts	62·38	2·73	17·06	15·59	·75	·31	18·09	·31	1·05	trace
Canned ox-tongue :										
Average	55·17	3·11	19·43	15·64	1·33	1·23	20·23	·24	3·71	2·900
Maximum	71·80	3·95	24·69	20·00	3·00	2·25	38·09	·36	6·22	4·420
Minimum	39·58	2·09	13·06	11·00	·12	·22	6·84	·12	·78	·370
Canned calf-tongue ..	68·83	2·86	17·88	14·88	·38	1·31	7·89	—	2·12	—
Canned lamb-tongue ..	63·41	2·21	13·81	12·19	1·19	·22	17·76	·36	1·04	·370
Potted beef :										
Minimum	28·24	2·87	17·94	12·88	·50	1·31	10·26	starch 14·26	2·30	1·300
Maximum	65·51	3·76	23·50	19·50	1·94	2·00	43·89	11·56	4·51	2·430
Potted ham :										
Average	48·26	2·23	16·90	13·68	1·61	·79	28·12	—	3·64	—
Maximum	66·19	3·08	22·13	19·25	3·50	1·50	43·95	—	5·71	4·100
Minimum	33·84	1·74	14·19	10·88	·31	·09	9·52	—	2·25	·250
Potted tongue : Average ..	52·50	2·85	17·80	14·07	2·23	·75	22·99	—	5·46	—
Potted tongue and ham ..	55·71	2·27	14·19	9·44	2·62	1·06	16·27	10·86	3·55	·650
Potted veal and ham ..	48·91	2·55	15·94	11·75	·94	1·62	20·59	10·98	4·58	3·480
Devilled tongue	50·17	3·07	19·19	15·38	2·62	·59	25·12	4·93	3·88	—
Devilled ham	41·32	2·90	18·13	15·69	·81	·81	33·96	—	5·53	4·410
Veal and ham pâté ..	55·63	—	—	—	—	—	20·15	1·10	—	—

[1] Bulletin 13, Bureau of Chemistry, U.S. Department of Agriculture.

The sarcolemma, or stroma-substance, deserves further mention. It consists of **elastin,** a sclero-protein. The proportion in muscle fibre of mammals varies from 7 to 16 per cent., according to the age of the animal. This proportion is of considerable importance by determining the digestibility, as well as the tenderness or otherwise, of the flesh. In the muscular tissue of young animals it is thin and delicate, but it becomes thicker and harder as age advances.

The **extractives** are (1) nitrogenous and (2) non-nitrogenous.

1. The nitrogenous extractives, or **meat-bases,** are creatin, xanthin, hypoxanthin, guanine, carnine, phosphocarnic acid, inosinic acid, and sometimes leucomaines. Kaufmann considers urea to be a constant constituent of the muscular tissue of all the higher animals, but other authorities dispute this opinion. The proportion of meat-bases in flesh, and the quantity of purin bodies alone in flesh, are given in the table on p. 121.

The *leucomaines* in fresh muscular tissue exist only in small quantities, but, according to Gautier,[1] their presence is undesirable. The principal are as follows:

Xantho-creatinin, $C_5H_{10}N_4O$.
Crusco-creatinin, $C_5H_8N_4O$.
Amphi-creatinin, $C_9H_{19}N_7O_4$.
Pseudo-creatinin, $C_4H_5N_5O$.

The proportion of leucomaines is liable to increase during "hanging," owing to the action of bacteria; at the same time ptomaines may be produced. Gautier and Brown draw this distinction between them: Leucomaines are vital alkaloids formed during life; ptomaines are cadaveric alkaloids produced after death.

The presence of extractives gives the characteristic taste and flavour to the meat; indeed, the flavour depends upon small variations in the proportion of these substances. When they are removed by boiling the meat is flavourless. The flesh of full-grown animals has more flavour than that of immature ones, and this corresponds to an increase in the proportion of the extractives. But feeding also influences the flavour: thus, the mutton fed on thymy heaths has a flavour which is unsurpassed; the flesh of wild rabbits, from their eating aromatic vegetables, is far better flavoured than that of tame rabbits; wild birds are always more highly flavoured than tame ones, and sea-birds have a flavour of fish.

2. The non-nitrogenous extractives are inositol (inosite), sugar, lactic acid, and glycogen. Inositol is said to be always present; glycogen is always present in living muscle, but may be absent from dead meat. The sugar is small in amount, but some is always present in the form of dextrose and maltose; and a little dextrin is obtainable.[2] Sarcolactic acid is always present in a variable proportion. Its influence in rendering the meat more tender by softening the stroma substance and connective tissues has been alluded to.

[1] Maly's *Jahres-Ber.*, xvi. 523.
[2] Osborne and Zobel, *Journal of Physiology*, xxix.

TABLE SHOWING THE PROPORTION OF MEAT-BASES AND THE QUANTITY OF PURIN BODIES IN FLESH.

(*a*) Meat Bases: Per Cent.[1]

Description of Meat.	Maximum.	Minimum.	Average.
Beef: Raw	1·65	1·02	1·29
Roast or boiled	3·21	·62	1·58
Corned	1·47	·62	1·11
Smoked	4·02	1·59	2·63
Horsemeat	3·81	·47	1·70
Ham and bacon	4·31	·16	1·67
Tongue	2·25	·22	1·23
Chicken: White meat	1·44		
Dark meat	·90		
Turkey: White meat	1·31		
Dark meat	·78		
Duck: Pekin	·43		
Mallard	·65		
Goose	1·37		
Potted beef	2·00	1·31	—
,, chicken	1·81	·40	—
,, turkey	1·40	·50	—
,, tongue	2·15	—	·75
Sausage	1·31	·12	·67

(*b*) Purin Bodies in Meat.[2]

Substance.	Per Cent.	Grammes per Kilo.	Grains per Pound.
Beefsteak	·206	2·06	14·45
Beef: Sirloin	·130	1·30	9·13
Ribs	·113	1·13	7·96
Veal, loin	·116	1·16	8·14
Mutton	·096	·96	6·75
Pork: Loin	·121	1·21	8·49
Neck	·056	·56	3·97
Fat ham	·115	1·15	8·08
Liver	·275	2·75	19·26
Sweetbread	1·006	10·06	70·43
Tripe	·057	·57	4·00
Rabbit	·097	·97	6·31
Turkey	·126	1·26	8·82
Chicken	·129	1·29	9·06
Codfish	·058	·58	4·07
Plaice	·079	·79	5·56
Halibut	·102	1·02	7·14

[1] Bulletin 13, Bureau of Chemistry, U.S. Department of Agriculture.

[2] *British Medical Journal*, 1902, i. 1461.

The **mineral substances** average 10 per 1,000; the largest proportion consists of potassium and phosphoric acid, next sodium and magnesium; least are calcium, oxide of iron, and chlorine.

Composition of Lean Meat (Muscle).—Hammarsten gives the following as representing the composition of mammalian muscular tissue: 1,000 parts contain water 745 to 783; solids 217 to 255, including organic substances 208 to 245, and inorganic 9 to 10; the myosin varies from 35 to 106, stroma or sarcolemma 78 to 161, creatin 2, xanthin or purin bodies 1·3 to 1·7, inosinic acid 0·1, inosite 0·03, glycogen 4 to 37, lactic acid 0·4 to 0·7, phosphoric 3·4 to 4·8, potash 3·0 to 4·8, soda 0·3, lime 0·2, magnesia 0·4, sodium chloride 0·04 to 0·1, iron oxide 0·04 to 0·1, per 1,000. The average percentage of nitrogen in lean meat, according to Voit, is 3·4. Lean beef, when freed from fat and dried *in vacuo*, after deducting the glycogen, was found by Kohler to consist of C 49·86, H 6·78, N 15·68, O 1·0, S 22·3, per cent., and by Argutinsky, C 49·6, H 6·9, N 15·3, O 1·0, S 23·0, per cent. It has a fuel value equal to 5·59 to 5·67 calories per gramme.

2. The Fatty Tissue.—The average composition of meat fat is as follows:[1]

	Parts per Thousand.		
	Water.	Membrane or Connective Tissue.	Fat.
Oxen	99·7	16·6	883·7
Sheep	104·8	16·4	878·8
Pigs	64·4	13·6	922·0

Fat consists of a slight framework of gelatinogenous connective tissue, with blood and lymph vessels, enclosing in its meshes the large fat cells. The membrane of these cells is a substance related to *elastin*; it withstands the action of alcohol and ether, and is not soluble in acetic acid or dilute mineral acid, but is dissolved by the gastric juice. The cells contain the nucleus and protoplasm, which, however, have been pushed aside by the increasing fat globules. The fat consists of the triglycerides of stearic, palmitic, and oleic acids. There are also glycerides of other fatty acids in the less solid fats, and a small amount of free, non-volatile fatty acids. Fat cells also contain a yellow pigment, *lipochrome*, and the subcutaneous tissues of emaciated animals may have a dark orange tint from the persistence of such colouring matter after the disappearance of the fat. The consistence of fatty tissue varies. The fat of domestic animals is less oily than that of wild animals of the same species; and the fat of connective tissues—*e.g.*, subcu-

[1] Schultze and Reineske, *Annal. d. Chem. und Pharm.*, cxlii.

taneous fat—is richer in olein, and therefore softer than that around the internal organs. The internal fat of the abdomen of oxen and sheep is called **suet**; it is a firm, white, smooth, odourless substance, and contains more stearin than fat of the subcutaneous or muscular tissues.

COMPOSITION OF SUET.[1]

	Water.	Protein (Membrane).	Fat.
	Per Cent.	Per Cent.	Per Cent.
Beef suet	13·7	4·7	81·8
Sheep (kidney fat)	3·4	1·8	95·4

Marrow is a very soft rich fat, especially that of the long bones; it contains 92·8 per cent. of fat, 2·2 per cent. of protein, and 3·3 per cent. of water.

There is always a certain amount of *lipoids*—cholesterin and lecithin—in animal tissues; the amount in pork appears to be noteworthy, as fifty-six samples yielded 0·18 to 0·51 per cent.

When fat is burnt, some of the glycerine loses water, and becomes transformed to acrolein: $C_3H_5.(OH)_3 - 2H_2O = C_3H_4O$. This is the substance which produces the disagreeable odour in burnt milk, fried fat, etc. The adjoining table (p. 124) shows the physical characters of various fats of animal origin.

3. THE CONNECTIVE TISSUE—GELATIN.—The connective tissue of mammalian flesh consists of cells, fibrils, and intercellular substances. A few only of the fibres yield elastin and reticulin; the principal are connective-tissue fibrils, which consist chiefly of **collagen,** a substance which is transformed by boiling into gelatin. According to Chittenden, the following is the chemical composition of **gelatin**: C 49·38, H 6·8, N 17·98, S 0·7, O 25·13, per cent. By digestion gelatin is transformed into gelatin-proteoses and gelatin-peptones, which diffuse more or less readily. Gelatin consists chiefly of **glutin,** and by hydrolytic cleavage it yields glycocoll, prolin, arginin, lysin, leucin, glutaminic acid, ammonia, etc. Gelatin and gelatin-producers do not seem to be converted into proteins in the animal body, being deficient in some particulars, but they are *protein-sparers* in a degree which is even greater than that of fat or carbohydrate, for they are decomposed instead of the circulating proteins. It is not a true proteid; it can only save half its weight of protein from destruction. Its use therefore is limited, although its effects in this respect should not be despised in cases of fever and other illnesses where rapid destruction of the tissues is advancing. An ordinary jelly contains about 2 per cent. of gelatin. Hutchison[2] says: "**A quart of jelly** would only be able

[1] Bulletin 28, U.S. Department of Agriculture.
[2] "Food and Dietetics," p. 76.

PHYSICAL CHARACTER OF ANIMAL FATS.[1]

Description.	Colour.	Specific Gravity at 15° C.	Butyro-Refracto-meter.	Index of Refraction at 35° C.	Melting-Point.	Chilling-Point.	Iodine Number.	Koetts Torfer's Number.	Soluble Acids.	Insoluble Acids.	Heat with H_2SO_4.
			Degrees.		Degrees.	Degrees.					Degrees.
Beef, roast or boiled : Average ..	Whitish-yellow to orange	·8589	52·8	1·461	40·10	32·2	45·6	194·8	·45	93·54	35·8
Maximum ..		·8679	55·5	1·462	43·90	37·0	50·6	200·0	·74	95·27	36·0
Minimum ..		·8563	47·0	1·457	36·50	27·8	36·1	188·0	·22	91·90	35·6
Canned and corned : Average ..	Light yellow to brown	·8572	53·9	1·461	40·14	31·0	42·7	196·3	·60	92·87	36·2
Maximum ..		·8581	56·0	1·463	43·40	34·5	48·6	210·0	1·62	94·50	37·0
Minimum ..		·8563	52·7	1·460	37·20	29·0	37·9	191·0	·09	89·51	35·5
Horsemeat : Average	Brown to dark orange or black	·8699	62·3	1·467	29·70	17·2	66·4	201·0	1·32	91·37	49·9
Maximum		·8811	76·5	1·476	32·50	25·0	77·0	205·0	2·76	95·44	56·5
Minimum		·8508	55·2	1·462	27·20	12·0	61·4	196·0	·19	88·18	46·2
Horse and beef, equal parts	Brown	·8540	54·1	1·462	37·00	28·0	49·7	200·0	1·44	92·80	43·2
Horse two parts, pork one part ..	Orange	·8558	55·1	1·462	38·70	27·5	55·9	196·0	·44	94·39	42·0
Ham or bacon, canned : Average ..	Lemon yellow to brown or orange	·8533	53·4	1·461	27·70	20·3	57·8	193·0	·98	90·80	41·4
Maximum ..		·8698	58·2	1·464	30·50	24·0	68·2	207·0	2·63	94·51	43·5
Minimum ..		·8260	49·0	1·458	23·60	17·5	48·5	179·0	·19	86·40	39·8
Ox-tongue, canned : Average ..	Yellow to orange	·8565	54·0	1·462	35·80	26·7	48·7	193·0	·97	90·91	37·8
Potted beef : Average	Do.	·8634	55·3	1·463	37·40	28·2	47·8	188·0	·28	91·28	—
Chicken, roast	Orange	·8556	54·6	1·462	32·50	—	68·1	199·0	·60	96·03	42·8
Turkey, light meat	Black to greenish-yellow	·8490	54·0	1·461	32·80	—	67·0	—	—	—	45·5
,, dark meat		·8670	58·1	1·464	33·10	16·0	86·4	199·0	·36	95·50	52·0
Duck	Orange	·8560	53·1	1·461	31·00	17·5	74·5	196·0	·15	95·39	48·0
Mallard	Do.	·8698	49·0	1·459	34·00	12·0	80·2	—	—	—	—
Goose	Do.	·8553	54·0	1·461	29·00	15·0	74·5	190·0	·46	90·83	51·5

[1] Bulletin 13, Part X., Bureau of Chemistry, U.S. Department of Agriculture.

to spare the proteid of 2½ ounces of meat; and assuming that 25 grammes of gelatin were contained in this diet, this would only effect a saving of 35 grammes (1¼ ounces) of meat and 40 grammes (1½ ounces) of bread. One can realize from this that the usefulness of gelatin as a proteid-sparer in fevers and diabetes is of limited range." The heat value of gelatin is equivalent to 3·88 calories per gramme.

The intercellular substance of connective tissues consists of **mucoid** and a small proportion of serum globulin and serum albumin. Young tissues contain more than old ones. Mucoid is not true mucin, but a mixture of several gluco-proteins; it contains 2 or 3 per cent. of sulphur. The composition of connective tissue is best obtained by the analysis of large masses.

Composition of Connective Tissue.

	Components per Thousand.	
	White Tissue (Achilles Tendon).	Yellow Tissue (Lig. Nuchæ).
Water	628·70	575·50
Collagen	315·88	72·30
Elastin	16·33	316·70
Mucoid	12·83	5·50
Protein	2·20	6·16
Fat	10·70	11·20
Extractives	8·86	7·99
Mineral substances	4·70	4·70

The Manufacture of Gelatin.—Gelatin is manufactured from all nitrogenous waste materials or refuse—bones, connective tissues, skins (hides), hoofs, intestines, and even fish-bones, etc. The bones are crushed and boiled with a mineral acid to remove the inorganic salts. They are then digested, along with the softer materials about to be used, in a solution of caustic soda or lime for fourteen to twenty-one days to dissolve out the fat. Excess of lime or soda is afterwards removed by washing. The material is then transferred to an air-tight, cement-lined digester or vat, where the material is steamed to convert the collagen to gelatin. The liquid is removed in a revolving cylinder, strained at 100° to 120° F., and bleached by sulphurous acid. It is then solidified in layers, being afterwards redissolved, washed free from acids, bleached if necessary by charcoal, and dried at a low temperature in sheets, or on nets, or *in vacuo*. When prepared under proper sanitary conditions, gelatin forms a useful article of food for making jellies, etc. It should be free from impurities; the presence of any quantity of mineral acids or sulphites would render it unfit for human food. There is little danger of properly-prepared gelatin containing micro-organisms, but such organisms have been found, including that of tetanus.

COMPOSITION OF GELATIN.[1]

	Nutrients per Cent.					Calories per Pound.
	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.	
Gelatin	13·6	91·4	0·1	—	2·1	1,705
Isinglass	19·0	89·3	1·6	—	2·0	1,730
Calf's-foot jelly ..	77·6	4·3	—	17·4	0·7	405

Gelatin dissolved in water in the proportion of 1 per cent. will set into a jelly ; but ordinary jelly usually contains 2 per cent., with some sugar, upon which its nutritive qualities largely depend. Jellies are readily digested, complete peptonization occurring in one hour. Jelly stimulates a flow of gastric juice, but at the same time fixes a good deal of acid ; it is therefore a useful food in cases of hyperacidity. We have already seen that, owing to certain deficiencies, it is not a tissue-former, but possesses the property of sparing the protein-tissues from destruction in a marked degree. *Isinglass* is considered in another chapter.

4. CARTILAGE.—The gristle of meat consists of cartilage cells with a hyaline matrix which is sometimes largely replaced by white fibrous or elastic tissue. The matrix consists of collagen, chondro-mucoid, chondroitin-sulphuric acid, and other albuminoid materials. The albuminoid is small in amount, and is a nitrogenous body loosely combined with sulphur. The chondro-mucoid is a gluco-protein, which is decomposed by dilute alkalies, and yields alkali albumin, peptone substances, chondroitin-sulphuric acid, and alkali sulphates. It contains 2·4 per cent. of sulphur. Chondroitin-sulphuric acid is one of the ethereal sulphuric acids ($C_{18}H_{27}NSO_{17}$). The collagen of cartilage yields a gelatin which differs from the ordinary kind by containing only 16·4 per cent. of nitrogen.

5. BONE has the following composition : Water 5 to 50, gelatiniferous substance 15 to 50, fat 0·5 to 20, ash 20 to 70, per cent. It consists of cells, matrix, nerves, bloodvessels, and a large amount of mineral matter. The *cells* contain no keratin, and do not yield gelatin on boiling. The *matrix* consists of organic and inorganic materials. The organic substance is **ossein** (identical with collagen), a little mucoid and an albuminoid, and yields gelatin on boiling. The *inorganic* substance, bone-earth, is nearly the same both as regards proportion and composition in all animals. It is that which remains after complete incineration. The bone-ash of the ox[2] has the following parts per 1,000 : Calcium phosphate, 877·2 ; magnesium phosphate, 15·3 ; calcium fluoride, 4·5 ; calcium chloride, 3·0 ; calcium carbonate, 119·6 ; iron oxide, 1·3.

The nutriment from bone consists of the fat from the marrow, albuminous substances from marrow and other cells, and gelatin,

[1] Bulletin 28, U.S. Department of Agriculture.
[2] Carnot, *Compt. Rend.*, cxiv.

amounting in all to 35 per cent. Bones require long boiling in order to obtain all this material, and it is better that they should be broken into small pieces, so as to present as many surfaces as possible to the water. According to Smith, 3 pounds of bone, when treated in a Papin's digester, will yield as much nitrogen as 7 pounds of meat; but this is chiefly in the form of gelatin, which we have seen is a valuable protein-sparer, but is not a flesh-forming food.

The Composition of Organs.

Tripe consists of the stomach and intestines of the ox, properly cleaned and boiled. Its average composition is—Protein, 16·8; fat, 8·5; and ash, 0·5 per cent. It consists largely of the involuntary muscular fibres, etc., of the viscera. The chief protein is a globulin similar to, but not identical with, myosin; it also contains a small amount of albumin, which coagulates spontaneously, but is not pure paramyosinogen. The connective tissue is mostly transformed into gelatin by boiling. It contains five times as much nucleo-protein as striated muscle; it also contains a small amount of creatin, creatinin, glycogen, sarcolactic acid, and mineral substances, in which sodium exceeds potassium. A large proportion of these soluble substances are removed by the care required in its preparation as human food; the corresponding deficiency in extractives renders it somewhat flavourless, but nevertheless a suitable food in cases where purins are not wanted. It is very easily digested.

Liver is a very nutritious food.

Average Composition of Liver.

	Nutrients per Cent.				
	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.
Ox liver	71·2	20·4	4·5	1·7	1·6
Calf liver	73·0	19·0	5·3	—	1·3
Sheep liver	61·2	23·1	9·0	5·0	1·7
Pig liver	71·4	21·3	4·5	1·4	1·4
Chicken liver	69·3	22·4	4·2	2·4	1·7
Goose liver	62·6	16·6	15·9	3·7	1·2
Turkey liver	69·6	22·9	5·2	0·6	1·7

The proteins of liver consist mostly of ferruginous nucleo-proteins, which yield nuclein on digestion, and are a source of uric acid in the system. When liver is boiled in water, a liquid is obtained containing nucleo-proteins which are rich in nucleic acids. The protein obtained in this manner has been called **ferratin**; when hydrolyzed by mineral acids, it yields nuclein bases and a pentose (xylose). There is also in the liver a small proportion of other proteins—

e.g., an albuminous substance which coagulates at 45° C.; a globulin which coagulates at 75° C.; a nucleo-albumin which coagulates at 70° C.; and another protein belonging to the class of coagulated albumins.[1]

(*a*) The *nitrogenous extractives* of liver are important. According to Kossel,[2] 1,000 parts of dried liver contain 1·97 parts of guanine, 1·34 hypoxanthin, 1·21 xanthin, a little adenine and uric acid, besides urea, leucin, cystin, and sometimes tyrosin. Walker Hall estimates the amount of these purin bodies in fresh liver as 0·275 per cent., or 2·75 grammes per kilo, or 19·26 grains per pound. This amount is very high when compared with that in lean beef, mutton, or chicken.

(*b*) The *non-nitrogenous extractives* are glycogen, paralactic acid, and sometimes inosite. The amount of glycogen varies from 0·5 to 5·0 per cent. If the animal is in a poor or emaciated condition, the glycogen may entirely disappear, but in well-fed animals it ordinarily varies from 12 to 40 per 1,000; and if the animal is killed after resting *and feeding*, it may rise to 120, or even 160, per 1,000. The custom of resting and fasting the animal before killing it prevails, and tends to reduce the proportion of glycogen. It is not known whether any portion of the glycogen is combined with a protein, but Seegen found in the liver a nitrogenous carbohydrate which he regarded as an intermediate in the production of carbohydrate from protein.

Fat occurs in the liver as small globules, and sometimes large drops, in the cellular protoplasm. The amount varies from 4 to 15 per cent. in different animals and in the same animal, according to its condition. It is increased by an excess of fat in the food, by fatty infiltration, and by the transportation of fat from other parts of the body. As a rule, a liver rich in fat is relatively poor in glycogen. **Lecithin** occurs normally in the liver to the extent of 2·35 per cent. Cholesterin and jecorin (a protagon-like body) occur in small quantities. The latter contains both sulphur and phosphorus; its exact constitution is unknown, but it contains a carbohydrate complex in its molecule.

Among the **minerals** of the liver, iron is a regular constituent, and varies from 0·01 to 0·355 per 1,000. The greatest proportion of iron occurs in the liver of young animals; it exists partly in the form of a phosphate, and partly as a ferruginous protein (*vide supra*). The liver also contains calcium, which in oxen amounts to 0·71 to 1·23 parts per 1,000 of the dried substance, besides salts of sodium, potassium, the alkaline earths, phosphoric acid, and chlorine.

Owing to the compactness of its substance, liver is an unsuitable food for persons whose digestion is feeble or whose stomach is tender; the large amount of nucleo-protein and purin bodies makes it unsuitable for the gouty.

[1] Hammarsten's "Physiological Chemistry."
[2] *Zeit. f. Physiol. Chem.*, viii.

The Lungs.—It is presumed that the lungs of animals are not regularly used for human food, but that they are sometimes consumed is a well-known fact. The composition of ox lungs is—Water, 79·7 ; protein, 16·4 ; fat, 3·2 ; and ash, 1·0—per cent. The nitrogenous bodies include elastic, muscular, and connective tissues ; besides fatty bodies, some glycogen or reducing substance, and probably cellulose. According to Robin, the salts are iron, 0·233 ; chlorine, 1·198 ; phosphoric acid, 1·358 ; magnesium, 0·076 ; potassium, 0·741 ; and sodium, 1·213—per 1,000.

The Kidneys, like liver, are indigestible, chiefly by reason of the closeness of their texture. According to Atwater, the average percentage composition is as follows :

Composition of Kidneys.

	Nutrients per Cent.				
	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.
Ox kidneys	76·17	16·6	4·8	0·4	1·2
Calf kidneys	75·80	16·9	6·4	—	1·3
Sheep kidneys	78·70	16·5	3·2	—	1·3

The proteins[1] are—Albumin, 1·11 to 1·39 ; globulins, 8·6 to 9·25 ; other proteins, 1·43 to 1·59, gelatin ; 0·99 to 1·84—per cent.

The proteins, according to Halliburton, consist of a globulin and a nucleo-protein, but *no albumin*. But Liebermann[2] recorded the discovery of a *lecith-albumin—i.e.*, a compound of lecithin and albumin—and Lownberg, a mucin-like substance, or muco-protein, and traces of chondroitin-sulphuric acid. The nucleo-protein yields purin bases on digestion.

The nitrogenous extractives or meat-bases are urea, uric acid, creatin, creatinin, xanthin bodies or purin bases, cystin (in ox kidney), leucin, and tyrosin. The non-nitrogenous extractives are glycogen and traces of inosite.

The **suprarenal bodies** are usually torn off the kidneys when preparing them for food, and therefore are of little interest here. They contain the same kind of proteins as ordinary connective tissue, some salts, and inosite ; and a considerable amount of lecithin, glycero-phosphoric acid, neurin, xanthin and other purin bases, besides adrenalin and chromogen. A point of interest attaches to the fact that the injection of watery extract of suprarenal capsule into an animal is followed by glycosuria.

The Spleen, commonly known as the " milt," is not eaten as meat, but is used for making gravy, soups, etc. It is therefore of considerable importance that its composition be known : Water, 69 to 77 ; organic matters, 22 to 32 ; inorganic matters, 0·9 to 1·3—per cent. It contains a large amount of nucleins, owing to its richness in cells, and a large amount of extractives. The proteins, like those of the liver, are ferruginous. It also contains neutral fats, cholesterin, jecorin, inosite, and glycogen. The extractives are chiefly xanthin bodies or purin bases, which Walker Hall

[1] Gottwalt, *Zeit. Physiol. Chem.*, iv. 431.
[2] *Pflüger's Archiv*, 50 and 54.

found in fresh calf's spleen to be 0·16 per cent., and consisted of uric acid, xanthin, hypoxanthin, and leucin. The spleen also contains paralactic, glycero-phosphoric, succinic, formic, acetic, butyric, and phosphoric acids, with chlorine, iron, sodium, and potassium. After autolysis of the spleen, the following amino-acids are found: arginin, lysin, histidin, leucin, amino-valerianic acid, aspartic acid; also tryptophan, proteoses, peptones, etc. (Hammarsten). The dried *water-free* spleen has been found to contain as much as 5 per cent. of iron;[1] it is present in organic combinations, mostly as hæmoglobin.

The Sweetbread.—According to Atwater, ox sweetbread has the following composition: Water 70·9, protein (N × 6·25) 16·8, fat 12·1, and ash 1·6, per cent. This requires some explanation, which may perhaps be best given by a reference to the two kinds of sweetbread. The organ commonly sold by the butcher for sweetbread is the thymus gland, the pancreas being distinguished from it as the "belly sweetbread."

The *thymus gland*, or "sweetbread," consists of a mass of cells held together by loose connective tissue. It is therefore very rich in nuclein or nucleo-protein, but is correspondingly poor in albumin and globulin. The principal substance is *nucleo-histon*, which forms 70 per cent. of the water-free substance; it splits on digestion or hydrolysis with hydrochloric acid into leuco-nuclein and histon. The former is a true nucleo-protein—that is, a compound of nucleic acid and a protein rich in phosphorus. When a sweetbread has been kept a very little while some autolysis occurs, and the pyrimidine bases—uracil and thymin—are produced. The fresh organ, however, contains some fat, lecithin, cholesterin, and glycogen, with smaller quantities of leucin, lactic acid, succinic acid, traces of arsenic, and iodothyrin. The ash includes potassium and other bases, the phosphates predominating. Lilienfield gives the following composition in parts per 1,000: Proteids, 17·6; leuco-nuclein, 687·9; histon, 86·7; lecithin, 7·51; fat, 40·2; cholesterin, 44·0; glycogen, 8·0; phosphates, etc.

The *pancreas*, or "belly sweetbread," has a very similar composition—*i.e.*, a very small porportion of albumin and globulin, and a very large proportion of nucleo-protein, besides a variable quantity of purin bases, leucin, tyrosin, inosite, lactic acid, some fat, volatile fatty acids, and salts, including calcium and magnesium. The nucleo-proteins are very important; according to Hammarsten, one of these is the mother-substance of guanylic acid, and yields this substance, besides proteoses and peptones, on digestion; another is the mother-substance of thymo-nucleic acid. Both these nucleic acids are transformed into purin bases. The purin bases obtained from sweetbread, according to Walker Hall, amount to 10 grammes per kilo, or 70 grains per pound. They exceed the amount in any other food, and include nuclein, xanthin, hypoxanthin, guanin, and adenin.

[1] Nasse; *cf.* Hoppe-Seyler, "Physiological Chemistry," p. 720.

The cellular nature of both sweetbreads, together with the laxity of the stroma or connective tissue, renders them about the most easily and quickly digested of animal foods ; 9 ounces were digested in two and three-quarter hours, whereas the same weight of beef-steak required four and a half hours. Sweetbread is considered a delicacy by many people, but it is not a suitable food for the gouty and other persons to whom the excretion of purin bodies is a matter of importance.

The Thyroid Gland.—Although the thymus is considered a delicacy and even a *bonne bouche* by connoisseurs, the thyroid is not a regular article of food, and stands out of count. Nevertheless, a work on the dietetic treatment of disease might be esteemed incomplete without some mention of this organ. Although the fresh gland is sometimes prescribed in the treatment of obesity, myxœdema, acromegaly, psoriasis, and other skin affections, it is rather to works of therapeutics than dietetics that one should be referred for an account of its action. The chief protein substances in the gland are iodo-thyreo-globulin and a nucleo-protein. Iodine is normally combined with the globulin, and arsenic with the nucleo-protein. The gland also contains **iodo-thyrin,** leucin, xanthin, hypoxanthin, lactic and succinic acids. The therapeutic virtues of the gland are referred by some authorities to the iodo-thyrin, and by others to the iodo-thyreo-globulin. It has been ascertained that the gland has an influence upon various metabolic functions and upon growth, which will be referred to later on.

The Brain.—The composition is given by Atwater as follows :

	Nutrients per Cent.			
	Water.	Protein.	Fat.	Ash.
Ox brain	80·6	8·8	9·3	1·1
Pig brain	75·8	11·7	10·3	1·6

The substances which make up the complex material of the brain are various, and of great importance when this organ is regarded as a foodstuff. Hammarsten gives the following composition in parts per 1,000 :

COMPOSITION OF BRAIN.

Water	732·66
Solids	267·34
Proteins : Protagon	17·96
Insoluble proteins and connective tissue ..	55·40
Nuclein	2·47
Neuro-keratin	14·68
Fats : Cholesterin	34·48
Lecithin and other phosphorized bodies ..	136·92
Extractives	—
Mineral substances	2·95 to 7·08

The proteins include albumin, globulin, nucleo-albumin (phospho-protein), and nucleo-protein, besides lecith-albumins or compounds of lecithin, albumin, and phospho-protein. The nucleo-proteins yield adenin and guanin. The nuclein predominates in the grey

substance, the neuro-keratin in neuroglia. Lecithin occurs in both the grey and white substance, alone or combined with albumin or fatty acids. Cholesterin is most abundant in the white substance, and exists alone or combined. The fatty acids are combined with lecithin, cholesterin, and protagon.

Protagon is a most important constituent, chiefly of the white substance. There are several protagons. They are nitrogenous substances having the following approximate composition: C, 66·39; H, 10·69; N, 2·39; P, 1·068; O, 19·46 (and sulphur, according to some authorities). Upon decomposition they yield cerebrin, lecithin, fatty acids, glycero-phosphoric acid, cholin, and (?) neurin.

The extractives are creatin, uric acid, and other xanthin bodies, inosite, lactic acid, neuridin, and jecorin. The mineral substances are 2·95 to 7·08 per 1,000, and consist of chlorides, sulphates, carbonates, and phosphates, of iron, lime, potash, soda, and magnesia.

It might be supposed that brain is a very proper food for persons whose occupation is chiefly mental or intellectual, but observations do not bear out this supposition. Brain rapidly becomes disintegrated in the stomach, owing to the small proportion of connective tissue. But an examination of the fæces shows that it is not readily absorbed; it is, in fact, absorbed less completely than any other organ. Voit[1] found that, when 100 grammes of liver was consumed, 5 grammes was recoverable from the fæces; from the same amount of lung, only 8 grammes, of thymus 7, and of brain 43 grammes was recoverable from the fæces. Bergeat[2] says likewise that *the unabsorbed nitrogen* of these foods is as follows: Meat 2·1, thymus 3·2, liver 3·3, lung 4·2, and brain 13·9, per cent. It cannot be said, therefore, that brain is a food specially suited for persons whose occupation is chiefly mental, nor that it is of any greater value for invalids and convalescents than any other easily digested food.

Tongue.—The tongues of oxen, sheep, and swine, are used as food, and a large number are canned or sold as potted meat. Tongue consists largely of muscular fibres, which, however, are fairly free from connective tissue, and are therefore easily digested.

Composition of Tongue (Atwater).

	Nutrients per Cent.			
	Water.	Protein.	Fat.	Ash.
Ox tongue, fresh: Minimum	63·5	17·0	0·8	0·9
Maximum	76·2	22·2	18·0	1·1
Average	70·8	18·9	9·0	1·0
Pickled: Average	62·8	12·8	20·5	4·7
Canned: Average	51·3	19·5	23·2	4·0
Potted (ground)	49·9	21·4	25·1	4·0
Sheep tongue, canned	47·6	24·4	24·0	4·8
Lamb tongue, spiced	67·4	13·9	17·8	0·5

[1] *Zeit. f. Biol.*, 1889, xxv. 332.

[2] *Ibid.*, 1888, xxiv. 120.

Tongue contains 1·23 per cent. of meat-bases, 0·24 per cent. of glycogen, and the ash of pickled or canned tongue includes 3 or 3·5 per cent. of salt. Potted tongue has about the same composition as canned tongue, but is liable to be adulterated with farinaceous materials, as much as 11 per cent. of starch having been observed. The preservatives used are common salt, saltpetre, and borax.

Blood as a food is chiefly used in the form of "black puddings," which contain rice and other ingredients sterilized by boiling. Obnoxious as the idea of consuming blood may be to most people, these sausages are highly esteemed by the poorer classes; they are undoubtedly nutritious, and are, if eaten while fresh, quite free from the danger of conveying any disease whatever.

The percentage composition of blood is as follows: Water 80·8, protein 18·1, fat 0·2, mineral substances 0·87, per cent.

The red blood-corpuscles consist of the stroma or protoplasm with the intracellular contents, consisting chiefly of hæmoglobin. The latter is a chromo-protein or compound of **globin** with hæmochromogen (an iron-containing substance), fatty acids, etc. The stroma consists of lecithin, cholesterin, and nucleo-albumin, together with a cell-globulin, which, according to Halliburton, is a nucleo-protein.

The white corpuscles, like ordinary cells, have a protoplasm consisting of myosin, serum-globulin, nucleo-histon, and glycogen.

The fibrin of blood, formed from fibrinogen, has the general characters of the globulins. The fibrin ferment is variously stated to be a globulin and a nucleo-protein.

Serum-globulin or paraglobulin is a mixture of proteins, viz., euglobulin or true serum-globulin, fibrin-globulin, and nucleo-protein. Euglobulin is a gluco-protein—*i.e.*, the molecule contains a carbohydrate which can be split off. Serum-albumin is likewise a mixture of at least two proteins, from one of which the amino-sugar (*glucosamine*) can be separated. Further particulars of the sugars, fats, soaps, extractives, and mineral substances, which go to make up this complex fluid, are to be found in the standard works on physiological chemistry.

The Digestibility and Absorption of Meat.—Meat is one of the most digestible of foods, so far as the stomach is concerned; it does not throw any great strain upon its mechanical resources, the fibres being acted upon chemically by the gastric juice. The fibres of the muscular tissue swell up and become softened; they change from red to a greyish-yellow colour, and fall apart, breaking up into longitudinal fibres and transverse discs, which are finally reduced to proteoses and peptones. The readiness with which this occurs depends upon the age and quality of the meat. The younger the animal, the thinner will be the sarcolemma, and the smaller the proportion of the connective tissue; with increasing age the converse holds true. The firmer and tougher the connective tissue which binds the fibres together, the slower will be the dissolution of the muscular substance, and digestion will be the more prolonged. The amount of fat upon and between the muscular fibres also influences the digestion by protecting these fibres from the action of the gastric juice. The influence of cooking tends to delay the digestion of meat, according to the conclusions of most observers. During

roasting or boiling the meat loses water and fat, thereby upsetting the proportion of nutritive constituents. The meat loses about 35 per cent. of its weight, the fibres are somewhat loosened, but the sarcolemma and connective tissues are not so easily digested, especially after roasting. But this delay in digestion is more than counterbalanced by the gain in safety from undesirable contaminations. Raw meat is digested more rapidly than boiled, and boiled more quickly than roast meat. Jessen[1] found that a meal of 100 grammes (3½ ounces) of beef disappeared from the stomach in the time stated, according to the mode of cooking.

TIME REQUIRED FOR DIGESTION.

Raw beef	2 hours.
Half-boiled beef	2½ ,,
Well-boiled beef	3 ,,
Half-roasted beef	3½ ,,
Well-roasted beef	4 ,,

These observations correspond with the time occupied in artificial digestion experiments. More raw meat is digested in a given time than cooked meat. Underdone meat is digested more rapidly than thoroughly boiled or roasted meat, and the normal gastric juice digests meat more quickly than a weakly acid juice. This influence of heat upon meat is quite opposite to its effect upon fruit and vegetables; digestion is delayed by cooking the meat, hastened by cooking vegetables.

Different Kinds of Meat.—It is generally considered that mutton is more easily digested than beef. But Jessen did not find it so in his experiments, for 100 grammes of raw mutton disappeared from the stomach in precisely the same time as 100 grammes of beef. Chittenden found that in artificial digestion experiments mutton was slightly less digestible than beef, or as 92 : 100. Of course the age of the animal, the fine fibres of the mutton and loose connective tissue, and the different composition of the fat, may account for differences in the time of digestion. Veal and pork are not so quickly digested as beef or mutton. Jessen found that 100 grammes raw beef disappeared from the stomach in two hours, the same amount of veal in two and a half hours, and pork three hours.

The Losses of Meat in Cooking.

All civilized people cook their meat, because it thus becomes more palatable and more pleasing in appearance, while at the same time animal parasites and bacteria are destroyed. Our knowledge of the physical and chemical changes produced by cooking the meat are incomplete. But it is probable that the increased palatability is due to the development of certain odours and flavours from the browned meat and fat, and to the loosening and softening of the tissues. The temperature of the interior of a piece of meat during roasting varies from 160 to 200° F., while that of a joint weighing 9 pounds did not exceed 190° F. after

[1] *Zeit. f. Biol.*, 1883, [xix.] 129.

boiling for four hours. These temperatures, however, are quite sufficient to destroy parasites and most of the bacteria, and sterilization is aided by the duration of the exposure.[1] The time required for cooking meat by **boiling** is usually given as fifteen minutes for every pound, and fifteen minutes over for beef or mutton; but pork, ham, or bacon, should be allowed thirty minutes per pound. The time required for **roasting** a joint is also fifteen minutes for every pound, and fifteen minutes over, for beef, veal, mutton, or lamb; but twenty minutes to the pound, and twenty minutes over, is allowed for leg or loin of pork.

COMPOSITION OF RAW AND COOKED MEAT COMPARED.

	Nutrients per Cent.				
	Water.	Nitrogen.	Protein.	Fat.	Ash.
Beef round: Raw, average	60·40	—	19·50	19·50	1·00
Boiled, 16 samples ..	60·55	5·20	32·50	9·44	·72
Pan-broiled	69·99	4·30	26·88	2·25	1·26
Gas-broiled	66·97	4·81	30·09	4·26	1·33
Sautéd	61·98	4·47	27·92	9·03	1·21
Beef ribs: Raw, average	57·60	—	17·80	24·60	·90
Roasted, 11 samples ..	45·20	3·07	19·14	39·06	·82
Boiled	54·10	4·30	26·89	18·18	·91
Veal leg: Raw, average	71·70	—	20·70	6·70	1·10
Boiled	64·88	4·51	28·21	5·11	1·05
Mutton leg: Raw, average	63·20	—	18·70	17·50	1·00
Boiled	57·67	4·42	27·60	14·38	1·05
Roast	50·90	—	25·90	22·60	1·20
Pork leg: Raw, average	50·10	—	15·70	33·40	·90
Roasted, 7 samples ..	54·42	3·98	23·98	19·37	1·03

The losses in cooking meat were well studied by Grindley and Mojonnier, and the results published by them are as follows:

LOSSES IN BOILING: MEAT BOILED FOR THREE HOURS.[2]

	Percentage Loss of Nutrients in the Uncooked Meat.			
	Water.	Protein.	Fat.	Ash.
Average of 91 tests	45·07	7·25	11·70	44·62
Highest	69·90	12·67	37·40	67·39
Lowest	18·05	3·25	·60	20·04

[1] In his Report to the Royal Commission on Tuberculosis, Professor Woodhead stated that the temperature in the interior of joints did not exceed 140° F. (60° C.) during ordinary cooking. It is considered, however, if his statement is correct, that infection of the consumer by various bacterial diseases, tænia, trichinæ, etc., would be more prevalent than is generally supposed, the common opinion being that cooking the meat is a safeguard against them.

[2] "Losses in Cooking Meat," Bulletin 141, U.S. Department of Agriculture.

Example.—Exp. 66—Beef round :

Weight of meat before cooking	.. ..	2,502·55 grammes.
Weight of meat after cooking	.. ..	1,543·47 ,,
Loss of weight in cooking	.. .. ..	959·08 ,,
Percentage loss of weight	.. .. ..	38·32

Losses in Roasting.[1]

	Percentage Loss of Nutrients in the Raw Meat.			
	Water.	Protein.	Fat.	Ash.
Beef, average	33·73	1·21	24·71	15·12
Beef and pork, average	36·58	1·97	34·27	15·92

Example.—Exp. 106—Rib of beef roasted in open pan in gas-heated oven one and a quarter hours ; time, twenty minutes per pound :

Weight of meat before cooking	.. ..	1,353·68 grammes.
Weight of meat after cooking	.. ..	946·15 ,,
Loss of weight in cooking	.. .. ..	407·50 ,,
Percentage loss of weight	.. .. ..	30·10

Roast pork loses more water than beef, owing to longer cooking ; it also loses more nitrogenous matter and fat. The loss of mineral substances is less in roasting than in boiling. Underdone roasted beef loses 13·87 per cent. of water, 5·51 fat, 0·07 nitrogenous, and 0·03 of ash per cent.

[1] "Losses in Cooking Meat," Bulletin 141, U.S. Department of Agriculture.

CHAPTER VI

SOUPS, BEEF-TEA, AND MEAT EXTRACTS

Soups.

When minced meat or meat cut into small pieces is infused in cold water, diffusion occurs, and there passes out of the meat some soluble albumin, meat extractives, and salts. As the infusion proceeds, a small amount of lactic acid is formed ; this acts upon the meat, and changes some of the insoluble into soluble protein, which is dissolved out. The extent of this action, and the amount of substance which actually goes into solution, depend upon the extent of surface exposed to water, the duration of the exposure, and temperature. The smaller the pieces of meat, the greater the extent of surface a given weight of meat will present to the water ; therefore the diffusion will be more rapid, and more of the soluble substances of the meat will pass into the water ; that is to say, the richer the soup, the poorer the meat will become. If the water is heated gradually, more and more of the soluble materials are dissolved out of the meat. When, however, the temperature rises to 134° F., the soluble albumin will begin to coagulate, and at 160° F. the dissolved albumin is coagulated, and forms a " scum " of brownish material, which floats upon the surface of the soup, and is usually removed by the cook. As the temperature of the water rises still higher, the collagen of the connective tissues is transformed to gelatin and dissolved out, and some of the fat passes into the broth. The longer the meat is cooked, the stronger the soup or broth becomes ; but the insoluble proteins are coagulated and hardened, and the meat becomes tough and tasteless. The meat may lose as much as 40 per cent. of its weight in cooking, but this is chiefly water, although from 5 to 8 per cent. of the constituents of the meat, consisting of soluble albumin, gelatin, extractives, mineral matters, organic acids, muscle-sugar, and flavouring materials, goes into the broth. The meat, however, retains most of its protein and fat, and, although devoid of flavour, contains most of the original nutriment (see Losses in Boiling). Such meat has been found to be as easily and completely digested as roast meat, and, when boiled with vegetables or " pot-herbs " and salt to give it a flavour, forms an exceedingly agreeable and nutritious food.

The amount of nutriment in broth or soup is not very great. An experiment was made with 1 pound of beef and 7 ounces of veal bones, the result being 1 pint of strong soup, which on analysis

was found to have the following composition. The composition of beef, miscellaneous parts *free from visible fat*, such as would be used for making beef-tea, is also given for comparison.

STRONG SOUP AND RAW MEAT COMPARED—PERCENTAGE.

	Soup.	Raw Beef.
Water	95·2	73·8
Protein	1·2	22·4
Fat	1·5	2·9
Extractives	1·8	0·5 to 2·5
Mineral matters	0·3	1·2

Broth is usually made with more water, however, and frequently contains no more than 2 per cent. of nutrients, besides gelatin in proportion to the amount of connective tissue and duration of the cooking. The nutriment in broth is therefore very small, and its stimulating effect on the nervous system is to be ascribed to the extractives and the salts of potash which it contains. The following composition of various soups is given by Atwater and Bryant:

COMPOSITION OF SOUP.

	Nutrients per Cent.					Fuel-Value per Pound (Calories).
	Water.	Protein.	Fat.	Carbo-hydrates.	Ash.	
(*a*) Home-made Soups:						
Beef soup, average	92·9	4·4	·4	1·1	1·2	120
Chicken soup	84·3	10·5	·8	2·4	2·0	275
Meat soup	84·5	4·6	4·3	5·5	1·1	379
Bean soup	84·3	3·2	1·4	9·4	1·7	295
Clam chowder	88·7	1·8	·8	6·7	2·0	195
Soup stock	89·1	5·8	1·5	—	3·6	170
(*b*) Canned Soups (as purchased):						
Asparagus, cream of ..	87·4	2·5	3·2	5·5	1·4	285
Bouillon	96·6	2·2	·1	·2	·9	50
Celery, cream of	88·6	2·1	2·8	5·0	1·5	250
Chicken-gumbo soup ..	89·2	3·8	·9	4·7	1·4	195
Chicken soup	93·8	3·6	·1	1·5	1·0	109
Consommé	96·0	2·5	—	·4	1·1	55
Corn, cream of	86·8	2·5	1·9	7·8	1·0	270
Julienne soup	95·9	2·7	—	·5	·9	60
Mock turtle	89·8	5·2	·9	2·8	1·3	185
Mulligatawny	89·3	3·7	·1	5·7	1·2	180
Ox-tail	88·8	4·0	1·3	4·3	1·6	210
Pea soup	86·9	3·6	·7	7·6	1·2	235
Tomato soup	90·0	1·8	1·1	5·6	1·5	185
Turtle soup	86·6	6·1	1·9	3·9	1·5	265
Vegetable soup	95·7	2·9	—	·5	·9	65

It is obvious from these analyses that soup, if it is to be made nutritious, must be made a vehicle for other substances than those extracted from meat. The materials commonly used for increasing the value of soup are peas, pea-flour, lentils, lentil-flour, vermicelli, semolina, macaroni, barley-flour, wheaten flour, potato, etc. Meat infusions or broth contain very little nutriment, and even that consists partly of gelatin derived from bones or connective tissue. The best broth that can be made never contains more than 6 per cent. of nutriment derived from the meat, including at most 3 per cent. of dissolved and 3 per cent. of coagulated albumin, besides extractives (creatin, creatinin, inosinic and sarcolactic acids), which may also amount to 3·5 per cent.; 1·5 per cent. of salts, which give it aroma and flavour; and gelatin, which adds to its density. Their chief value is that of stimulating the digestive powers; they sometimes arouse a flagging appetite, and in cold weather serve the purpose of warming the body by aiding the cutaneous circulation.

It is, however, pretty certain that the custom of preceding a heavy meal by a small quantity of soup has a physiological warranty. It was pointed out by Schiff that soup, or, rather, the extractives contained in it, stimulate the gastric glands, and encourage in a remarkable way the digestion and assimilation of the more solid repast. Similar evidence was given by Pawlow, who clearly demonstrated that the extractives of meat are the most powerful exciters of gastric digestion that we possess. We therefore look upon the small amount of soup usually taken at dinner as serving the important function of stimulating the appetite and promoting the digestion and assimilation of the meal.

When, therefore, the soup is intended as a first course, and for the purpose indicated, *clear* soups, or those only slightly thickened, such as bouillon, consommé, chicken broth, julienne, mulligatawny, or ox-tail soup, are the best. But if the soup is an important part of the meal, as it often is in large families, it should be a *thick* soup, such as pea or bean soup, or those thickened with pea-flour, lentils, or potatoes. A few notes on some of the above-mentioned soups may not be out of place.

Bouillon is meat broth containing vegetables and flavouring herbs.

Consommé is clear soup, made by simmering together meat and bones, such as calf's head and feet. The broth is strained, the fat skimmed off, and flavoured with various herbs and spices. When vegetables are used, they are first boiled, and then rubbed through a fine sieve before they are added to the soup.

Cock-a-Leekie is prepared by boiling fowls and leeks together in water, seasoned with pepper and salt.

Hotch-Potch is a Scotch vegetable soup, made of onions, carrots, turnips, cabbage, parsley, etc., all finely cut up, boiled with mutton, and seasoned with pepper and salt.

Julienne is a French vegetable soup (see Desiccated Soup).

Mock Turtle Soup consists of ordinary stock boiled with calf's

head and ham. It is flavoured with lemon-juice, madeira wine, and other seasonings.

Real Turtle Soup is made by boiling the flesh of green turtle in water and white wine to make a stock. The latter is diluted with any good kind of soup, such as ox-tail, and fortified by the addition of madeira and lemon-juice to add piquancy.

Mulligatawny Soup is of Indian origin. It consists of stock boiled with vegetables—carrots, turnips, and savoury herbs; it is then mixed with curry-powder, cayenne pepper, lemon-juice, salt, or other flavouring substances.

Ox-Tail Soup is made by frying together ox-tails, cow-heels, and any scraps of meat, with a little fat; they are afterwards simmered together for many hours with various savoury herbs. The soup is strained, mixed with spices, ketchup, and sometimes butter.

Tomato Soup is made by scalding and crushing the tomatoes, boiling the pulp with rice and water, straining, and adding butter, and sometimes stock.

DESICCATED SOUPS.

Composition.	Pea Soup.	Household Soup.	Consommé.
	Per Cent.	Per Cent.	Per Cent.
Water	11·0	13·3	7·4
Ash	11·4	13·3	64·4
Common salt	8·5	7·4	58·9
Nitrogen (total)	4·1	3·0	3·5
Phosphoric acid	—	—	1·9
Soluble in water	42·1	48·5	—

Dried vegetable soups usually consist of vegetables mixed with meat extract, yeast extract, or a concentrated stock specially made. Any vegetable may be used: onions, leeks, garlic, carrots, turnips, parsnips, salsify, chicory, sorrel, marjoram, mint, thyme, savory, pepper, etc. Each maker has his own formula. *Julienne soup* has no meat or extract; but for export purposes Lazenby's julienne consists of an inner cube containing 25 per cent. by weight of vegetables, and an outer covering (75 per cent.) formed by a gelatinous solidified soup, which has the following composition: Water 32·0, ash 13·5, salt 6·8, nitrogen 8·5, phosphoric acid 2·3, and material insoluble in alcohol 40·0, per cent.

Soup tablets frequently consist of a large proportion of gelatin, meat extract, and vegetable flavouring. The nitrogenous extractives and gelatin are extracted in the following way: Meat freed from bone and fat is minced by machinery; 100 pounds of minced meat is infused for three hours in cold water; the temperature is then slowly raised to 140° F., and maintained at that degree for three hours, during which all the soluble constituents are extracted, and only sarcolemma, fibrin, and connective tissues, are left. During the whole of this period it is constantly agitated by a mechanical device in the extractor, and care is taken that the temperature does

not exceed 140° F., in order to avoid coagulation of albumin on the surface of the fibres, which prevents the extraction of the materials within. Up to this point the liquid remains clear. It is, however, now sterilized by raising the temperature to 195° or 200° F., by which albumin is coagulated, the liquid becomes cloudy, and a scum forms on the surface. It is then filtered, and afterwards concentrated in vacuum pans or in shallow pans, until a portion of it will coagulate on becoming cold ; it is poured into moulds to set. Such tablets, when dissolved in hot water, form a clear brown soup or beef-tea.

Other soup tablets are made without meat. The feet of calves, sheep, pigs, or oxen, bones, tendons, and other cartilaginous tissues, are boiled together for a prolonged period, until all the collagen is extracted and converted into gelatin. When the liquid is sufficiently strong to make a firm jelly on cooling, it is flavoured with a decoction of vegetables and salt, and coloured with caramel. Others are made of vegetables alone. Such a soup is that proposed for adoption by the French army ; it is composed as follows : Beef fat 100, carrots 5, leeks 7, onions 7, kilos ; celery 1, parsley ½, garlic ½, basil $\frac{1}{20}$, thyme $\frac{1}{20}$, laurel leaves $\frac{1}{20}$, kilo, together with pepper, cloves, and salt. The whole is boiled until it will set into a jelly when cold ; it is, however, strained, and poured into moulds which contain about 1 ounce, which sets into a tablet, and is of sufficient strength to make 1½ pints of good soup when dissolved in water.

Ju-vis tablets are composed of extract of meat, gelatin, and a mixture of vegetables.

Beef-Tea.

The great demand for beef-tea as an article of invalid dietary would lead one to imagine that it possesses some hidden virtue which is unfathomable by the chemist or physiologist. If this is so, the virtue or effect must be entirely psychological, for, from a dietetic point of view, it is one of the least valuable of the foods usually administered to an invalid. Like broth and soup, it only contains about 6 per cent. of nitrogenous matter from the meat, besides a little carbohydrate—*e.g.*, glycogen or inosite ; in fact, 1 pint of good beef-tea only contains the nutriment of 1 ounce of beef. The author has shown elsewhere that beef-tea, *when not strained*, contains 6 per cent. of nitrogenous matters, including dissolved and coagulated albumin and extractives, 0·3 per cent. of fat, and 1·0 per cent. of carbohydrates, and yields *nine calories per ounce*. Hutchison found that it contains 1·75 per cent. of protein, and about the same of meat-bases or extractives. Patients are very fastidious about their food, and desire their beef-tea to be strained ; this they will usually take. But when we recognize that the coagulated albumin or "grounds" form the principal nitrogenous food in it, we must conclude that *clear* beef-tea has very little food value, unless some attaches to the extractives. The "grounds" cause the beef-tea to be *muddy*, which a patient objects to. But

seeing that clear beef-tea contains little more than extractives, salts, and water, it is obvious that it should not be strained. Germain Sée said beef-tea contains very little albumin and very little carbohydrate; the glycogen, inosite, and sarcolatic acid, are all altered, and the fat is removed. The creatin, creatinin, carnin, and other quaternary products, to which the *stimulating* effects of beef-tea are due, are of low chemical composition, already on their way to form urea. The salts are out of all proportion to the albuminates, and consequently the effects of drinking such a fluid are increased thirst, increased rise of temperature, and an extra burden thrown upon the system in the form of nitrogenous waste substances.

Respecting the food value of the nitrogenous extractives or meat-bases, a little further consideration is necessary. The chief of these are creatin and creatinin. Creatin forms 0·3 per cent. of muscular tissue, and is one of the chief constituents of meat extracts and beef-tea. Opinions differ as to their food value. But they were investigated by Professor Mallet. The chief physiological effects of creatin are—A notable reduction in the pulsations and a slight reduction in the force of the heart, a slight reduction in the number and depth of the respirations, and possibly a slight reduction in the temperature. Creatinin slows the heart even more than creatin. It is usually granted that creatin and creatinin do not build up muscular tissues, but the opinion has been expressed that they spare the muscular tissues or prevent tissue waste. If this is so, it is reasonable to suppose they yield energy in the body. Now, it has been ascertained that on combustion 1 gramme of water-free creatin yields 4·267 calories, and 1 gramme of creatinin 4·583 calories. But very little creatin or creatinin are used in the body, even when large quantities are taken. This is shown in the following experiments:[1]

Amount of Creatin taken.	Amount recovered.	Percentage recovered.	Amount of Creatinin taken.	Amount recovered.	Percentage recovered.
5 grammes ..	4·806	96·12	5 grammes ..	4·809	96·18
10 ,, ..	9·749	97·49	10 ,, ..	9·768	97·68
15 ,, ..	14·703	98·02	15 ,, ..	14·736	98·24

It must therefore be concluded that by far the largest amount of flesh bases ingested, if not the whole, is eliminated by the kidneys. Creatinin is excreted unchanged, and most of the creatin is changed into creatinin. These bases therefore do not build up the tissues, and we cannot regard them as a source of energy, because they are excreted unchanged. Soups, beef-tea, and meat extracts, derive no nutritive value from them. They must therefore be carefully excluded in any calculation of the nitrogenous portion of all foodstuffs. Even if we view them as nerve stimulants, classed

[1] "Physiological Effects of Creatin and Creatinin," Bulletin 66, U.S. Department of Agriculture.

with tea and coffee as adjuncts of our food, they are much less active than is commonly supposed, while the depressing effects of the potassium salts, so prominently associated with them in meat extracts, should not be overlooked.

The Manufacture of Beef-Tea, etc.—**Beef-tea** can be made by infusing beef in cold or hot water. Hassall found that a pint of beef-tea made from a pound of lean meat and *hot water* contained only 22 grains of nitrogen ; but when the beef was infused in the same amount of *cold water*, the liquid contained 41 grains of nitrogen. He also estimated that 14½ pounds of beef would be required to yield enough nutriment in the form of beef-tea to supply the nitrogenous requirements of an individual doing an average day's work, calculating the waste nitrogenous materials excreted during an ordinary day's work as 512 grains of urea and 12 grains of uric acid.

A good method of making beef-tea is as follows : Let a pound of beef be freed from fat, beaten with a rolling-pin, and cut into small pieces or torn to shreds. Put the beef into a vessel with a pint of *cold water* and a teaspoonful of salt. Allow it to stand for half an hour to extract the juice from the meat. Then put the whole into a bain-marie, or double-pan, cover it down, heat it gradually, and keep it simmering. The temperature of the liquid should never exceed 160° F., and care should be taken that the outer vessel, containing water, does not boil dry. The meat has a tendency to become clotted together, and should be separated occasionally by two forks. Any desired condiment can be added a few minutes before removing it from the fire. When it is ready, pour off the liquid, without straining it, and press the meat. Much more liquid can be removed from the meat by means of a meat-juice press—*e.g.*, the Hercules press—than by ordinary means. Fat can be removed *en masse* from the liquid when it is cold. The flocculent sediment in the liquid contains the chief part of the nutriment.

Hassall showed that beef-tea made with cold water contains double the amount of nutriment in that made by heat in the ordinary way. Liebig also favoured this method, and gave the following directions for making it : Let the meat be cut very small, mix it with cold water and salt, digest it and agitate it frequently for one hour. Finally add the flavouring, and boil it for ten minutes ; pour off the liquid and press out the meat, and it is ready for use. It appears to the writer that an error is made by boiling it, as the soluble albumin is thereby coagulated. If it is considered desirable to sterilize it, this end will be attained by raising the temperature to 150° F., as in the former method. Bartholow recommended it to be prepared in a similar way : One pound of meat is freed from fat, tendon, etc., minced and digested in a pint of cold water for an hour. Let it simmer on a stove for two hours, taking care that the temperature of the liquid does not exceed 160° F. Pour off the liquor, express all fluid from the beef, making up any loss in bulk by washing the meat fibre in a little cold water.

A lemon-squeezer is recommended as a suitable instrument for expressing the beef-tea.

Good beef-tea should not solidify when it is cold; solidification is a proof that the meat has been boiled for a considerable time to convert collagen into gelatine, but all the albumin would be precipitated by prolonged heat.

There are many modes of making **mutton broth, chicken broth,** etc., but all these liquids differ little in point of nutriment. The main things to observe are the proportion of meat to water, the reduction of meat to small pieces or shreds, and care in the application of heat. As regards proportion, beef-tea should have 1 pound of meat to 1 pint of water; mutton-broth, 1 pound of meat to 1½ pints of water; and a chicken or rabbit will make 2 pints of broth. It is of great importance, during illness, to frequently change the flavouring of these liquids if they are administered for a length of time. Onions, celery, bay-leaf, parsley, mint, thyme, ketchup, tomato, peppercorn, allspice, and other condiments, may be used in them. The heavy vegetables, such as turnips, carrots, parsnips, etc., should never be used when preparing such foods for invalids, and all vegetables should be removed before serving the broth.

There is an enormous waste of material in making beef-tea. This is clearly shown by a comparison of the composition of miscellaneous parts of beef, free from fat and bone, such as would be used in making beef-tea or strong broth, with that of the liquid when ready for use. Jessop,[1] in an article on this subject, calculated that 5·2 tons of beef are used weekly for making beef-tea in the London hospitals, of which at least 67 per cent. is wasted. It is possible to minimize this waste by reducing some of the remnant to a pulp and adding the same to the beef-tea, which improves the nutritive value of the latter. Jessop suggested the following mode of manufacture: Let 25 pounds of beef be boiled for three hours in 100 pints of water; pour off the liquid, let the meat be reduced to a fine pulp, and mix the whole together. Thirty ounces of such beef-tea daily, in divided doses, would contain the best part of 6 ounces of beef. An improvement in this method would consist in the infusion of the minced meat in an equal weight of cold water for one hour, as in the cold method of making beef-tea; pour off the liquid; boil the meat in three times its weight of water for three hours, strain off the liquid; then reduce the fibre to a fine pulp in a sausage-machine, finally mixing it with the two liquids previously obtained. Ordinary beef-tea can also be enriched by the addition of milk powders or various peptone preparations.

Meat-Juices.

These fluids are different from beef-tea; they consist of the juice of raw meat, expressed without any previous application of heat. Some preparations are concentrated *in vacuo*. These preparations contain the liquid proteins of the meat, in an uncoagulated form,

[1] *British Medical Journal*, August 31, 1889.

besides hæmoglobin, extractives, and mineral matters. The composition of natural beef-juice is found to vary as follows: Water, 88 to 94 per cent.; coagulable proteins, 3 to 7 per cent.; extractives, 2 to 4 per cent. It differs slightly according to the mode of preparation.

Home-made Beef-Juice.—Bartholow recommends that round or sirloin of beef should be cut into pieces of a proper size to fit a lemon-squeezer. Each piece is then quickly broiled or scorched to prevent the escape of the juice. As soon as it is cooked it is put into the lemon-squeezer (previously made hot by being dipped in boiling water). The juice is expressed and received in a coloured wine-glass, seasoned with salt and cayenne pepper to taste, and drunk while it is hot. Holt obtained 2½ ounces of juice from 1 pound of broiled steak. Sometimes it is better to give *raw-meat juice* made by cold infusion. Holt recommends that a pound of minced beef be infused with 8 ounces of cold water for six hours, and the liquid then pressed out; he obtains about 8½ ounces of liquid containing 3 per cent. of coagulable protein and 1·9 per cent. of extractives. Cheadle recommends it to be prepared in the same way, but with only 4 ounces of water. The Hercules meat-press is a useful instrument for obtaining the juice.

COMPOSITION OF HOME-MADE BEEF-JUICE.

Juice obtained from—	Water.	Albuminates.	Extractives.	Authority.
	Per Cent.	Per Cent.	Per Cent.	
Minced meat, heated in a bottle	92·1	2·19	2·09	Bulletin 21, U.S. Department of Agriculture.
Round of beef, slightly broiled and pressed ..	88·1	6·97	3·90	
Neck of beef, ditto ..	90·1	5·18	2·09	
Holt's raw-meat juice ..	94·9	3·00	1·90	"Diseases of Children," p. 153.
Cheadle's meat-juice ..	91·1	5·10	3·10	"Feeding of Infants," p. 115.

Commercial Meat-Juice.—The average composition of beef-juice according to Wiley,[1] is as follows:

COMPOSITION OF BEEF-JUICE.

Water	90·65 per cent.
Total nitrogen	1·15 ,,
Proteins, soluble and coagulable ..	·68 ,,
Proteoses	·04 ,,
Peptones	·14 ,,
Meat-bases	·30 ,,
Fat	·19 ,,
Ash	1·36 ,,
P_2O_5	·36 ,,
NaCl	·15 ,,
Lactic acid	·15 ,,

[1] "Foods and their Adulteration," p. 81.

The composition of commercial meat-juices varies, thus: Water, 36·6 to 74·1 per cent.; proteins, 9 to 30 per cent.; extractives, 3 to 19 per cent.; ash, 1 to 17 per cent. The following table shows the composition of some of the important kinds:

COMPOSITION OF MEAT-JUICES—PERCENTAGE.

Preparation.	Water.	Protein.	Extractives.	Ash.	Authority.
Valentine's meat-juice	51·21	9·65	11·16	10·84	Candy. *Cf.* Hutchison. "Food and Dietetics."
Burgoyne's meat-juice	49·51	13·00	8·10	14·20	
Brand's meat-juice ..	59·15	15·45	16·55	8·85	
Esco beef-juice ..	52·43	7·60	5·90	20·39	Tankard: N-free, 13·62 per cent.
Valentine's meat-juice	60·31	0·55	29·15	11·30	Chittenden.
Vitalia meat-juice ..	66·50	21·00	6·00	6·50	*Lancet.*
Armour's meat-juice	74·10	8·30	9·54	7·51	Attfield.
Bovril meat-juice ..	52·01	7·23	14·03	5·97	(*Plus* carbohydrates, 20·76.) The makers.
Lipton's fluid beef ..	42·91	22·13[1]	18·71	14·20	*Lancet.*
Liquor Carnis ..	56·06	6·916	5·01	2·55	The makers.
Bovinine	81·09	13·98	3·40	1·02	Chittenden.
,, ...	78·42	13·32	0·55	1·60	(*Plus* carbohydrates, 6·01.) O. Hehner.
Puro	36·60	30·33	19·16	9·79	Fresenius.
Wyeth's meat-juice ..	44·87	38·01		17·12	

Meat-juices differ from meat extracts because they contain the soluble and liquid proteins in an uncoagulated form: most of them contain hæmoglobin, extractives, and mineral matters. Valentine's, the Bovril Company's, and Armour's meat-juice contain less protein than the others. Bovinine contains a large amount of hæmoglobin, which suggests that it is not a meat-juice entirely. Puro was originally a concentrated meat-juice, but Hutchison says it is now enriched by the addition of raw egg-albumin. Brand's meat-juice contains 5·28 per cent. of coagulable material, presumably soluble protein. Burgoyne's has 3·07 per cent., Valentine's only 0·55 per cent., of coagulable material. Curtis's meat-juice has 2·3 per cent. coagulable material, with hæmoglobin, and 6·54 per cent. of mineral matters. *Vinsip* is said to be an alcoholic extract of blood; it contains 16 per cent. of protein, with a little boric acid and alcohol.

The cost of meat-juices is out of all proportion to their value, although some of them appeal to the æsthetic sense. They are not all natural beef-juice; indeed, some of them have been concentrated in the vacuum-pan, others are enriched by the addition of egg-albumin; some, judging by the amount of hæmoglobin or

[1] 6·54 per cent. coagulable.

methæmoglobin contained in them, are presumably prepared, at least in part, from blood ; and most of them contain glycerine, salt, boric acid, or sulphite of soda, as preservatives. The use of preservatives is condemned, because the juice is intended as food for invalids whose digestive organs are already enfeebled by disease, and might be further injured by foods containing such chemicals. They are all expensive preparations, sold at a price which is far beyond their nutritive value, which probably arises from the mode of their manufacture. *Home-made* beef-juice can easily be prepared, and has a composition like those given in the first table, and is cheaper than the commercial preparations. When meat is cut into small pieces, put into a bottle, corked down, and slowly heated in water over a fire until the water just boils, and is then removed from the fire and allowed to cool gradually, the meat contracts and presses out the juice more or less. The fluid contains 2 or 3 per cent. of coagulable proteins and as much extractives. It is an easy but wasteful mode of preparation. The most satisfactory method is to mince the meat and infuse it with cold water, as recommended above by Holt, afterwards expressing the liquid by a lemon-squeezer or meat-press. It is really beef-tea prepared by cold infusion, but is a little richer when forcibly expressed. Cheadle and Hutchison found such a liquid contained 5·5 per cent. of protein when only 25 per cent. of water was added to the meat. But, owing to the cost of such liquids, Hutchison recommends the following agreeable substitute : Take the white of one egg, add twice its volume of water, strain it through muslin ; stir in a little Liebig's extract dissolved in a teaspoonful of hot water. The resulting liquid contains 4 per cent. of soluble proteins and the extractives ; it is as nutritive as beef-juice, scarcely distinguishable from it, and costs only about one penny per ounce.

Where liquid preparations of meat are used largely as in public institutions, **Von Leube's soluble meat** is a suitable material, and can be prepared by the cook. It is highly praised by Bauer,[1] who gives the following mode for preparing it : 1,000 grammes of lean meat finely minced is placed in a porcelain vessel with 1,000 c.c. of water and 20 c.c. of pure hydrochloric acid. It is placed in a Papin's digester, and boiled for ten or fifteen hours. The mass is taken out, and rubbed to a paste in a mortar, put again into the digester, and boiled for another period of ten to twenty hours. The acid is then neutralized by sodium carbonate, and the paste is ready for use. It contains unaltered albumin, peptones, and extractives ; none of the meat is taken out ; it therefore contains all the meat in a partly digested form. It keeps well, is easily digested, and has a milder taste than meat extract. It has the following composition : Water, 67·21 ; fat, 5·93 ; albumin, 11·0 ; peptone, 6·51 ; extractives and fibre, 7·55 ; mineral matters, 1·34 ; salt, 0·46—per cent. It can be given to patients in its original form or diluted with an equal quantity of water.

[1] Bauer's "Dietary of the Sick," p. 83.

Meat Extracts and Essences.

Liebig's extract is the archetype of beef extracts, and has been imitated by many makers. Liebig himself was not the first to make an extract of meat, as a substance of the same character was described by Proust in 1801. But it was due to the enterprise of Baron von Liebig that its manufacture on a commercial scale was begun in 1847, and that the first manufactory was opened at Fray Bentos in Uruguay. It is unnecessary to enter here into the history and legal proceedings surrounding the name of Liebig's extract of meat. The enormous plains of grass in South America afford excellent feeding-ground for cattle, where, prior to Liebig's time, they were chiefly bred for their hides. But Uruguay is not now the only place where extract of meat is manufactured, although a considerable quantity comes from South America. There are numerous manufactories in the United States, and also in Australia.

The mode of manufacture varies in different establishments, but the principal method is as follows: Lean beef is reduced to a pulp and mixed with an equal bulk of water, and heated in a steam-jacketed pan. The juice is then removed by hydraulic pressure; it contains all the soluble constituents of the flesh. This liquid is boiled to coagulate the albumin, which is allowed to deposit by gravity. The de-albuminized and supernatant liquid is then drawn off and concentrated in a vacuum-pan until the extract is reduced to about $\frac{1}{32}$ part of the original bulk of the beef. Common salt is added in the proportion of 7 or 8 per cent. as a preservative, and a few makers intentionally leave in it some of the coagulated albumin, or a portion of the finely divided meat fibre, or powdered beef is added to it. When properly made, meat extract is wholly soluble in water and forms a clear solution. It should contain no fat, which causes it to become rancid, nor any gelatin, which predisposes it to become mouldy and deprives the product of the unalterability of the pure extract. There is, however, another class of meat extracts, of which Bovril and Oxo are good examples. In this class the makers endeavour to insure that the extract contains something more than extractives, by the addition of meat fibre or peptonized meat. Yeast contains an enzyme having the power of rendering albumin soluble, which is taken advantage of by the makers of extracts of meat. The analysis of Bovril by Stützer shows that it contains 17·0 per cent. of protein and 20 per cent. of extractives; and Hutchison[1] says a teaspoonful of Bovril has the same food value as a cubic inch of beef weighing 8 grammes. Bovril therefore contains a fair proportion of protein in addition to extractives, and is theoretically a good food. But if it were consumed in sufficient quantity to supply the protein necessary to the human economy, it would cause diarrhœa, and great thirst would arise from the excess of salines. Similar remarks apply to others of this class.

[1] *Lancet*, 1902, pp. 1-6.

PERCENTAGE COMPOSITION OF EXTRACTS OF MEAT.

Variety.	Moisture.	Total Nitrogen.	Insoluble Protein.	Solub Protein.	Extractives.	Creatin and Creatinin.	Non-Nitrogenous.	Mineral Substances.	P_2O_5.	NaCl.
Liebig's extract of beef	18·35	—	traces	9·45	29·67	—	18·85	23·68	—	—
American extract of beef	18·50	7·90	,,	—	24·00	—	—	24·00	5·30	8·90
Australian extract of beef	17·70	8·00	,,	—	21·40	—	—	23·00	4·50	8·00
Armour's extract of beef	15·85	—	,,	10·89	43·23	—	25·91	9·51	—	—
Kemmerick's extract of beef	20·95	9·72	7·86	14·42	6·16	—	—	18·24	—	—
Lemco : Minimum	17·12	9·48	·25	14·12	—	9·50	—	18·35	3·00	2·68
Maximum	21·50	11·60	·88	19·30	—	12·50	—	26·30	6·70	5·60
Oxo	39·71	6·63	4·61	13·50	—	4·70	—	18·04	4·88	8·46
Nursing Oxo	23·27	11·35	5·83	33·51	—	4·00	—	15·73	4·38	4·80
Bovril fluid beef	38·10	—	8·40	3·84	12·04	—	19·75	17·85	—	—
Bovril	39·58	—	9·12		34·10	1·92	—	25·90	—	—
,, invalid	21·16	—	8·47	8·19	16·13	—	29·23	16·82	—	—
Bouillon Fleet	61·95	—	—	11·81	9·87	—	3·81	12·50	—	—
Brand's essence of meat	89·19	1·48	2·25	6·05	·15	—	—	1·31	—	—
,, beef bouillon	36·36	—	9·58		19·75	—	19·34	15·07	—	—
Savory and Moore's fluid meat	27·01	8·76	5·43	2·66	7·47	—	—	12·10	—	—
Viking beef essence	90·68	—	—	3·63	1·85	—	2·41	1·43	—	—
Mason's essence	77·07	—	—	3·03	7·47	—	1·58	9·51	—	—
Armour's soluble beef	23·70	—	33·82		13·44	—	6·75	13·27	—	—
Johnston's fluid beef	44·49	7·20	17·65	17·73	1·39	—	—	5·19	—	—
Hipi (essence of mutton)	35·20	—	7·72	1·21	16·60	—	1·56	8·42	—	—
Beef-plasmon	25·50	8·25	—	45·00	6·00	—	6·95	16·00	—	—
Dried meat	5·40	—	86·70		7·80	—	—	5·40	—	—
Dried Bovril	24·70	—	49·70		25·60	—	—	24·70	—	—
Marmite	30·10	7·14	4·10		46·90	—	—	18·70	—	—
Yeast extract	26·80	7·25	10·50		34·67	—	—	26·90	—	—
Vejos vegetable extract	25·00	—	19·35		21·02	—	17·09	14·09	—	—
Primox meat and vegetable extract	35·00	4·00		25·00		—	22·58	17·42	—	—
Odin vegetable extract	27·30	8·53		52·35		—	—	20·33	—	—

Liebig's extract is the typical extract of meat. Oxo is a good example of meat extract which is modified by the addition of powdered beef. Nursing Oxo is enriched by the addition of peptonized meat, and when a liquid is prepared by the addition of a teaspoonful to a cupful of water, it has the following composition: Water, 95·65; organic matters, 3·42 (including protein, 1·96; extractives, 1·46); and mineral matters, 0·93—per cent.[1] Savory and Moore's fluid meat resembles Liebig's extract in the proportion of protein and peptone. Johnston's fluid beef is a Canadian preparation, and is one of the better meat extracts. It contains 0·148 per cent. of indigestible fibre not given in above table.

Primox is an extract of meat and vegetables, consisting of a brown paste having a saline taste, and odour of meat and vegetables. The addition of vegetables improves the taste, but adds little to the dietetic value. According to the *Lancet*, 1902, ii. 1265, it contains 4·00 per cent. of nitrogen, 47·58 per cent. of organic matter, 17·42 per cent. of inorganic matter, and 35 per cent. of moisture. The nitrogenous matter, including extractives, amounts to 25 per cent.; the non-nitrogenous matter to 22·58 per cent.

Hipi is an extract of mutton, and is useful as a change from beef-tea or ordinary extracts of meat. It contains 38·22 per cent. of nitrogenous matter, including 16·6 of meat bases, 7·72 of protein insoluble in cold water, and 1·21 per cent. of protein precipitated by boiling with acetic acid, the balance of nitrogenous matter being gelatin, and fat 1·56 per cent. (*Lancet*, December 3, 1898).

Turtle-cup, turtle-soup, and turtle-jelly are preparations made from the green turtle in a concentrated form. By the aid of these preparations real turtle-soup can be made at a moment's notice. Turtle-soup has the reputation of being more stimulating and invigorating than other soups and meat extracts, and is a useful restorative.

Meat extracts contain very little nutriment, and their value was for a long time overrated. What nutriment they contain is readily assimilated, and gives very little trouble to the digestive organs. On the other hand, they are rich in "extractives," or nitrogenous substances of a lower order; but these are not proteins, and, so far as we know, neither form protein nor spare its destruction. The creatin, carnin, phosphate of potash, etc., which meat extracts contain give to the substance restorative and stimulating properties, which act upon the circulatory, digestive, and nervous systems.

It was shown in the section on beef-tea that the extractives creatin and creatinin have no food value, and do not yield energy in the body. It must therefore be distinctly understood that meat extracts have no food value beyond that of the small proportion of soluble proteins, peptones, coagulated albumin, and globulin, which they contain. They provoke appetite and the secretion of gastric juice, and thereby aid in the digestion of other foods. Consequently, while not replacing meat, they may render less meat necessary, because of the better digestion following their use. The stimulating effect of meat extracts has also been questioned. When they are taken in hot water they slightly increase the action of the heart, but hot water alone will do that; whereas the physiological effect of creatin is to cause a slight reduction in the force and frequency of the pulse. It has been shown that Liebig's extract does not increase the force and frequency of the pulse. Nor is there any

[1] *Lancet*, 1908, ii. 1242.

evidence that they act on the brain and nervous system in the same way as tea, coffee, and other stimulants. But they do seem to remove the sensation of muscular fatigue, and enable an exhausted muscle to become active again. Liebig said meat extract cannot make us strong, but it makes us aware of our strength. Their chief merit lies in their condimental value, for Pawlow showed that the extractives are most powerful exciters of gastric secretion. This is due to the meat-bases, of which creatin is the chief one. Creatin, xanthin, and hypoxanthin, which form 50 per cent. of the nitrogenous material in meat extracts, are the products of a retrograde process. They still yield heat on combustion, and while being reduced to a lower grade in the organism, and to this extent have a food value. It has been thought that their stimulating effect arises partly from their ready oxidation in the system. But it has been shown that creatin and creatinin are largely excreted unchanged.

Whatever view may be held as to the nutritive value of meat extracts, one thing is certain—viz., that the ingestion of meat from which these principles are removed places a heavy tax upon the digestive organs. The extractives in meat are, in fact, essential to the enjoyment, digestion, and assimilation, of meat. Milk possesses no substance calculated, like these extractives, to excite gastric digestion, and is therefore in notable contrast to meat. A decided advantage might accrue from the addition of some extract of meat to milk, especially for the sick and badly nourished.

The stimulating effect of meat extract has been compared with that of alcohol, and the comparison is on the whole unfavourable to alcohol, especially in illness, where alcohol stimulates the heart to do more work, but is followed by cardiac depression. No such effect follows the use of meat extract, the heart is not excited, and no cardiac depression follows ; on the other hand, it overcomes fatigue or removes the sensation by restoring the tired muscle to activity. The value of meat extracts, therefore, not as a food, but as a stimulant to gastric secretion and assimilation, and as a restorative after muscular fatigue, have been established both by experiment and experience.

Yeast Extracts.—Brewer's yeast yields on pressure a juice which, when evaporated, resembles extract of meat in colour, taste, and smell. In 1903 it was discovered that such an extract was being sold as "Liebig's extract, made from the finest beef only." In some cases the deception was aided by mingling with the yeast extract a small amount of genuine extract of meat. The characteristics of beef extract and yeast extract are so close that the fraud escaped detection for a long time. The mode of its detection was discovered by Searle, who found that yeast extract gives a bluish-white precipitate with a modified Fehling solution, but genuine meat extract does not.

The following method, he says, will enable the detection of as small a proportion of yeast extract as 1 per cent. Take 100 grains of extract, dissolve it in 2 drachms of water. Add enough alcohol to precipitate all that is

insoluble in alcohol, shake vigorously, allow it to settle, pour off the liquid. Dissolve the residue in 1½ ounces of water. Add to this half the quantity of modified Fehling solution, and boil it for a minute or two. "With genuine meat extract no precipitate occurs, but yeast extract gives a bulky curdled precipitate of a bluish-white colour, which is almost insoluble in water." When washed, dried, and weighed, 1 grain represents 10 grains of yeast extract. The modified Fehling solution of Searle is made as follows:

(*a*) Take	Sulphate of copper	200 grains.
	Neutral tartrate of soda	250 grains.
	Water	4 ounces.
(*b*) Take of	Caustic soda	250 grains.
	Water	4 ounces.

Dissolve, and mix the two solutions together.

Yeast extract has the same nutritive value as extract of meat. The principal example is Marmite. Ju-vis is a mixture containing, according to Chapman, 18 per cent. of extract of meat and 21 per cent. of yeast extract. Salamon says yeast extract has a softening influence on the flavour of meat extract.

Odin vegetable extract, according to the *Lancet*,[1] consists of a paste obtained from the protoplasm of vegetable cells. It has a taste and smell like extract of meat, and contains albumin, albumoses, and peptones. Composition: Moisture, 27·32; minerals, 20·33; organic, 52·35; total nitrogen, 8·53 per cent. In nutrient elements it gives a solution which is decidedly superior to beef-tea.

Meat Powders.—Meat powder consists of lean meat dried and reduced to a fine powder. The best-known example is the **Pemmican** of the Canadians, which consists of beef or venison dried hard and reduced to a powder, and afterwards pressed into cakes. It is often mixed with nearly the same quantity of fat, and sometimes with sugar and spices. Such a preparation is in common use in Queensland at the present day, containing 50 per cent. of dried beef and 40 per cent. of fat. Voit[2] says 2 pounds of such food would contain 222 grammes of protein and 445 grammes of fat; and 1¼ pounds would yield 3,230 calories, or enough for the daily supply of a man. It is a highly concentrated food, and an excellent preparation for those who go beyond the reach of fresh food, or who need to carry their provisions in a small bulk, but it is of little use in the sick-room. Dried meat powder, however, has a value in certain cases of illness which can be appreciated. It is a useful addition to soup or broth, in which the natural proportion of protein is very low, and for use in artificial feeding—*e g.*, when food has to be poured into the stomach through a nasal or œsophageal tube. Dujardin-Beaumetz had great experience of such preparations, and strongly recommended them as being easily administered and readily digested. They are of especial value in cases requiring forced feeding, or in obstruction of the pylorus, and whenever it is desirable that the food should leave little residue in the intestinal canal. His method of preparation was to have the beef boiled,

[1] *Lancet*, 1902, ii. 1135. [2] *Zeit. für Biol.*, 1889, xxv. 232.

then dried in a water-bath (bain-marie), and ground in a coffee-mill. Such a powder can be made semi-fluid by mixing it into a paste with a little water, or given by adding it to some broth, milk, or cocoa. Either beef, fowl, or fish, can be powdered in the same way, the fat and connective tissue being removed, so that only muscle fibre remains. There are various commercial preparations, such as Karnoid, Brand's nutrient powder, Mosquera's beef meal, etc. The latter is partly digested by the addition of pineapple-juice or papaw-juice which contain a proteolytic ferment, but produce no bitter by-product of digestion. Chittenden found that it contains 77 per cent. of protein, including 29 per cent. of albumose and peptones, and 13 per cent. of fat. Another valuable meat powder is Somatose, a greyish substance, soluble in water and devoid of taste or odour. In this case also the meat is partly digested, and it therefore consists largely of proteoses (albumoses) and peptones. According to Tankard,[1] it has the following composition :

Composition of Somatose.

Water	14·25 per cent.
Alkali-albumin	21·83 ,,
Albumin	3·40 ,,
Albumoses	33·96 ,,
Peptones	3·06 ,,
Meat-bases	2·62 ,,
Ash and salt	5·30 ,,

In the preparation of Oxo, a proportion of meat powder is combined with the meat extract. This is prepared from the best lean meat of loin of beef, cut, minced, and slowly dried upon steam-heated tables ; it is then reduced to a powder and passed through a fine sieve. The powder has the following composition :[2]

Composition of Beef Powder.

Water	9·20 per cent.
Mineral salts	4·00 ,,
Organic matter	86·80 ,,
Total nitrogen	14·00 ,,
Fat	8·00 ,,
Sodium chloride	0·02 ,,
Phosphoric acid	2·90 ,,

If all the nitrogen is in an organized form, the protein would be 86 per cent., but the meat contains 3·0 per cent. of extractives.

Composition of Meatox Powdered Beef.[3]

Water	5·0 per cent.
Protein	73·8 ,,
Fat	12·1 ,,
Extractives	7·7 ,,
Salts	2·2 ,,

[1] Allen's "Commercial Organic Analysis," iv. 384.
[2] *Lancet*, 1908, ii. 1242.
[3] The makers.

Peptone Preparations.—There are various preparations of meat upon the market, consisting of digested or partially digested meat and containing albumoses and peptones. These preparations are sometimes useful in cases of feeble digestion, atony of the stomach, and other forms of illness. It is a question for the physician to decide whether his patient should have peptonized foods. They are not proper food for healthy persons. Roberts showed that they tend to demoralize the digestive functions, and render the stomach incapable, through want of practice, to perform its normal functions. It may therefore be safely urged against them that it is contrary to the principles of chemical physiology and dietetics to deprive any organ of its normal function, and that such deprivation for any length of time must ultimately end in the normal function becoming more enfeebled, and the organ becoming more and more liable to diseases which might not affect it when in its ordinary active state.

The following table shows that some of these preparations contain very little albumose and peptone, but a considerable proportion of "extractives" of the same character as those in beef extract, and therefore their nutritive value is small. Other preparations contain carbohydrates, which add somewhat to their value. (See next page.)

The solid peptone preparations usually contain a large proportion of starch and sugar. Carnrick's peptonoid is a fine dry powder made of wheat gluten and evaporated milk and vegetable protein. It contains 13·41 per cent. of carbohydrate (chiefly sugar) and 2·7 per cent. of phosphates. According to Attfield, its composition is—Water, 4·92 ; protein, 69·25 ; fat, 10·71 ; carbohydrate, 9·50 ; salts, 5·62 ; total organic matters, 89·46—per cent. According to the makers, Carnrick's liquid peptonoids contain—Protein, 6·89 ; meat-bases, 2·87 ; fat, 2·00 ; lactose, 48·52 ; and starch, 23·64—per cent. Murdoch's liqiud food is a preparation of beef, mutton, veal, and *fruit*. It contains about 13 per cent. of albumin and 8·3 per cent. of alcohol. Most of the liquid preparations contain alcohol. *Ju-vis* is a mixture of vegetables and meat extract. It has the following composition : Water, 28·8 ; albumin, 1·10 ; peptone, 4·76 ; albumose, 9·92 ; meat-bases, 20·63 ; non-nitrogenous matter, 9·37 ; mineral ash, 25·42—per cent.

Beef plasmon is a combination of beef and casein of that name. It is a reddish-brown powder, and when prepared as directed is more nutritive than beef-tea. It contains, according to Dr. Thrush, 15 per cent. of proteoses and peptones, besides 32 per cent. of other proteins.

Peptonized preparations are of little value. They are very apt to cause diarrhœa, and the cost of the preparations is out of proportion to their value. Where the simple protein foods, such as white of egg, milk, dried milk or casein powder, fresh minced meat, chicken panada, custard, junket, and so forth, cannot be digested, then home-made peptonized foods, prepared with peptonizing powders or liquids, can be tried for a time ; but the patient should be encouraged as soon as possible to return to a more natural kind of dietary.

COMPOSITION OF PEPTONE PREPARATIONS—PERCENTAGE.

Name.	Water.	Total Nitrogen.	Insoluble Protein.	Albumoses.	Peptones.	Extractives.	Carbohydrates.	Fat.	Ash.	Authority.
Antweiler's peptone	6·92	12·85	3·22	14·54	60·15	1·74	—	·54	13·31	König.
Armour's peptone wine	83·00	—	—	3·00		12·90	—	—	1·10	Hutchison.
Benger's peptonized beef jelly ..	89·68	1·55	—	2·41	4·75	2·27	—	—	·89	König.
Brand's essence of beef	89·19	1·48	2·25	—	6·05	·15	—	—	1·31	Stützer.
,, beef peptone	84·60	—	—	7·00		—	—	—	1·40	Hutchison.
Carnrick's peptonoids (liquid) ..	5·50	—	—	24·00		65·40[1]	—	—	5·20	—
,, ,, (solid).. ..	6·75	10·49	56·25		6·93	·10	13·41	10·67	5·50	Stützer.
Darby's fluid meat	25·71	8·06	—	—	30·60	—	—	—	13·50	König.
Denayer's peptone	78·45	—	—	12·15		4·32	—	—	2·54	Leyden.
Fairchild's Panopepton	81·00	—	—	—	3·00	15·00[2]	—	—	1·00	—
Kemmerick's peptone	20·95	9·72	7·86	14·56	32·57	6·16	—	—	18·24	Stützer.
Koch's peptone	40·16	7·80	1·42	15·96	18·83	15·96	—	·79	6·89	König.
Mosquera's beef meal	—	—	48·00	29·00		13·00[3]	—	—	—	—
Murdoch's fluid meat	83·61	2·29	—	12·91	·23	1·87	—	—	·56	Stützer.
Savory and Moore's fluid beef ..	27·01	8·76	—	5·43	2·66	7·47	—	—	12·10	Stützer.
Somatose	14·25	—	25·23	33·96	3·06	2·62	—	—	5·30	Tankard.
Valentine's meat-juice	59·07	2·50	—	1·81	4·87	22·73	—	—	11·52	König.
PEPTONIZED MILK	87·50	—	2·24	1·76		trace	4·50	4·00	·72	Tibbles.

[1] Chiefly sugar. [2] Mostly sugar. [3] Mostly fat.

CHAPTER VII

THE AVES

THERE is, so far as is known, no bird or bird's egg which may not safely be consumed for food. But although all birds are edible, the flesh of some birds is sometimes rendered poisonous by foods which they eat; thus, the pheasants and partridges of America, especially the former, who eat the buds of *Calmia latifolia*, are considered to be poisonous in winter and spring. Some wild-fowls require a strong digestive power on the part of the consumer, and the flesh of others is rendered peculiar and unpalatable to many people by the food they eat; others are so small that they are not worth the trouble of killing and dressing them, and therefore need no more attention than to mention their names. The birds will be disposed of in a few notes, after giving a classification founded on those of Huxley and Ainsworth Davis. The list is compiled chiefly from the "Birds of our Country," by H. E. Stewart. Most birds belong to the natural order of **Carinatæ** (Keeled or Flying Birds), which includes the following suborders:

BIRDS.

I. PASSERES.

1. *Fringillidæ:* Genus (1) *Loxia:* Crossbill.
   (2) *Pyrrhula:* Bullfinch.
   (3) *Cacothranstus:* Hawfinch and grosbeak.
   (4) *Passer:* House-sparrow, tree-sparrow.
   (5) *Fringilla:* Finches; bunting, or water-sparrow; linnet; red-pole; canary, etc.
   (6) *Emberiza:* Ortolan; corn-bunting; yellow-hammer.
   (7) *Hirundo:* Swallow; house-martin; sand-martin.
2. *Icteridæ:* American starlings.
3. *Ptoccidæ:* Weaver-birds.
4. *Certhiidæ:* Creepers.
5. *Sturnidæ:* Starlings.
6. *Corvidæ:* Genus (1) *Corvus:* Raven, or corbie; carrion crow; hooded crow; rook; jackdaw.
   (2) *Pica:* Magpie.
   (3) *Garrulus:* Jay.
   (4) *Pyrrho-corax:* Chough.
7. *Paradiseidæ:* Birds of paradise.
8. *Paridæ:* Tits, many species.
9. *Sittidæ:* Nuthatch, woodcrackers.
10. *Lanidæ:* Butcher-bird.

11. *Sylviidæ :* Genus (1) *Locustella :* Grasshopper ; sedge-warbler.
(2) *Acrocephalus :* Reed-warbler.
(3) *Sylvia :* Blackcap ; garden-warbler ; white-throat and other warblers.
(4) *Troglottides :* Wren.
(5) *Phylloscarpus :* Furze-wren ; willow-wren, and other wrens.
12. *Cinclidæ :* Water-ouzel, or dipper, etc.
13. *Turdidæ :* Genus (1) *Turdus :* Song-thrush ; throstle, or mavis ; storm-cock.
(2) *Merula :* Blackbird ; merle, or black ouzel ; moor blackbird, or ring ouzel.
(3) *Erithacus :* Nightingale ; robin redbreast.
(4) *Accentor :* Hedge-sparrow ; Alpine sparrow.
(5) *Ruticilla :* Redstart.
(6) *Saxicola :* Wheat-ear.
(7) *Pratinocola :* Whinchat and stonechat.
(8) *Musicapa :* Goldfinch ; spotted flycatcher ; pied flycatcher.
14. *Motacillidæ :* Wagtails and pipits.
15. *Alaudidæ :* Skylark and woodlark.

II. Picariæ.

1. *Picidæ :* Woodpecker ; wryneck.
2. *Ramphastidæ :* Toucans.
3. *Capitonidæ :* Honey-guides; barbets.
4. *Trogonidæ :* Trogons ; colies.
5. *Trochilidæ :* Humming-birds.
6. *Cypselidæ :* Swifts.
7. *Caprimugilidæ :* Whip-poor-will ; nightjar, or goatsucker.
8. *Upupidæ :* Hoopoe.
9. *Meropidæ :* Bee-eaters.
10. *Bucerotidæ :* Hornbills.
11. *Alcedinidæ :* Kingfishers.
12. *Cuculidæ :* Cuckoos.

III. Striges.

Strigidæ : Owls.

IV. Psittaci.

Psittacidæ : Parrots ; paraquets ; love-birds ; macaws ; crested cockatoos, etc.

V. Columbæ.

Columbidæ : Wood-pigeon ; rock-pigeon ; stock-dove ; turtle-dove.

VI. Lariformes.

1. *Laridæ :* Gulls and terns, many species ; kittiwake ; skua, etc.
2. *Alcidæ :* Auk ; razor-bill ; guillemot, etc.
3. *Colymbidæ :* Divers, various species.
4. *Procellaridæ :* Stormy petrel ; fulmar petrel ; dabchick ; albatross.

VII. Limicolæ.

Charadridæ : Genus (1) *Charadrius :* Ringed plover ; golden plover ; grey plover ; Kentish plover ; dotterel ; turnstone, etc.
(2) *Vanellus :* Lapwing.
(3) *Hæmatopus :* Oyster-catcher.
(4) *Numenius :* Waup, or curlew ; whimbrell ; Esquimau curlew.
(5) *Totanus :* Sandpiper ; godwit ; ruff ; rock-shank ; greenshank.

Charadridæ: Genus (6) *Tringa:* Dunlin sandpiper; knott; stint; curlew sandpiper.
(7) *Scolopax:* Woodcock; snipe, great and little.
(8) *Glareole:* Pratinocole.
(9) *Himanopus:* Avocat; stilt.
(10) *Phalaropus:* Phalarope.

VIII. GRALLÆ.

Rallidæ: Genus (1) *Crex:* Corn crake; spotted crake; little crake and water-rail.
(2) *Gallinula:* Waterhen, or moorhen.
(3) *Fulica:* Coots, various.

IX. ALECTORIDÆ.

1. *Otididæ:* Bustards, various species; stone-curlew, or stone-plover.
2. *Gruidæ:* Cranes.

X. GALLINÆ.

1. *Megapodiidæ:* Mound-builders; brush-turkeys; Australian jungle-fowl.
2. *Gallinaceæ:* Asiatic jungle-fowl; domesticated fowls (*vide infra*).
3. *Phasianidæ:* Genus (1) *Phasianus:* Common, golden, silver, and argus pheasants; impeyan; tragapan; guinea-fowl; turkey, and peacock.
(2) *Coturnix:* Quail.
(3) *Perdrix:* Partridge; Guernsey partridge.
(4) *Tetrao:* Capercailzie; black grouse; red grouse and white grouse, or ptarmigan.

XI. FALCONIFORMES.

Accipitres, or Raptores: Falcons; hawks; kites; kestrel buzzard; eagles and vultures.

XII. ANSERES.

1. *Anatidæ:* Genus (1) *Anas:* Mallard, or wild-duck; gadwell, or grey duck; widgeon; teal; shoveller; garganey.
(2) *Tadorna:* Sheldrake; ruddy sheldrake.
(3) *Fuligula:* Pochard; crested pochard; tufted duck; scoter; scaup.
(4) *Somateria:* Eider-duck.
(5) *Mergus:* Smew; goosander; red-breasted goosander.
(6) *Cygnus:* Swan, various species.
(7) *Anser:* Goose; greylag, or wild-goose; snow-goose; bean-goose, etc.
(8) *Podiceps:* Grebe; crested grebe; little grebe, etc.
2. *Phœnicopteridæ:* Flamingoes.

XIII. HERODIONES.

Genus (1) *Ardea:* Heron; egret.
(2) *Botaurus:* Bittern; American bittern.
(3) *Palatalea:* Spoonbill.
(4) *Ibis:* Ibis.
(5) *Ciconia:* Storks.

XIV. STEGANOPODES.

Genus (1) *Pelicanidæ:* Pelicans.
(2) *Phalacrocorax:* Cormorant; shag.
(3) *Sulidæ:* Gannet, or solan goose.

XV. IMPENNES.

phenicidæ: Penguins.

The most important food birds are those which have been domesticated, and are bred in large numbers for the use of mankind. These are chiefly the fowls and ducks. There are others highly esteemed for food, which afford sport as well as aliment.

Fowls (Gallinaceæ).

The natural order of Gallinæ consists of the scratching birds (*Rasores*), such as the fowls, pheasants, peafowl, turkey, grouse, partridge, and quail. They are represented all over the world. They resemble each other in structure and habits, and are distinguished from other birds in the fact that the flesh of their breast and wings is of a lighter colour than that of the rest of the body. The reason for this difference is not clearly defined, but it is generally supposed that the light flesh has less muscular power. The paler breast and wing flesh occurs in those birds which chiefly *walk* about, and do not exercise the muscles of these parts to the same extent as those which fly about chiefly. The difference in the flesh is mainly due to colouring matter, which is derived from the blood, and believed to be due to differences in muscular exercise. That is to say, the muscles which are actively used, as in the breast and wings of flying birds, develop a darker or reddish tint ; while those which are not so actively used, as the breast and wing muscles of walking and wading birds, are pale or white in comparison. Birds therefore are divided into light-fleshed and dark-fleshed birds ; but it has been shown by analysis that there is but little difference in the composition, that there is practically no difference in the amount of extractives, and none in the proportion of purin bodies.

The **Domestic Fowls** (*Gallinaceæ*) are believed to be descended from the red jungle-fowl, *Gallus bankiva* or *G. ferrugineus*, with which it agrees in most characteristics. The red jungle-fowl is a native of India, Sumatra, the Philippines, Celebes, and Timor. There are other species of jungle-fowl—*e.g.*, *G. sonnerati*, of Central and Western India ; *G. Lafayettii*, of Ceylon ; and *G. varius*, of Java—which do not breed with the common fowl. There are numerous varieties of the domesticated bird which have arisen by breeding from time immemorial, probably from the Malay breed, *G. bankiva*. Some of these are prized for their tendency to grow large and fatten rapidly, others for their egg-producing qualities. Some of the most important are given by Professor James Long in the following table (see p. 160).

The best table fowls are Dorking, Modern Game, Indian Game, Orpington, and the French varieties named above. Their growth and fattening depend upon the kind of food and hygienic surroundings.

Besides the English supplies, a very large number of fowls are imported from Ireland, France, Canada, and Australia. In temperate regions fowls lay best in spring and early summer. " Spring " chickens are ready for the table at two to four months old ; older

DOMESTICATED FOWLS.

Useful Breeds of Poultry.	Varieties.	Character.	Average Weight of Cockerel (Pounds).	Average Weight of One Dozen Eggs (Ounces).	Average Number of Eggs per Annum.
Dorking	4	sitters	8 or 9	27½	120
Indian Game	—	,,	7	24	100
Old English Game	several	,,	4½ to 5½	24	90
Modern Game	many	,,	6 to 7	24	85
Orpington	several	,,	6½ to 7	27	120
American—Plymouth Rock	3	,,	7½	27	120
Wyandotte	—	,,	6 to 6½	27	120
French—La Flèche	—	non-sitters	6½	30	120
Crèvecœur	—	,,	7	31	120
Houdan	—	,,	5½	26	125
Bresse	—	,,	5	33	155
Faverolle	—	sitters	6½	27	115
Andalusian—Spanish	2	non-sitters	5	30	75
Minorca	2	,,	5	28	130
Andalusian	—	,,	5½	28	130
Leghorn	several	,,	4½	23 to 27	140 to 160
Ancona	—	,,	4½	24	140
Asiatic—Brahma	2	sitters	8 to 9	28½	85
Langshan	—	,,	8	27	100
Cochin	5	,,	8 to 9	25	80
Hamburg	6	non-sitters	4	17 to 19	170 to 200
Red Cap	—	,,	5½	20	170 to 200
Scotch Grey	—	sitters	6½	29	120
Campines	2	non-sitters	4½	25	150
Scotch Dumfries	—	sitters	5	—	100
Ornamental—Malay	—	,,	7	21	80
Aseel	—	,,	5	—	—
Polish	6	non-sitters	5 to 6	23	—
Sultan	—	,,	3	16	—
Silkies	—	sitters	3	15	50
Yokohamas, Rumpless, Naked Necks, and Bantams	—	—	—	—	—

chickens are killed all the year round. As their "laying" falls off they are fattened for the table, and sent to market in the winter months. The flesh of a mature cock is considered too tough and too highly flavoured to be palatable. The cockerels, however, are usually killed young, and sent to market as "spring chickens." Those which are not disposed of are caponized—*i.e.*, castrated. They afterwards grow to a good size and fatten readily ; their white parts develop more than in ordinary fowls, while they retain the tenderness of a chicken and are better flavoured. Hens are not often "spayed," but are kept as egg-producers. French breeders, however, practise spaying to a small extent. Such birds are called "poulards" ; they fatten better than ordinary hens, though it is doubtful whether their flesh is better or finer flavoured than that of the unspayed hen.

Pheasants.—The common name of birds of the genus *Phasianus*. They are natives of Southern Asia, but are found in all temperate regions and most parts of the earth. They are very common in France. There are many species—*e.g.*, the true pheasant (*P. colchicus*), golden pheasant (*P. pictus*), silver pheasant (*P. nycthermus*), the argus, impeyan, and tragapan. Pheasants are bred largely in Norfolk and Suffolk and in all private woods ; but the market is largely supplied by birds imported from Austria and France. In South America the place of the pheasants it taken by the curassow (*Cracidæ*) ; there are several species—*e.g.*, *Crax rubra* (the red curassow), which is about the size of a turkey ; *Crax elector* (the crested curassow), etc. The Guan (*Penelope cristata*), a large, wild bird of Guiana and Brazil, resembles the curassow in appearance and habits.

Guinea-fowls are the African representatives of the pheasants. They are domesticated birds derived from *Numidea meleagris*, a native of West Africa.

Pheasants are a delicacy and provide variety in our food ; their flesh is tender and very well flavoured after hanging a few days. Hens are preferred to cocks for the table. Guinea-fowls do not breed so freely in the domesticated state as ordinary fowls. Their flesh and eggs are a delicacy. Young birds are ready in early autumn, and are in the markets all the winter. The young and caponized birds have flesh like that of partridge, and older birds like that of pheasant, for which they make a good substitute. They require to be hung several days to develop the game flavour.

Peacock (*Pavo cristatus*), which is allied to the pheasant, is the common peafowl of Great Britain. It is a native of India, said to have been introduced to Europe by Alexander the Great. The only other known species is the Javanese or Thibetan peafowl (*P. muticus*). Peafowls have a large amount of flesh in proportion to the bone. Young peahens are as delicate as pheasants ; but mature ones are dry and tasteless, and the flesh is not esteemed so highly as that of the pheasant. Their value as ornamental birds alone keeps them from falling out of cultivation in Great Britain.

Turkeys.—The domestic turkey is derived from the wild bird (*Meleagris-gallo-pavo*), a native of North America, formerly abundant in the forests. The West Indian turkey (*Meleagris ocellata*) is closely allied. The varieties of turkey commonly bred in Great Britain are the American Bronze, the black Norfolk, and the Cambridge varieties. The Bronze variety may reach 35 to 45 pounds in weight; the two latter seldom exceed 30 pounds. Good cockerels of a year old reach 25 pounds, pullets about 17 pounds; other varieties, such as the white and buff turkeys, are much smaller, and are not bred to so large an extent.

Introduced into England in the sixteenth century, the turkey is now a common inhabitant of the farmyard, and is most highly esteemed for the excellence of its flesh and its large size. But much as they are esteemed in Europe, they are more commonly eaten in America. Turkey chickens are not much in demand—they are thin and scraggy; but when two or three months old they weigh from 2 to 3½ pounds and are sold as "broilers" in July and August. English turkeys are mostly from the shires of Norfolk, Cambridge, and Lincoln. French turkeys are from Normandy. The supply of the birds is plentiful in October, and the season lasts until March. New England turkeys are common in the Eastern States until January; later in the season they are derived chiefly from the Western States, whence they are sent in cold storage in large numbers until late in the spring. Canadian birds are also sent in cold storage to the United States and to Great Britain.

Brush Turkeys (*Megapodii*) are birds of Australia, closely allied to the former. The common variety (*Tali-galla Lathami*) is about the size of a turkey, and is much esteemed. The Australian jungle-fowl (*Megapodius tumulus*) is somewhat larger.

Grouse: The common name of birds of the genus *Tetrao*, including the capercailzie, or wood-grouse (*T. urogallus*), which exists chiefly in mountainous regions, and is common in the woods of Russia and Sweden; it weighs 10 or 12 pounds, or is often as large as a turkey. It is nearly exterminated from Britain. Red grouse, or woodcock (*T. Scoticus*), is plentiful in the heathy tracts of the North of England, Wales, and Highlands of Scotland, in the Ardennes, Brittany, and Burgundy, whence it is imported; it is much smaller than the former, its average weight being 19 ounces. Black-cock (*T. Tetrix*) is also found in the most northerly parts of Britain, but also on the moors and downs of other parts of England. They are often as large as a fowl, but are bigger in Norway, and some-times rival the turkey in size. White grouse, or ptarmigan (*T. mutus*), is about the same size as the red grouse, and is found in the Highlands and mountains of Scotland, in the Hebrides and the Orkneys. They are largely imported from Norway. In America there are also the prairie-hen (*T. cupido* or *Tympanomachus Ameri-canus*), the spotted grouse (*T. Canadensis*), the dusky grouse (*T. obscurus*), of the Rocky Mountains, etc.

Partridge (*Perdrix cinereus*) belongs to the grouse family. The

common partridge is the most plentiful game bird in Great Britain. It occurs in nearly all parts of Europe, Northern Africa, and Western Asia. Its food consists of grain, seeds, vegetables, berries, nuts, and larvæ. Besides the common partridge there are the red-legged or Guernsey partridge (*P. rufus*), the Greek partridge (*P. saxatilis*), the African, Arabian, and Indian partridges, each having distinguishing characteristics. In North America the name "partridge" is applied indifferently to birds of the genus *Ortyx*. They differ from birds of the same name in Europe in several anatomical particulars. The Virginian colin (*O. Virginianus*) is a well-known partridge. The Maryland and Californian quails are members of the same genus. The mountain partridge of America (*O. pictus*) also belongs to it. Partridges are largely imported into England from Austria, and the red-legged partridge from Guernsey and Russia, but they are not considered to be equal to native birds.

Quail: The common name of birds of the genus *Coturnix*, allied to the grouse and partridge. The common quail (*C. vulgaris*) is a migratory bird, smaller than the partridge, found in every country of Europe, Asia, and Africa, from the North Cape to the Cape of Good Hope. Its flesh is good food, and provides a luxury for the table. The taming and cultivation of quails is carried on in some countries; a small but increasing industry has arisen therefrom in America, the bird most commonly tamed being the variety known as Bob White. There are various other species which differ somewhat from the common form, as the Australian, Chinese, and Coromandel quails. The English supply of quails is largely derived from Italy, Sicily, Egypt, and Algeria.

Tinamou.—The tinamous of South America are gallinaceous birds, somewhat between a pheasant and a quail. The great tinamou (*T. Braziliensis*) is about 18 inches long, and inhabits the forests of Guiana; a smaller species (*T. elegans*), about the size of a grouse, is also common. Their flesh is white and delicate, and highly esteemed as food.

Pigeons belong to the subclass *Columbæ*, family *Columbidæ*. They are amongst the most numerous and widely distributed birds. All the common forms are believed to be descended from the rock-pigeon or stock-pigeon (*C. livia*). They are vegetarians, and are found in almost all parts of the world. There are several species and a large number of varieties. The wood-pigeon (*C. palumbus*), also called the cushat and ring-dove, is the largest British species, being about 17 inches long, and is highly esteemed for food.

Pigeons have always been used for food in Europe, more than in America. There is very little difference in the colour of the flesh on their breast and wings compared with that of the rest of the body. They are classed with the domestic fowls as white-fleshed birds. The young birds are better for the table at four weeks old—that is, before they begin to fly; they are then called **squabs**. The cultivation of pigeons for consumption at this stage is now very great. Adult pigeons are not so tender or so well

flavoured; in fact, after they have been allowed to fly, their flesh becomes tough and requires long and careful cooking to render it palatable.

Ducks.—The common mallard (*Anas boschas*) is the commonest of all our wild-ducks. It is well known as an inhabitant of Europe, Asia, and America. Its habitat is the marshy and fenny districts, Its numbers are enormously increased in winter by migration. Large numbers are taken in Lincolnshire and Picardy (France). It is the species from which all our farmyard **ducks** (*A. boschas*, var. *domesticus*) have descended. There are several breeds of domestic ducks in Great Britain, but those mostly bred for food purposes are the Aylesbury, the Rouen, the Pekin, and the Indian Runner. They attain a weight of 6 or 7 pounds, well-fed ducklings being about 4 pounds in weight at nine weeks old, when they are ready to kill.

The **Widgeon** (*A. penelope vel mareca*) is also one of the commonest wild-ducks in the British Isles in the winter; it is a migratory bird, few remaining to breed in Scotland. The natural breeding-grounds are the northern regions of Europe; they journey southwards in the winter. The American widgeon (*Anas vel Mareca Americana*) is very abundant in Carolina. They are much in request for the table. The garganey (*A. circia*) is a migratory bird, found expecially in Norfolk.

Teal (*Anas crecca*) is the smallest of the duck family; it makes its appearance in England in September, and remains until spring about fresh-water lakes. Their breeding-ground is in northern countries. There are several American varieties (*A. Carolinus* and *A. discor*), which are somewhat larger than the former, and are easily domesticated. They are all estimable for food.

Sheldrake.—There are two British species: *A. tadorna* or *Tadorna cornuta*, the common sheldrake; and *T. rutila*, the ruddy sheldrake.

The Goose.—The domestic goose (*Anser domesticus*) is distributed nearly all over the globe, being met with in Europe, America, Arabia, Persia, and as far north as Iceland and Lapland. It lives chiefly upon land, and is believed to be a descendant of the common wild-goose, or grey-lag goose (*A. cinerius*), which inhabits marshy districts in the temperate regions of Europe and Northern Africa, and as far east as Persia. The greylag is a migratory bird, and was a common visitor to England before the fens were drained; now it is only a winter visitor, although a few remain to breed in the Hebrides. Other wild varieties of geese are the bean goose (*A. segetum*), brent goose (*A. brenta*), bernacle goose (*A. leucopsis*), swan goose (*A. cygnoideus*), Canadian goose (*A. Canadensis*), etc.

The domestic varieties of geese known in this country are the White Embdem, the Grey Toulouse, the Canadian, and the Sebastopol. Embden geese reach 22 to 24 pounds in weight, ganders 30 pounds; Toulouse ganders attain a weight of 35 to 38 pounds. Geese are very abundant in Germany, where their flesh is eaten in every imaginable form. Goose-fat is eaten by orthodox Jews, and is

considered an excellent constituent of many dishes. The breasts of geese are smoked and dried ; their flesh is also pickled and preserved in fat. Pökelgans is a popular preparation. Pâté de foie gras is prepared from the liver of fattened geese. Green goose is the half-grown bird. Adults are eaten up to three years of age, but their flesh becomes tough and loses flavour as they become old. Geese are bred largely in the counties of Norfolk, Suffolk, and Lincoln, but great numbers are imported from Ireland, France, Hungary, and Russia.

Pâté de Foie Gras.—The fattening of geese in such a manner as to induce fatty infiltration of the liver has long been an industry in Alsace-Lorraine, Languedoc, Toulouse, etc. The liver frequently weighs 2 or 3 pounds. When the birds are considered ready they are killed, their livers removed, cleaned, and transferred to a refrigerator, where they are packed with **truffles** between them for about a week, in order that the aroma of truffles may permeate them. The proportion is two parts by weight of liver and one part of truffles. The livers are then cooked and seasoned. The pâté is not always genuine, but may be a mixture of goose liver, pork, and lard, reduced to a paste. In 1902 the American Consul at Bordeaux stated in his report that it was exported in three forms : (*a*) *Foie gras naturel,* consisting of the liver simply cooked, without seasoning or any sauce, excepting the oil from the liver itself ; (*b*) *Pâté de foie gras,* so named because it was originally packed in **paste** ; it now usually consists of the liver of geese and ducks combined with sausage meat, lard, and truffles ; (*c*) *Purée de foie gras,* consisting of pieces of liver, the trimmings of livers which have been packed, mixed with hashed meat and truffles.

Swan (*Cygnus*) was more commonly eaten in former than in present times. The flesh of the young is considered delicious by some authorities, but it is too highly flavoured to become a popular food. There are several species : The wild-swan, or hooper (*C. ferus*) ; tame swan (*C. olor*) ; the Bewick swan (*C. Bewicki*) ; the black swan (*C. atratus*), an Australian species ; the American swan (*C. Americanus*), etc.

The **Grebe** (*Podiceps* and species), abundant in England and elsewhere, are not despised for food. **Flamingoes** (*Phœnicopterus ruber*), common in Europe, were once esteemed, and their tongues were extravagantly prized as a luxury by the Romans. **Pelicans,** of which there are speces in all countries, were also formerly esteemed. The allied gannet, or solan goose, is now chiefly valued for its down, a great number of the birds being annually taken in the Hebrides. Cormorants, terns, petrels, gulls, are all eaten occasionally. The guillemot is esteemed a great delicacy, and affords a source of profit to the inhabitants of the Orkneys, where the birds breed in great numbers. **Penguins,** which inhabit the shores of high southern latitudes, are considered good eating.

Among wading birds there are several species which are highly esteemed. The **Plovers** (*Charadrius*) are much esteemed, especially for their eggs, which are esteemed a delicacy, and are collected and sent to the London markets in the season. The family of plovers inhabits the temperate regions of the whole world. They are seen in meadows, on the banks of rivers, and on the seashores. The chief British species are the golden plover (*C. pluvialis*), which is common in the Highlands and western isles of Scotland, where it resorts to breed in the heaths and moors. It is distributed throughout the

British Isles in winter, and is especially abundant in the eastern counties. Their flesh is good eating; large numbers are shot for the table in September and October, when they are in perfect condition. The ringed plover, (*C. hiaticula*) is a resident of British Isles, and one of the commonest coast birds; the numbers are increased by migration in the autumn. The grey plover (*C. helveticus*) is also a British bird, not so common as the former. The Kentish plover (*C. Cantianus*) is a visitor to our southern and eastern coasts, which breeds sparingly in Kent and Sussex. The dotterel (*C. morinellus*) is a summer visitor, its favourite breeding-places being the wildest and most mountainous districts of Scotland. The turnstone (*C. interpres*) is a visitor in spring and autumn, its breeding-ground being the Arctic regions. The lapwing, or green plover (*Vanellus cristatus*), also known as "peewit," frequents the open and uncultivated districts, being especially frequent about low-lying and marshy lands. Their eggs are a great delicacy; many thousands are sent to London annually, and are sold at fourpence to sixpence each, and have even fetched ten shillings each for the royal table in the early season.

The **Woodcock** (*Scolopax rusticola*) is a winter visitor, breeding sparingly in the British Isles. Its flesh is a great delicacy. It is common throughout Europe and the North of Asia as far as Japan. The American woodcock (*S. minor*) is a smaller bird than that of the Old World. The **Common Snipe** (*S. gallinago*) is distributed all over Europe, and is plentiful in Britain, where it frequents marshy grounds. The jack-snipe (*S. gallinula*) closely resembles it; is common in Europe, but only seen in England in winter. Godwits, sandpipers, culrews, and ruffs, allied to the woodcocks and snipes, are visitors whose flesh is esteemed for food.

The coots (*Fulica*) are found throughout Europe and Asia. Those of India and China are said to be identical with the European; but the American species (*F. Wilsonii*) is a distinct species. The rails also have delicious flesh. The European species are the water-rail (*Rallus aquaticus*) and the land-rail, or corncrake (*Crex pratensis*). The moorhen, or waterhen (*Gallinula chlorinopus*), has also well-flavoured flesh.

The storks (*Ciconia*) and cranes (*Gruida*) are not esteemed for food; but the **Herons** (*Ardea cinerea*) were formerly most highly esteemed for the table, and were the special object of hawk-hunting. The green heron of America (*A. virescens*) is much esteemed for food, as also is the allied tantalus of America and Africa, and the spoonbill.

Sea-Ducks (*Fuligula*).—**Pochard** is the common name of various sea-ducks which are natives of the Arctic seas, but flock to European, Asiatic, and American temperate regions in the winter. They are fine eating. The common pochard (*F. ferina*) is commonly sold in London markets in winter. The **Scaup** (*F. marila*) is common in Northern Europe and America, and is abundant on the British coasts in winter. It feeds on small fish and mollusca; hence its flesh is coarse. The **Canvas-back Duck** of America (*F. valisneria*) is highly prized for food. The **Garrot** (*Clangula chrysophthalmus*), or golden-eyed garrot, is a common species in Britain. There are other species widely distributed over the temperate seas of Europe and America. The **Scoter** is a genus of oceanic ducks common in northern waters; several species visit the British seas. The common or black scoter (*F. nigra*), about the size of a duck, is common on our coasts in winter, but retires to Arctic waters in the summer. Others are the velvet scoter (*F. fusca*) and surf-scoter (*F. perspicillata*). Their food consists of shellfish and crustaceans, and their flesh has a fishy taste. The **Eider Duck** (*Somateria mollissima*) is a northern bird, abundant in Iceland and Greenland. They visit the British shores in great numbers, especially the rocky coasts of Scotland and the western islands. They are of especial value for their down.

Many of the song-birds have delicate flesh, and are now, or were formerly, much sought after as luxuries, especially thrushes (*Turdus* and its species), larks (*Alauda arvensis* and varieties), and ortolans. The latter (*Emberiza hortulana*) are natives of Northern Africa, but visit Europe in the spring and autumn, when they are killed in great numbers, while some are caught in nets in France and Italy, and fattened for the table. Ortolans have always been much esteemed by epicures.

Flesh only.	Nutrients per Cent.					Calories per Pound.
	Water.	Protein.	Fat.	Carbohydrate.	Ash.	
Fowls: Chicken	66·90	22·60	10·10	—	1·1	1,000
Capon	55·80	21·60	22·10	—	1·2	1,460
Broiler	69·20	21·20	8·80	—	1·1	880
All others	63·40	19·40	16·60	—	1·0	1,215
Giblets	72·80	18·70	6·10	—	1·3	730
Pheasant	70·00	24·70	4·60	—	1·1	815
Partridge (König)	71·60	25·35	1·45	—	—	—
Turkey: Light meat	63·90	25·70	9·40	—	1·3	1,065
Dark meat	57·00	21·40	20·60	—	1·1	1,435
Giblets	56·70	17·70	23·50	—	1·2	1,480
Duck: Breast	73·90	22·30	2·30	—	1·3	685
Other meat	55·50	17·40	26·10	—	1·0	1,540
Duckling	48·30	13·50	37·90	—	0·7	1,950
Green goose	46·00	15·00	38·30	—	0·8	2,030
Goose	51·80	16·20	31·50	—	1·0	1,755
,, very fat (König)	38·02	15·89	45·61	—	—	—
Pigeon	63·20	22·90	12·10	—	1·4	1,100
,, squabs	56·60	18·50	23·80	—	1·4	1,470
Quails	66·30	25·40	7·00	—	1·4	945
Guinea-hen	68·90	23·40	6·50	—	1·3	865
Canned turkey	47·40	20·70	29·20	—	2·7	1,790
,, chicken	57·60	27·70	12·80	—	2·2	1,245
,, quail	66·90	21·80	8·00	—	1·7	935
Potted turkey	56·00	17·20	22·00	—	3·0	1,390
,, chicken	56·10	19·40	20·30	—	2·5	1,390
Poultry, average composition (Parkes)	74·00	21·00	3·80	—	1·2	—
Cooked: Roast capon	59·90	27·00	11·50	—	1·3	985
,, turkey	52·00	27·80	18·40	—	1·2	1,295
,, plover with sauce	57·70	22·40	10·20	7·6	2·1	985
,, quail ,, ,, ..	66·90	21·80	8·00	1·7	1·6	775
Fricassee of chicken ..	67·50	17·60	11·50	2·4	1·0	855
Pâté de foie gras	41·30	13·60	38·20	4·3	2·6	2,075

The above analyses are mostly by Atwater and Bryant.

The edible portion of the flesh of birds has the following composition: Water 55 to 73, proteins 15 to 25, fat 5 to 38, mineral salts 0·7 to 1·4, per cent. The table on p. 167 shows the composition of birds of the genera commonly eaten. The flesh resembles that of the mammalia in composition, but is never marbled by fat like that of sheep and oxen. In some birds the whole flesh is white, and in others it is dark-coloured. The colour also varies in different parts of the same bird, that on the wings being whiter, drier, and of a more delicate flavour, than that on the legs. In blackcock the layer of muscles forming the outer part of the breast is of a dark-brown colour, whilst the deeper part is white. The amount of fat varies from 1·45 in partridge to 38 per cent. in green goose. In young birds it is distributed throughout the tissues, but in old birds is accumulated in the subcutaneous regions and about the internal organs. The composition of the muscular tissue, according to Hammarsten, is as follows:

MUSCULAR TISSUE OF BIRDS—PARTS PER THOUSAND.

Solids	227 to 282
Water	717 ,, 773
Organic bodies	217 ,, 263
Inorganic bodies	10 ,, 19
Myosin	30 ,, 111
Stroma substance	88 ,, 184
Creatin	3·4
Purin bodies	0·7 to 1·3
Glycogen, sugar, fat, etc.	10·0 ,, 30·0
Inosinic acid	0·1 ,, 0·3
Salts	7·0 ,, 10·0

A comparison of the composition of birds with mammalian muscular tissue shows that bird's flesh contains 10 to 30 parts per 1,000 less water, and in consequence contains a greater proportion of organic bodies. But owing to the muscular fibres of birds being smaller, the proportion of stroma substance is greater than in mammalia, and therefore the actual amount of myosin is about the same—viz., an average of 70 per 1,000. The creatin in bird's flesh is 3·4 per 1,000, as compared with only 2·0 per 1,000 in mammals. On the other hand, the purin bodies are less, being only 0·7 to 1·3 in birds and 1·3 to 1·7 per 1,000 in mammals. This account by Hammarsten does not quite agree with the report of some other authorities, who state that the total amount of **meat-bases** (which includes creatin) is as follows: Fowl, white meat 3·7, dark meat 10·3; duck, 6·5; turkey, 13·0—per 1,000. The notion that the flesh of birds, along with that of lamb, veal, and rabbit, is more healthy than **red** meat is not true if the supposed difference depends on the proportion of purin bases. It was for a long time customary to forbid certain patients to consume red meats, but to allow white meats, on the supposition that red meat was more injurious in gout

and kidney diseases. Von Noorden and others, however, assert that the difference in the proportion of extractives in red and white meat is inconsiderable, and that where one is allowed the other, also, may be permitted. With respect to the purin bodies, Walker Hall, who thoroughly investigated the subject, gave the following :

PERCENTAGE OF PURINS.

Tripe	0·057	Salmon	0·116
Codfish	0·058	Pork loin	0·121
Plaice	0·079	Turkey	0·126
Mutton	0·096	Chicken	0·129
Rabbit	0·097	Beef sirloin	0·130
Halibut	0·102	Beef steak	0·206
Beef ribs	0·113	Beef liver	0·275
Veal	0·116	Sweetbread	1·006

The flesh of young birds contains a larger proportion of protein, that of old ones a larger proportion of fat ; the flesh of young birds also contains more water, and is not so compact as that of old ones. Although certain parts of the flesh of birds are of a light colour, while others are darker, and contain more extractives and colouring matter, artificial digestion experiments show that about the same proportion of light and dark meat is digested in an equal space of time. Some parts of the flesh contain more fat than others ; *e.g.*, the flesh of the legs and back contains more fat than that of the breast and wings. The breast is therefore digested more easily than the legs. The breast also contains somewhat more protein, and therefore yields a little more nutriment than that of legs for an equal digestive effort.

The chief differences in the nutritive value of the different kinds of birds depends on their chemical composition. The proportion of the protein absorbed is 97 per cent., and of the fat about 95 per cent. But the texture of the fibres also lends a difference, those of the breast being as a rule more tender than those of the leg. Young birds are also more digestible than old ones, because of the greater development of sarcolemma and tendinous tissue in the latter. White-fleshed birds are more digestible than dark-fleshed ones, because the fibres are less closely set in the white flesh, such birds being less active, while in dark-fleshed ones the muscles become more compact by exercise. In a boiled fowl the fibres are softened by moist heat more than they are by roasting ; therefore a boiled fowl or turkey is more easily digested than a roasted one. It should, of course, not be overlooked that the power of digestion varies in different individuals. In normal individuals the variations in digestion are slight, and the above figures refer to digestion in such persons. In invalids the digestive functions vary so much that no exact standard can be given, excepting that boiled or stewed birds are more easily digested than roasted ones, and young birds than old ones.

The available energy of the edible portion of birds is as follows: Chicken 780, pheasant 830, guinea-hen 870, quail 935, pigeon 1,060, fowl 1,070, duck 1,125, turkey 1,195, goose 1,485, calories per pound of flesh. This compares well with other foods—*e.g.*, beefsteak 555, lean beef 575, leg of lamb 585, sirloin of beef 970, leg of mutton 1,085, halibut steak 477, eggs 605, white bread 1,165, potato 305, calories per pound.

The place of poultry in the diet is that of providing variety of food and preventing the satiety and loss of appetite which is apt to follow constant feeding, even with the best materials, of any class of food. Birds provide delicious meat, which forms a palatable nitrogenous food. Whether it is as economical as mammalian meat is another matter, and depends upon place and circumstances. The meat of birds is so delicate and appetizing to most people that it has a value for invalids and convalescents, and all those whose appetite is capricious, which is far above any consideration of economy.

Many conditions influence the flavour and quality of the flesh of birds. With respect to the domestic birds, the *breed* is of undoubted importance. Not less important is the age: while a young bird is tender, and has flesh of a delicate flavour, old ones are tougher, owing to hardening of the muscular fibres and increase of the sarcolemma. The fat of young birds is distributed throughout the muscular system, while that of older ones tends to become subcutaneous, and decidedly accumulates in some parts of the body more than others. Although the flavour of the flesh is increased by age, it does not always remain of the delicate character observed in that of young birds; it becomes stronger owing to an increase of extractives in the muscular tissues. While the extractives increase, the nucleo-proteins decrease, as adult life is reached. The flavour of the bird is also dependent on the sex, the flesh of cocks being usually stronger than that of hens, which retain more or less the delicacy of chickens. The influence of the sexual organs on the flavour and tenderness of the flesh is remarkable. A three-year-old capon (castrated male bird) is as tender and delicate as a young pullet; at the same time it is fatter and of greater bulk than an ordinary cock. To be effective, caponizing should be performed as soon as the sex is distinguishable, and the birds are best killed at a year old. The unsexing of the bird, when properly done, has the following effects: The head remains small, somewhat like that of a hen; the comb becomes pale and withered, instead of becoming red and turgid, as in the properly developed bird; and the spur is rendered abortive. If the operation is incomplete, the head is like that of an ordinary cock, and the body less plump than in a proper capon; such birds are called "slip-capons," and have not the value of the properly castrated bird.

Birds are fattened for the table by good feeding, and in domestic birds the system of cramming by hand or funnel, or the French cramming machine, is largely adopted. The effect of the food on

the flesh is of great importance, especially in birds bred for the market. It is well known that the flavour of both eggs and flesh is thus influenced. The consumption of strong food—*e.g.*, onions—by fowls gives an undesirable flavour to the eggs. Ducks and geese, like other water-birds, develop a fishy flavour if they consume too many fish, water-insects, or larvæ. On the other hand, the characteristic flavour of some birds is due to vegetables ; *e.g.*, the flavour of the canvas-back duck is due to the wild-celery which they eat on the shores of the Chesapeake Bay. Birds fed upon scraps of meat, offal, and other flesh food, have a darker-coloured flesh than those fed almost entirely on grain ; this is especially so in the case of the domestic fowls. Even the kind of grain causes a difference in the flesh. At Cornell experiment station, two lots of chickens were fed, one with wheat, the other with maize. The maize-fed chickens contained large masses of fat, but their flesh was paler and drier than that of the birds fed on wheat and milk, whose flesh was darker, but more juicy and tender. Yellow Indian corn makes the flesh yellow, but oats, buckwheat, and milk, cause it to be of a creamy colour.

The activity of birds also influences the flesh, as already noted. In birds who fly about, the breast and wings are darker than in those who wade or walk about. The flesh is also fatter and more tender in less active birds, but it has less flavour than in active and wild birds. Captivity influences the amount of fat. This well-known fact is taken advantage of by breeders, who confine their birds in small pens ; such birds become plumper, in consequence of their inactivity, than birds which are allowed more liberty. In many feeding-stations, fowls, ducks, geese, etc., are not only fed liberally, but, during the last week or two before being sent to the market, are fed by a cramming machine, which gives them a finer appearance and greater plumpness than similar birds which are merely confined in pens. A great industry has thus arisen in fattening birds in England, France, Germany, and Belgium. The fattening of geese is practised on a large scale about Toulouse, Strasbourg, and other places, where the birds are confined in crates, and fed two or three times a day with maize or wheat meal. The liver undergoes fatty degeneration in about three weeks, when the birds are killed and the liver removed. This organ often weighs 2 to 3 pounds after such treatment, the special object of which is to produce *pâté de foie gras*.

The birds are usually killed after fasting half a day to empty the organs of food and excrementitious matter. They are plucked at once. The removal of the feathers is aided by dipping them in boiling water ; but this method injures the skin, and induces decomposition more rapidly than when they are dry-plucked. In large establishments the birds are removed at once to a cool room, as the retention of animal heat hastens decomposition. Some poulterers plunge them into cold water to cool them before putting them into cold storage. This has the further effect of making them look plumper. There is no objection to plunging the birds for a few minutes in pure cold water, but the use of unclean water is very

objectionable, because the skin absorbs water (and micro-organisms), and the birds have a plumper appearance after being soaked. This method of treating the birds is frequently resorted to by salesmen, but the injuriousness of the practice should be observed, as well as the fraud of selling birds swollen beyond their natural size in this manner. Another practice of the poulterer is to inflate the birds by pumping air into them by the mouth or bellows, which is even more objectionable than that of soaking them in water.

Changes in the Birds after Slaughtering.—Rigor mortis sets in when the body is well cooled, and lasts a few hours, passing off, as in other animals, probably as the result of the action of cellular enzymes. Birds which are cooked immediately after being killed have a different flavour from those which are not cooked until after the rigor mortis passes off. Rigor mortis is succeeded by changes produced by normal cellular enzymes or by micro-organisms. These changes consist in the softening of the flesh and tendons, which begins soon after the passing of the rigor mortis, and gradually increases. At the same time certain substances are produced from the flesh which give rise to a characteristic flavour known as the *game flavour*. The development of this flavour is desired in many birds to increase the palatability of the flesh. But if the changes are allowed to continue beyond the primary stage, the flesh develops the characteristic odour and taste due to decomposition, when it is unsafe to be eaten owing to the probable presence of poisonous ptomaines.

When dead birds are sent to market, the abdominal viscera are removed or not removed, according to the custom of the district. It is argued against the removal of the organs, that by evisceration the internal surface of the carcase is exposed to the atmosphere and micro-organisms, and that such exposure does not occur when they are not eviscerated, and consequently the birds keep better. On the other hand, the viscera are more prone to decomposition than the muscular tissues, and the putrefactive organisms may spread from the viscera to the muscles. A diffusion of the visceral contents may also occur—*e.g.*, bile—and thus communicate an undesirable flavour to the flesh. It has also been shown by observation that eviscerated birds actually keep fresh several days longer than non-eviscerated birds.

Birds are transported long distances after death, and are often stored for a considerable period after arriving at their destination. Some means is then usually taken to delay the putrefactive process. Antiseptics, such as sulphurous acid and salicylic acid, have long been used for the purpose of sponging the interior of eviscerated birds ; brine is also used by some poulterers. Birds will remain " sweet " for about a week after death without any special preparation if hung in a cool place, with temperature not exceeding 50° F. But when there is a prospect of a longer interval intervening before their consumption, they are kept in **cold storage** at a temperature just above freezing-point—say 34° F. They may thus be kept for a long and indefinite period without injuring their palata-

bility. Sometimes, especially in hot weather, the birds are frozen by submitting them to a temperature of 5° to 10° F. for a time, and afterwards kept at 30° F. ; but freezing injures the delicate flavour of the flesh, and decomposition sets in very rapidly after their subsequent exposure to the ordinary atmospheric temperature.

Changes produced by Cooking.—Water is driven off, fat dissolved out, and the flesh loses weight. The exposure to heat develops various flavours, destroys micro-organisms, and produces changes in the flesh. A moderate temperature, as in stewing, softens the muscular fibres and connective tissues. But very great heat, as in roasting and boiling, hardens the protein substances, and renders them less digestible ; but this disadvantage is counterbalanced by the development of flavour and an improvement in appearance. The fats are more or less changed ; those upon the surface are rendered empyreumatic, and the surface of the flesh is more or less browned and changed by the heat. The flesh below the surface is softer than before cooking, and certain acids are produced which affect the fibres in a manner similar to digestion, and assist the action of the gastric juice on the flesh. In roasting or broiling, the bird is at first exposed to a high temperature, so that the protein on the surface is coagulated and keeps in the juices of the flesh ; the coagulation of the exterior is aided by *basting*—that is, by pouring the exuded fat at intervals over the surface. In boiling, the bird is put at once into boiling water, which hardens the surface and forms a coating which keeps the juices in the flesh. In frying, the meat is cooked in fat which coagulates the proteins on the surface ; fried birds, however, are less easily digested than either boiled or roasted birds, because the fat is rendered empyreumatic. In the case of old birds, the flesh is softened by stewing or boiling more than by roasting, whence this method of cooking is preferred. An old fowl can be rendered very tender by cooking it in a bain-marie, or double pan, but this requires a much longer time than any other mode of cooking. The accompaniment of sauces or "stuffing" is common. Sauces consisting of cornflour and milk or eggs and milk are suitable for fowls which have been boiled, and do not disagree with invalids. The customary "stuffing," containing parsley, thyme, sage, or marjoram, is a valuable accompaniment of many birds ; it stimulates appetite, but is not very digestible. Onions and sage, the common accompaniment of ducks, stimulate a flow of the digestive juices, create appetite, and add to the pleasures of eating. Chestnuts and peccan-nuts are considered the best stuffing for a turkey. The gravy made from the gizzard and other organs is palatable, and also adds to the pleasures of the repast.

Eggs.

The eggs of birds are used for food in all parts of the world. The eggs of domesticated birds are used to an enormous extent, especially those of the fowl ; the eggs of ducks, geese, turkeys, and guinea-fowls, are also much used, but to a less extent than the former.

Some eggs are prized for their flavour rather than for their bulk—*e.g.*, the plover's and guinea-hen's eggs are esteemed a delicacy. The eggs of wild birds, as those of the woodcock, gull, tern, cormorant, kittiwake, plover, and heron, are eaten. Those of the ostrich are occasionally eaten in countries where ostrich-breeding is an industry. The eggs of other animals, such as the turtle and terrapin, are highly esteemed for food where they are abundant. Those of the sturgeon and shad also have a food value, which is referred to in another chapter.

Generally speaking, when reference is made to eggs as an article of food, those of the domestic birds, and usually of the ordinary fowl, are intended. The table (on p. 175) of the composition of eggs is from Langworthy's " Eggs, and their Uses as Food."

There are, of course, many analyses of eggs obtainable, but the accompanying table is believed to give sufficient, and is the most complete. The **refuse** of eggs consists of the shell and its lining membrane ; the average amounts to 11 per cent. of the hen's egg, 13·7 per cent. of the duck's, 14·2 per cent. of the goose's, 13·8 per cent. of the turkey's, and 9·6 of the plover's.

Eggs are a very nutritious article of food ; without the shell a hen's egg contains an average of 25 per cent. of nutriment, and yields forty-five large calories per ounce. The proportion of protein and fat is such that they may be considered a well-balanced food. They contain a small amount of carbohydrates, not shown in the table, amounting in ducks' eggs to 0·3 ; fowls' eggs, 0·67 ; turkeys' and guinea-fowls' eggs, 0·8 ; geese's eggs, 1·3 ; and plovers' eggs, 2·0—per cent. In the hen's egg one-third of the carbohydrate is in the yolk, and two-thirds in the white.

It is generally considered that eggs of a darker colour of shell are richer than those having a pale or white shell ; but the difference on analysis is so small as to be negligible. With respect to the proportion of protein, analyses show a discrepancy between protein by factor and protein by difference ; thus, the average composition of a hen's egg is, Water, 73·7 ; protein (by factor), 13·4 ; fat, 10·5 ; and ash, 1·0—per cent. But the proportion of protein by difference would be 14·8 per cent. Eggs contain some nitrogenous fats, and therefore the factor—protein = N × 6·25—is probably incorrect as applied to them, and accounts for the error.

The white of an egg consists of innumerable thin-walled cells of large size. It contains four proteins : ovalbumin, conalbumin, ovomucin, and ovomucoid. The chief protein is ovalbumin, which forms nearly the whole of the egg-white ; conalbumin is similar to it, but in a much smaller proportion ; ovomucin and ovomucoid, also in very small proportions, are gluco-proteins—*i.e.*, they contain a carbohydrate in their molecule. There is also a small amount of a separate carbohydrate. The proportion of phosphorus is equal to 0·03 per cent. of phosphoric acid ; there is also some sulphur. These elements account for the formation of phosphuretted and sulphuretted hydrogen during the decomposition of eggs.

THE COMPOSITION OF EGGS AND THEIR SUBSTITUTES.

	Nutrients per Cent.					Calories per Pound.
	Water.	Protein.	Fat.	Carbohydrate.	Ash.	
Hen's egg: Whole, as purchased ..	65·5	11·9	9·30	—	·9	635
Edible portion	73·7	13·4	10·50	—	1·0	720
Boiled: Edible portion	73·2	13·2	12·00	—	·7	765
White	86·2	12·3	·20	—	·6	250
Yolk	49·5	15·7	33·30	—	1·1	1,705
Duck's egg: Edible portion	70·5	13·3	14·50	—	1·0	860
White	87·0	11·1	·03	—	·8	210
Yolk	45·8	16·8	36·20	—	1·2	1,840
Edible portion of—						
Goose's egg	69·5	13·8	14·40	—	1·0	865
Turkey's egg	73·7	13·4	11·20	—	·9	720
Guinea-fowl's egg	72·8	13·5	12·00	—	·9	755
Plover's egg	74·4	10·7	11·70	—	1·0	695
Turtle's egg	76·4	18·8	9·80	—	·4	738
Evaporated hen's egg	6·4	46·9	36·00	7·1	3·6	2,525
White	11·7	73·2	·30	8·6	6·2	1,501
Yolk	5·9	33·3	51·60	5·7	3·5	2,794
Egg-substitute	11·4	73·9	·30	5·3	9·1	1,480
Custard powder	13·0	2·1	3·40	80·9	·6	1,690

The yolk contains considerably less protein, but considerably more fat, including 20 per cent. of palmitin, stearin, and olein, besides lecithin, 7·2; cholesterin, 0·4; cerebrin, 0·3; and glycero-phosphoric acid, 1·8—per cent. The protein of yolk is **vitellin,** which is largely combined with nuclein and lecithin, and behaves like a globulin, being soluble in a salt solution. This compound was named "lecithin-nucleo-vitellin" by the experimenters of the Connecticut State Experiment Station, who found that it contained 15 to 30 per cent. of lecithin. Another compound protein, free from lecithin, was also separated by them, and named "nucleo-vitellin." The colouring matter of the yolk is called **lutein**; it amounts to 0·5 per cent. and is of a yellow colour, but its exact character is not known. The proportion of phosphorus is rather more than 1 per cent., and is chiefly in the form of phosphorized fats.

The shell is of no food value. That of the hen's egg consists of calcium carbonate, 93·7; magnesium carbonate, 1·3; calcium phosphate, 0·8; and organic matter, 4·2—per cent. The shell of other birds' eggs has a similar composition. Of much greater importance are the **mineral substances** of the interior. They are precisely those needed for the growth of a young bird, and are important tissue-forming elements. Analyses of the ash show that phosphoric acid and lime predominate in the yolk, potassium, sodium, and chlorine, in the white. König gives the following:

COMPOSITION OF THE ASH OF EGGS.

	Percentage. White.	Yolk.
Potassium	31·41	9·29
Sodium	31·57	5·87
Lime	2·78	13·04
Magnesium	2·79	2·13
Oxide of iron	0·57	1·65
Phosphoric acid	4·41	65·45
Sulphuric acid	2·12	—
Fluorine	1·06	0·86
Chlorine	28·82	1·95

It is probable that most of these elements are in organic combination with the proteins. This is so, at any rate, with regard to some of them, especially calcium, which is thus made a very assimilable compound, and exists in highest proportion in the yolk. The same remark applies to phosphorus, which, with the exception of a little glycero-phosphoric acid, is practically all in an organized form in the proteins and fats. The iron is combined with nuclein in the form of a hæmatogen, and is the source of the colouring matter of the blood of the young bird. Sodium is also partly in combination with protein. The importance of sodium and potassium in the formation of the tissues is well known. This remarkable combination of mineral matters makes eggs an important food: 100 grammes of yolk contain 0·01 gramme of iron, and, as the daily

amount required by human beings is about 10 milligrammes, it could be derived from seven and a half eggs eaten daily.

Eggs as Food.—They are used by practically every family in a proportion which is calculated as equal to 6 per cent. of the total protein, and 4·3 per cent. of the total fat. Compared with other nitrogenous foods, they are cheap and easily cooked. They are valuable as providing variety in the diet. Their composition compared with that of moderately lean beef is as follows :

	Percentage.	
	Whole Egg.	Lean Beef.
Water	73·7	70·88
Protein	14·8	22·51
Fat	10·5	4·52
Extractives	—	0·86
Ash	1·0	1·32

As regards digestion, the absence of fibrous tissue, muscular stroma, or tough cellular membranes, affords them an easiness and readiness of digestibility which is only equalled by a very few nitrogenous foods, such as milk and oysters. It is usually said that raw and soft-boiled eggs are very easily digested — that is, without pain or discomfort — that hard-boiled and fried eggs are less easily digested, and may cause pain or discomfort. Beaumont, in his experiments on Alexis St. Martin, who had a fistula of the stomach, found that eggs required the following time for chymification in the stomach : Hard-boiled and fried eggs, 3½ hours ; soft-boiled eggs, 3 hours ; roasted eggs, 2½ hours ; raw eggs not whipped, 2 hours ; and whipped raw eggs, 1½ hours. Penzoldt[1] more recently found that raw eggs remained in the stomach 2¼ hours, whereas lightly boiled ones left the stomach in 1¾ hours, and therefore they are more easily digested when lightly cooked ; that poached eggs remained 2½ hours, and boiled eggs and omelettes 3 hours. These figures, of course, only apply to gastric digestion, and not to digestion in the intestines. Artificial digestion experiments with conditions approximating as nearly as possible to those of the living organism gave the following results : Hard-boiled eggs required 8 hours for complete digestion ; soft-boiled eggs, 6½ hours ; raw eggs not whipped, 4½ hours ; whipped raw eggs, 4 hours. German observations on the length of time food remains in the stomach showed that two eggs consumed raw, poached or as omelette, leave the stomach in 2 or 3 hours—that is, in the same time as white bread, milk, and oysters. As the time required for ordinary fresh meat to leave the stomach was observed to be 3 hours, and smoked meat or salt fish 4 to 5 hours, it is regarded that eggs compare favourably with the others. Stern found that the raw yolk of two to four eggs in a cup of hot coffee left the stomach in 60 to 70 minutes, and in 60 to 90 minutes when lightly cooked.

Rubner experimented with a healthy man who consumed a

[1] *Deutsch. Archiv f. Klin. Med.*, 1893, Bd. 51, 535.

number of hard-boiled eggs without any other food. An examination of the fæces showed that 95 per cent. of the total matter of the egg was absorbed, including all the fat and 97 per cent. of the protein. He concluded that eggs are as completely digested as meat; that there is no difference between the digestibility of hard- and soft-boiled eggs; but it did not follow that hard-boiled eggs were digested in the same length of time as soft-boiled ones, or that hard-boiled and fried eggs did not upset the digestive organs.

Dangers from the Consumption of Eggs.—As a general rule it may be stated that eggs are as innocuous as meat or milk. It is, however, a fact that, owing to some idiosyncrasy, certain persons are unable to consume them in any form. Such people are liable to attacks of dyspepsia, cramp in the stomach or bowels, probably vomiting, diarrhœa, and other unfortunate symptoms. Anybody can become ill from eating an excess of eggs, and, as with other foods, an excess for one person would be a bare sufficiency for another. But the more serious cases of illness are due to bacterial contamination. An eggshell is porous, and offers no resistance to the entrance of micro-organisms. Contamination is therefore easy. The common putrefactive organisms enter readily, and are the source of "staleness" in eggs, the changes produced being the same as in other nitrogenous matters. Illness arising from stale eggs is usually caused by ptomaines elaborated by micro-organisms from the substances on which they thrive, and the symptoms are those of ptomaine-poisoning. Such poisoning may arise from the consumption of various articles of food containing eggs—*e.g.*, custards, creams, cakes, and various confections. Eggs which are apparently good are liable to contamination in the oviducts of the bird or by being laid in a dirty nest. Dr. André le Coq investigated some cases of poisoning by *éclairs* or cream-cakes, and concluded the cause was due to the eggs, and never to mineral poisons or other ingredients of the cream. He says:[1] "The white plays a more important part than the yolk, and is generally at fault when the poisoning is due to fresh eggs, since it is commonly beaten up raw, while the yolk is sterilized by cooking. The microbes in it find the sugar, milk, and gelatin of the custard an extremely favourable culture medium. The yolk does its work when the poisoning is due to decomposed eggs, for cooking cannot destroy the toxins and ptomaines of putrefaction. Chemical analysis shows the presence, in the poisonous cakes or in the bodies of their victims, of alkaloidal substances not identified with any hitherto known, and it cannot be positively affirmed that these toxins are not simply due to putrefaction."

The consumption of uncooked eggs may be the cause of typhoid fever, if the micro-organisms of that disease have been carried to the nest upon the feet or feathers of the bird, or if the eggs become contaminated after their removal from it. The eggs of worms have been found upon and within the shell of birds' eggs; they may have

[1] *Bull. Comm. de la Pharm.*

been accidentally included while the white and the shell were being added to the yolk in the ovaries. The danger from these sources, however, is infinitesimal, judging from the reports in medical literature. Ptomaine-poisoning from eggs is more common, especially when stale eggs are used. To guard against poisoning by fresh eggs, it is simply necessary to cook *all* parts of the egg, especially the white, in making creams, and prolonging the application of heat sufficiently to insure sterilization.

The eggs of birds are influenced by their food; this is shown in the following table:[1]

Number Analyzed.	Ratio in Food of Fowls.		Composition of the Eggs.				
	Albuminoid to Carbohydrate.	Ash to Total Dry Food.	Water.	Total Solids.	Protein.	Fat.	Ash.
29	1 : 7·27	1 : 51·3	72·83	27·12	13·36	11·06	0·87
11	1 : 3·81	1 : 27·0	75·22	24·79	12·78	9·29	1·47
22	1 : 7·24	1 : 51·0	74·27	25·73	12·79	9·94	0·74

If the bird eats unclean food or food containing onions, sage, thyme, and similar articles, the eggs have a disagreeable flavour. When unclean food is eaten, the eggs may contain toxins arising from the food or in the body of the bird; therefore absolutely fresh eggs may possibly be contaminated as the result of improper food and insanitary surroundings of the birds. Again, if the birds are allowed much meat, it may be absorbed in a partially digested form, and is a source, not merely of irritation to the animal, but of toxic conditions by which the egg itself is affected. Such eggs, when consumed by human beings, may give rise to symptoms of distress and toxæmia, especially in persons of peculiar idiosyncrasy.

The Storage of Eggs.—In former years eggs were sold in local markets only, but they are now sent thousands of miles from their place of origin to be consumed as human food. This necessitates consideration for their preservation. But the use of special precautions is unnecessary when they are likely to be consumed within eight or ten days of being laid. They should, of course, be kept apart from substances likely to impart a flavour to them—*e.g.*, apples, onions, cheese, fish, bran, and musty straw. The methods adopted for the preservation of eggs depend upon their power to restrain the growth of bacteria. Thus, when eggs are kept in "cold storage," with a sweet pure atmosphere of about 34° F., little or no change in their quality occurs. Eggs laid in April and May can be preserved for a year in cold storage. Some English authorities consider that a temperature of 40° to 45° F. is equally satisfactory as a preservative. It is, however, generally found that eggs stored in a temperature of 30° F. do not keep so

[1] Rep. New York Experiment Station.

well when taken out of storage as those which have been stored in an atmosphree of 35° to 40° F. ; the latter, when taken out of storage, have the flavour of fresh eggs, and will keep good for a considerable time.

Numerous other methods of preventing the contamination of eggs by micro-organisms have been devised—*e.g.*, wrapping them closely in paper, packing them in dry lime, varnishing the shells with glycerine and salicylic acid, boroglyceride, collodion, shellac, or vaseline. The best method appears to be that of placing them in a solution of **water-glass** (silicate of soda) ; but placing them in lime-water is said to be almost equally effective.

Canned Eggs.—The white and the yolk are usually put into separate tins, and kept in cold storage at 30° F. ; they should be used soon after being thawed. The white and yolk are also canned together after being transformed into a homogeneous substance, and combined with glucose to form a syrup. The composition of eggs preserved in glucose, according to Leach, is as follows : Water, 35·29 ; fat, 11·89 ; protein, 14·03 ; **glucose, 35·52 ;** ash, 0·94 ; unestimated, 5·83—per cent.

Desiccated Eggs.—The eggs are reduced to a homogeneous condition, aided by the addition of water and a little sodium bicarbonate. This emulsion is sprayed upon a heated revolving cylinder or drum, the water is quickly evaparated, and the substance of the egg forms a skin upon the cylinder, which is removed and reduced to a powder. They are sometimes evaporated in a vacuum pan or by currents of air, at a temperature of 113° F. (45° C.). The result is a dry, horny solid, which, being reduced to a powder, will keep for a year or two. Some manufacturers add salt or sugar when powdering them. The following analysis by Leach shows the composition of desiccated eggs :

Composition of Dried Eggs—Percentage.

	Sample A.	Sample B.
Water	6·8	5·95
Proteins (N × 6·25)	45·2	48·15
,, by difference ..	51·2	—
Fat	38·5	40·56
Ash	3·5	5·34

The white or yolk may be separately dried. The white dries into a greyish horny substance, which is readily powdered. The dried yolk is a yellow cheesy substance of a granular nature, which is not easily powdered.

Egg-Substitutes.—Canned and desiccated eggs are chiefly used by confectioners, who also use as egg-substitutes commercial albumin, casein, gelatin, gluten, and egg-powders. It is appropriate to give a brief account of these materials at this point.

Commercial albumin is serum-albumin, obtained from the blood of slaughtered animals. The serum is collected after the coagulum (cells and fibrin) has been removed. The albumin is then precipitated, washed, and refined. There are several grades, the superior being in thin, transparent flakes, which are soluble in cold water. Inferior qualities are not so well refined, being darker in colour, and often adulterated with casein, dextrin, or gum. Commercial albumin is a good substitute for white of egg, but, as it contains no cellular membranes, such as occur in eggs, it does not, when beaten up, make such a good foam.

Casein is also used by confectioners as a substitute for eggs. It is precipitated from skim milk by acetic acid, washed, dried, and powdered. A solution of casein can be whipped like the white of egg, but does not form a permanent stiff froth; consequently it has very little aerating power. It is largely used in making starch-free foods for diabetics.

Gluten is another egg-substitute, and is obtained as a by-product in the manufacture of starch from wheat and other cereals. It does not exactly possess the same physical properties as egg-albumin; but a solution of gluten can be beaten into a froth wherein the insoluble glutenin acts like the filamentous fibrous membrane in egg-white, and the gliadin makes a film upon it and forms a frothy foam, which possesses even superior aerating properties to those of eggs.[1]

Gelatin and *isinglass* are also used as egg-substitutes in various confections—*e.g.*, macaroons and meringues. Gelatin is not such a good aerator as eggs, and consequently the substances made with it are not bulky. Egg-white sets into a firm substance under the influence of heat, but gelatin does not; indeed, it begins to soften just at that temperature which is required to form a firm support to the macaroon or meringue.[2] Isinglass is even inferior to gelatin.

Egg-powders bear no resemblance to eggs except in colour. They consist chiefly of starch with a chemical aerating substance, such as cream of tartar or tartaric acid and bicarbonate of soda. They are coloured with turmeric or an aniline dye. They may be called "coloured baking-powders." Some of them contain gelatin, casein, gum, or dextrin, which, as stated above, are not of the same value as eggs, and the froth obtained from them has not the same stiffness and permanence. The following is fairly representative of their composition:

EGG-POWDER.

Tartaric acid	10·45 per cent.
Sodium bicarbonate	21·30 ,,
Albumin	6·50 ,,
Starch	51·25 ,,
Water	10·50 ,,

[1] "The Modern Baker," vol. ii., p. 283.
[2] *Ibid.*, p. 282.

Custard-powders have a similar composition. They do not represent eggs in any degree. Custards made from them are merely preparations of starch coloured with a vegetable pigment, usually turmeric. Their approximate composition is as follows :

CUSTARD-POWDER.

Starch	85·34 per cent.
Albumin	·60 ,,
Colouring matter	·91 ,,
Ash	·40 ,,
Water	12·75 ,,

CHAPTER VIII

THE PISCES

THE following classifications of British fresh-water and marine fishes and the American food fishes are given from the sources stated.

BRITISH FRESH-WATER FISHES.

CLASSIFICATION BY SIR HERBERT MAXWELL, F.R.S.[1]

I. Acanthopterygii.

Family.	Genus—Species.	Common Name.
Percidæ.	Perca fluviatilis.	Perch.
	Labrax lupus.	Bass, or sea-perch.
	Acerina cornua.	Ruffe, or pope.
Cottidæ.	Cottus gobio.	Bullhead, cult, etc.
Gastroteidæ.	Gastroteus aculeatus.	Stickleback.
Scienidæ.	Sciena aquila.	Maigre.

II. Anacanthini.

Gadidæ.	Lotus vulgaris.	Burbot, or eel-pout.
Pleuronectidæ.	Pleuronectus flessus.	Flounder, or butt.

III. Physostomi.

Cyprinidæ.	Cyprinus carpio.	Carp.
	Carpassius vulgaris.	Gobel, or crusian carp.
	Barbus vulgaris.	Barbel.
	Gobio fluviatilis.	Gudgeon.
	Leuciscus rutilus.	Roach.
	,, erythrophthalmus.	Rudd, or red eye.
	,, cephalus.	Chub, or pollard.
	,, vulgaris.	Dace, or dart.
	,, phoxinus.	Minnow.
	Tinca vulgaris.	Tench.
	Abramis brama.	Bream.
	,, blicca.	White bream, or bream-flat.
	Alburnus lucidus.	Bleak.
	Nemachulus barbatulus.	Loach, beardie.
	Cobitis tænia.	Groundling, or spine-loach.
Esocidæ.	Esox lucius.	Pike, pickerel, luce, jack, gedd.
Salmonidæ.	Salmo salar.	Salmon.
	,, trutta.	Salmon-trout, sea-trout, white-salmon, whitling.
	,, eriox.	Sea-trout, bull-trout.

[1] "British Fresh-Water Fishes," pp. 32, 33.

Family.	Genus—Species.	Common Name.
Salmonidæ.	Salmo fario.	Trout, brown-trout, lake-trout, brook-trout.
	,, alpinus (salvelinus).	Char.
	Osmerus eperlanus.	Smelt, or sparling.
	Coregonus clupeoides.	Powan, fresh-water herring
	,, pollan.	Pollan.
	,, vendesius.	Vendace.
Clupeidæ.	Clupea alosa.	Alewife, or allis-shad.
	,, finta.	Twait-shad.
Muranidæ.	Anguilla vulgaris.	Eel.
	,, latirostris.	Bottle-nosed eel.
	Subclass : Cyclostomata. Order : Marsipobranchii.	
Petromyzonidæ.	Petromyzon marinus.	Lamprey.
	,, fluviatilis.	Lampern.
	,, branchialis.	Mud-lamprey.
	Myxine glutinosa.	Hag.
	Subclass : Palæicthys. Order : Ganoidei.	
Accepenseridæ.	Accipenser sturio.	Sturgeon.

BRITISH SEA-FISHES.

The following are the sea-fishes which are native to or visit British seas, as given by F. G. Aflalo.[1]

Order I. Pharyngobranchii.

The lancelet (Amphioxus).

Order II. Marsipobranchii.

The hag (Myxine).
Lamprey (Petromyzon marinus).

Order III. Elasmobranchii.

1. *The Sharks* (*Selachoidei*).

Family.	Genus—Species.	Common Name.
Lamnidæ (porbeagles).	Lamna cornubica.	Porbeagle shark.
	Alopias vulpis.	Thresher shark.
	Selache maxima.	Basking shark.
Carchariidæ (white sharks).	Carcharias glaucus.	Blue shark.
	Zygæna malleus.	Hammerhead shark.
	Galeus vulgaris.	Tope.
	Mustulus vulgaris.	Smooth-hound.
Scyllidæ (dogfishes).	Scyllium catullus.	Nurse-hound.
	,, canicula.	Row-hound.
	Pristinus melanostoma.	Black-mouthed dogfish.
Notidanidæ.	Notidaneus griseus.	Six-gilled shark.
Spinacidæ.	Acanthius vulgaris.	Pickled dog, or dogfish.
	Læmargus microcephalus.	Greenland shark.
	Echinorhinus spinosus.	Spinous shark.
	Centrina salviana.	Centrina.
Rhinidæ.	Rhina squatina.	Monk or angel fish.

Sharks have no commercial value on British coasts, although they are eaten in the East, where portions are highly appreciated as food. But the small dogfishes, called "flake," find a ready

[1] "British Sea-Fishes."

market at Brighton and elsewhere on the British coasts. Many of the above sharks visit our shores ; they follow shoals of smaller fish, herrings, pilchards, whiting, mackerel, etc., upon which they prey.

2. *The Rays* (*Batoidei*).

Family.	Genus—Species.	Common Name.
Raiidæ (the rays).	Raia batis.	Common skate.
	,, clavata.	Thornback.
	,, fullonica.	Shagreen ray.
	,, oxyrhynchus.	Long-nosed skate.
	,, microcellata.	Painted ray.
	,, circularis.	Sandy ray.
	,, radiata.	Starry ray.
	,, alba.	Sharp-nosed ray.
	,, maculata.	Homelyn.
	,, blanda.	Blonde.
Torpedinidæ.	Torpedo nobiliana.	Torpedo.
Trygonidæ.	Trygon pastinaca.	Sting-ray.
Myliobatidæ.	Myliobatis aquila.	Eagle-ray.
	Cephaloptera giorna.	Ox-ray.

The common skate, thornback, and homelyn, are amongst the fishes ordinarily consumed in England. The common or grey skate on the Irish coasts reaches 224 pounds in weight. The eagle and ox rays find their way from the warm waters of Florida and Mexico.

Order IV. Ganoidei.

Family.	Genus—Species.	Common Name.
Accipenseridæ.	Accipenser sturio.	Sturgeon.

Order IV. Teleostei.

A. *Physostomi.*

Siluroidæ.	Siluris glamis.	Sheatfish, or catfish.
Cyprinoidei.	Cyprinus.	Carps and their allies.
Esocidæ.	Esox.	The pike family.
Clupeidæ.	Clupea harengus.	Herring.
	,, pilchardus.	Pilchard.
	,, sprattus.	Sprat.
	Engraulis encrasicholus.	Anchovy.
	Clupea finta.	Twaite-shad.
	,, alosa.	Alewife, or allis-shad.
Muranoidei.	Conger vulgaris.	Conger-eel.

B. *Anacanthini.*

Gadidæ.	Gadus morrhua.	Cod.
	,, merlangus.	Whiting.
	,, luscus.	Pout.
	,, æglefinus.	Haddock.
	,, pollachus.	Pollack.
	,, virens.	Coalfish.
	,, minutus.	Poor-cod.
	,, pontassan.	Pontassan.
	Merlucius vulgaris.	Hake.
	Molva vulgaris.	Ling.
	Motella tricirrata.	Rockling.
	,, cimbria, mustella.	
	Brosmius brosme.	Torsk.
Ophidiidæ.	Amnodytes lanceolatus.	Launce.
	,, tobianus.	Sand-eel.

Family.	Genus—Species.	Common Name.
Pleuronectidæ.	Pleuronectes platessa.	Plaice.
	,, limanda.	Dab.
	,, flessus.	Flounder, butt.
	,, microcephalus.	Lemon-dab.
	,, cynoglossus.	Witch.
	Hippoglossus vulgaris.	Halibut.
	,, limandoides.	Long rough dab.
	Rhombus maximus.	Turbot.
	,, lævis.	Brill.
	Lepidorhombus megastoma.	Megrim.
	Zeugopterus punctatus.	Topknot.
	,, unimaculatus.	One-spotted topknot.
	,, norvegicus.	Norwegian topknot.
	Arnoglossus laterna.	Scaldfish.
Soleidæ.	Solea vulgaris.	Sole.
	,, lascaris.	French sole.
	,, variegata.	Thickback.
	,, lutea.	Solonette.
	C. *Acanthopterygii.*	
Percidæ.	Labrax lupus.	Bass.
	Serranus cabrilla.	Dusky perch.
Sparidæ.	Pagellus centrodontus.	Common sea-bream.
	,, owenii.	Axillary bream.
	,, erythrinus.	Pandora.
	,, bogaraveo et acarne.	Spanish bream.
	Pagrus vulgaris.	Couch's sea-bream.
	,, auratius.	Gilt-head.
	Cantharus limatus.	Old-wife.
	Box vulgaris.	Bogue.
Mullidæ.	Mullus surmulletus.	Red mullet.
Mugilidæ	Mugil chelo.	Grey mullet.
Cottidæ.	Cottus scorpus.	Sea-scorpion.
	,, quadricornus.	Four-horned cottus.
	,, norvegicus.	Norway bullhead.
	Trigla cuculus.	Red gurnard.
	,, gurnardus.	Grey gurnard.
	,, lineata.	Streaked gurnard.
	,, hirunda.	Saphirine gurnard.
	,, obscura.	Lanthorn gurnard.
	,, lyra.	Piper gurnard.
	,, murrayi.	Murray's gurnard.
Cataphracti.	Peristhelus cataphractum.	Armed gurnard.
	Agonus cataphractus.	Armed bullhead.
Sciænoidei.	Sciæna aquila.	Maigre.
Scomberoidei.	Scomber scomber.	Mackerel.
	,, colias.	Spanish mackerel.
	Orcynus thynnus.	Short-finned tunny.
	,, germo.	Long-finned tunny.
	Thynnus pelamys.	Bonito.
	Pelamys sarda.	Belted bonito.
	Auxis rochii.	Plain bonito.
	Echenis remora.	Remora.
Carangidæ.	Caranx trachurus.	Horse mackerel.
	Naucrates ductor.	Pilot-fish.
	Caprus aper.	Boar-fish.
Cyttidæ.	Zeus faber.	John Dory.
Stromatridæ.	Centrolophus pompilus.	Black-fish.
	,, Britannicus.	
Gobioidei.	Gobius and species.	The gobies.

Family.	Genus—Species.	Common Name.
Blennioidei.	Blennius and species.	The blennies.
Pediculati.	Pediculatus.	The angler-fish.
Sygnathidæ.	Sygnathus.	The pipe-fishes.
	D. *Pharyngonathi.*	
Labroidei.	Labrus mixtus.	Striped wrasse.
	,, maculatus.	Ballan.
	Crenilabrus melops.	Connor.
	Ctenolabrus rupestris.	Jago's goldsinny.
	Acantholabrus pallori.	Scale-rayed wrasse.
	Centrolabrus exoletus.	Rock-cook.
	Corie julis.	Rainbow wrasse.
	Hiatula onitis.	Black-fish (American).
Scomberesocidæ.	Belone vulgaris.	Garfish.
	Scomberesox saurus.	Saury pike.
	Exocatus volitans.	Flying-fish.

THE PRINCIPAL FISHES USED FOR FOOD IN AMERICA.

The following list, from the Report of the United States Commission on Fish and Fisheries, 1888, pp. 679-868, comprises the principal fishes used for food in America. It should be observed that the technical name of some of the fishes, which correspond with those of British waters, is different, and is apt to lead to confusion.

Family.	Genus—Species.	Common Name.
Accipenseridæ.	Accipenser sturio oxyrhynchus.	Sturgeon.
Catostomidæ.	Moxostoma velatum	Small-mouthed red-horse.
Clupeidæ.	Clupea harengus.	Herring.
	,, pilchardus.	Sardine.
	,, vernalis.	Alewife (allis-shad).
	,, sapidissima.	Shad (twaite-shad).
Salmonidæ.	Salmo salar.	Salmon.
	,, sebago.	Land-locked salmon.
	Oncorhynchus chouicha.	California salmon.
	Salvelinus namaycush.	Lake-trout.
	,, fontalis.	Brook-trout.
	Coregonus clupeiformis.	White-fish.
	,, tullibee vel artedi.	Ciscoe.
	Osmerus eperlanus.	Smelt.
Esocidæ.	Esox lucius.	Pike.
	,, reticulatus.	Pickerel pike.
	,, nobilior.	Muskellunge.
Anguillidæ.	Anguilla rostrata.	Eel.
Mugillidæ.	Mugil albula.	Mullet.
Scombridæ.	Scomber scombrus.	Mackerel.
	Scomberomorus maculatus.	Spanish mackerel.
	Orcynnus thynnus.	Tunny.
Carangidæ.	Trachynotus carolinus.	Pompano.
Pomatomidæ.	Pomatomus saltatrix.	Blue-fish.
Stromateidæ.	Stromateus triacanthus.	Butter-fish.
Centrarchidæ.	Micropterus salmoides.	Black bass (large-mouthed).
	,, dolomius.	,, (small-mouthed).
Percidæ.	Perca fluviatilis.	Perch (yellow).
	Stizostedion canadense.	Grey pike.
	,, vitreum.	Wall-eyed pike.
Serranidæ.	Centropristus atrarius.	Sea-bass.
	Roccus lineatus.	Striped bass.
	,, americanus.	White perch.

Family.	Genus—Species.	Common Name.
Serranidæ.	Epinephalus morio.	Red grouper.
Sparidæ.	Lutjanus blackfordi.	Red snapper.
	Stenotomus chrysops.	Porgy.
	Diplodus probatocephalus.	Sheepshead.
Scienidæ.	Sciena ocellata.	Red bass.
	Menticirrus saxatilis.	King-fish.
	Cynoscion regale.	Weak-fish.
Labridæ.	Hiatula onitis.	Black-fish.
Gadidæ.	Gadus morrhua.	Cod.
	Microgadus tomcod.	Tomcod.
	Pollachius virens.	Pollack.
	Melanogrammus æglefinus.	Haddock.
	Phycis chuss.	Hake.
	Brosmius brosme.	Cusk.
Pleuronectidæ.	Hippoglossus hippoglossus.	Halibut.
	Platysomalicthys hippoglossus.	Turbot.
	Paralicthys dentata.	Flounder.
	Pseudopleuronectes americanus.	
Petromyzonidæ.	Petromyzon marinus.	Lamprey.
Raiidæ.	Raia batis.	Skate.

Fish as a Food.—It has generally been considered that fish holds a place intermediate between meat and vegetables in the list of food-stuffs. The place for fish, however, is the same as that of meat—namely, amongst the nitrogenous animal foods, although, taken weight for weight, fish is less nutritious than meat. The average, composition of fish shows that it is essentially a source of protein. Fish contains more water and less fat than the same weight of meat; therefore a larger bulk of fish must be eaten to obtain therefrom the nutriment represented by a given weight of meat. This is shown by the following comparison :

THE COMPOSITION OF MEAT AND FISH COMPARED.

	Protein.	Fat.	Water.
Beef, average	17·5	27·5	54·0
Fish ,, ...	18·0	3·0	79·0

The average calorie value of 1 ounce of fish is only 30; that of 1 ounce of beef is 89.

COMPOSITION OF FISH : MUSCULAR TISSUE.

Solids :	Organic matter	180 to 190	200
	Inorganic ,, ...	10 ,, 20	
Water			800
Parts per 1,000 :	Myosin	30 to 87	
	Stroma	70 ,, 121	
	Creatin	2·3	
	Purin bodies	0·5 to 1·2	
	Protic acid	7·0	
	Glycogen	1·3	
	Salts	7 to 10	

	Reference Page.	Refuse.	Edible Portion : Nutrients per Cent.				
			Water.	Protein.	Fat.	Carbo-hydrate.	Ash.
Abalone (mollusc) : Fresh	232	—	72·80	22·20	·30	3·3	1·40
Dried	232	—	39·70	36·00	·50	20·9	2·90
Canned	252	—	73·20	21·70	·10	3·7	1·30
Alewives, fresh	208	49·5	74·41	19·17	4·92	—	1·47
Allis-shad ,,	207	—	70·62	18·56	9·47	—	1·35
Anchovy, preserved	206	—	57·80	22·30	2·20	—	23·70
Bass : Black, fresh	217	54·8	76·70	20·60	1·70	—	1·20
Red ,,	217	63·5	81·60	16·90	·50	—	1·20
Sea ,,	217	56·1	79·30	19·80	·50	—	1·40
Striped ,,	217	55·0	77·70	18·60	2·80	—	1·20
Black-fish (tantog), fresh	222	60·2	79·40	18·50	1·40	—	1·30
Blue-fish, fresh	222	48·6	78·52	19·10	1·17	—	1·27
Brill ,,	216	—	87·00	11·86	·53	—	·71
Butter-fish ,,	219	42·8	70·00	18·00	2·30	—	1·20
Cat-fish ,,	223	19·4	64·10	14·40	20·60	—	·90
Caviare ,,	225	—	56·97	27·87	12·85	—	2·31
,, canned	225	—	50·92	27·92	13·59	—	7·55
Ciscoe, fresh	202	42·7	73·00	18·50	6·80	—	1·70
Clam : Long, fresh	251	—	85·80	8·60	1·00	2·0	2·60
canned	231	—	84·50	9·00	1·30	·8	2·30
Round, fresh	231	—	86·20	6·50	·40	4·2	2·70
canned	231	—	82·90	10·50	·80	3·0	2·80
Cod : Whole, fresh	209	52·5	82·64	15·77	·36	—	1·23
Steak ,,	209	9·2	79·70	18·70	·50	—	·20
Shredded, preserved	209	—	46·52	30·87	·33	—	22·81
Salt-dried	209	24·9	—	45·65	·53	—	53·82
Crab, fresh	234	—	77·60	16·80	2·20	1·2	2·10

COMPOSITION OF FISH AND SHELLFISH—*Continued.*

	Reference Page.	Refuse.	Edible Portion: Nutrients per Cent.				
			Water.	Protein.	Fat.	Carbo-hydrate.	Ash.
Crab, canned	234	—	79·40	16·10	1·50	1·0	2·00
Crayfish, inside	233	—	81·20	16·00	·50	·10	1·30
Dab, fresh	214	—	86·14	11·94	·25	—	1·67
Eel ,,	208	—	71·60	18·68	9·11	—	1·01
,, conger, fresh	209	—	70 to 73	16 to 19	10 to 15	—	—
Flounder ,,	214	61·5	83·80	14·26	·63	—	1·31
,, summer, fresh	214	—	84·21	13·82	·69	—	1·28
Haddock, fresh	212	51·0	81·40	17·20	·30	—	1·10
,, smoked	212	32·2	72·40	23·70	·30	—	3·60
,, ,, cooked	212	—	68·70	22·30	2·30	—	6·70
Hake, fresh	213	52·5	83·25	15·29	·71	—	1·00
Halibut (steak), fresh	215	17·7	74·83	18·47	5·30	—	1·40
Herring ,,	204	42·5	71·51	19·49	7·59	—	1·41
Kingfish ,,	218	56·6	79·20	18·90	·90	—	1·20
Lamprey ,,	224	45·8	71·00	15·00	13·30	—	·70
Ling ,,	213	—	84·00	16·00	·90	—	1·00
Lobster ,,	233	61·7	79·40	16·20	1·70	·50	2·20
,, canned	233	—	77·40	18·10	1·10	·60	2·80
Mackerel, fresh	220	44·7	77·78	18·52	7·43	—	1·27
,, Spanish, fresh	220	34·6	68·10	20·97	9·43	—	1·50
Menhaden ,,	208	—	77·15	18·94	3·91	—	—
Mullet ,,	219	—	74·88	19·42	4·53	—	1·17
Muskellunge ,,	203	49·2	76·31	20·27	2·73	—	1·69
Mussels ,,	230	46·7	78·57	12·62	1·68	5·29	1·84
Oysters ,,	226	81·4	77·99	10·63	2·61	6·56	1·20
Pecten (scallop) ,,	231	—	80·25	15·04	1·46	2·00	1·25
Perch: Yellow ,,	216	62·7	79·30	18·70	·80	—	1·20
White ,,	216	62·5	75·70	19·30	4·00	—	1·20

Perch-pike, fresh	204	57·3	79·70	18·60	·50	—	1·40
Pike, or pickerel-pike, fresh	203	47·1	75·70	19·30	2·50	—	1·10
Pickerel, fresh	203	—	79·19	18·41	·50	—	1·10
Plaice ,,	214	—	87·00	11·86	·53	—	·71
Pollack ,,	213	28·5	76·00	21·60	·80	—	1·50
Pompano ,,	221	45·5	72·81	18·68	7·45	—	1·06
Porgy ,,	218	60·0	74·99	18·52	5·11	—	1·38
Red grouper, fresh	217	55·9	79·50	19·30	·60	—	1·10
,, snapper ,,	217	46·1	78·50	19·70	1·00	—	1·30
Salmon ,,	198	34·9	77·70	17·80	3·30	—	1·20
,, canned	198	14·1	63·50	21·80	12·10	—	2·60
,, Atlantic, fresh	199	—	63·61	21·60	13·38	—	1·40
,, Pacific (sections), fresh	200	10·3	63·62	17·46	17·87	—	1·00
,, land-locked, fresh	199	45·5	78·54	17·24	2·98	—	1·20
Salmon-trout, fresh	201	—	70·80	17·80	10·30	—	1·20
Sardines, canned	205	5·0	56·30	24·80	12·70	—	5·00
Scallop and cockle, fresh	231	80·1	80·30	14·80	·10	3·40	1·40
Shad, fresh	207	50·0	70·62	18·56	9·47	—	1·30
,, roe, fresh	207	—	71·20	20·90	3·80	2·60	1·50
Sheepshead, fresh	218	66·6	75·60	20·10	3·70	—	1·20
Shrimps and prawns, fresh	234	—	70·80	25·40	1·00	·20	2·60
Skate (ray), fresh	223	51·0	80·20	18·18	1·42	—	1·10
Sole ,,	216	—	86·14	11·94	·25	—	1·60
Smelt ,,	201	41·9	78·90	17·48	1·81	—	1·70
Sturgeon, sections	224	14·4	78·71	17·96	1·90	—	1·43
,, dried	224	—	50·60	31·80	9·60	—	7·60
Tomcod	212	59·9	81·50	17·20	·40	—	1·20
Trout: Brook, fresh	201	48·1	77·70	19·27	2·10	—	1·20
Lake ,,	201	—	69·00	18·29	11·60	—	1·14
Salmon ,,	201	48·5	70·80	17·80	10·30	—	1·20
Tunny, fresh	221	—	72·70	20·30	4·10	—	1·70
Turbot ,,	315	47·7	71·40	14·80	14·40	—	1·30
Weak-fish, fresh	218	51·9	78·60	17·67	2·40	—	1·20
White-fish ,,	202	53·5	67·70	22·69	5·90	—	1·60
Whiting ,,	212	—	81·00	17·50	·50	—	1·30
White-fleshed fish, average	—	—	78·00	18·10	2·90	—	1·00

In addition to glycogen, the tissues contain, *after cooking*, a reducing substance, probably split off from gluco-proteins in the tissues, amounting from 2 to 15 per cent. of the water-free or dried substance. The protein consists mostly of muscle myosin and stroma, with some creatin and purin bodies, as shown in the above table. Although the average proportion of protein is 18 and fat 3 per cent., these items vary considerably; and as regards fat, the variation is from 0·5 to 25 per cent. or more. The table on pp. 189, 190, and 191 indicates the average composition of the flesh, or edible portion, of the most important fishes consumed as food.

The above table shows how much various species of fish differ from each other in composition, and especially in their proportion of fat. It, however, does not show the variations in the solidity of the flesh, which is as great as the variation of fat, although it may be taken as a general rule that the smaller the proportion of fat the lighter is the fish. Certain kinds of fish are therefore more suitable to replace meat than others, and some kinds are most decidedly better food for invalids than others. Salmon and members of the herring family all contain a fair proportion of fat interspersed among the muscular fibres and deposited under the skin. Halibut has firmer flesh than other flat fishes, and, containing a fair proportion of fat, is a well-balanced food. Mackerel and tunny also contain plenty of fat, and, along with eels and conger-eel, are well-balanced foods. Cod, haddock, flounder, skate, and the alewives, also form good food for working men when supplemented by a fair amount of fat, such as buttered bread. Trout is one of the best fresh-water fishes, and forms an admirable food; but most fresh-water fishes—carps, pikes, perches, breams, etc.—are deficient in fat; their flesh is lax, and they do not make a satisfactory dinner for a man who has to do laborious work. The preference for salt-water or fresh-water fish is merely a matter of taste and suitability to yield a good meal. Both are equally wholesome. Many kinds of fish are eaten in some districts which are little thought of in other parts. For instance, skate is eaten on the western shores of America, but until recently it was considered of no value on the east coast. Sturgeon, which formerly was not eaten in America, is now highly prized there, and commands a high price.

Fish is lighter, not so stimulating, and as a rule easier of digestion than meat or game. These facts—lightness and ease of digestion—render it a food of great value for those who are convalescent, as well as for those whose occupation is of a sedentary character and chiefly mental. But the same qualities militate against it when it is considered as a food for the working man, for, although it is a valuable source of nitrogen, it is deficient in energy-producing qualities; it does not satisfy the appetite like meat, but, on the contrary, the stomach is sooner empty, and hunger sooner returns. Nevertheless, the health and vigour of fishermen and their families, and the inhabitants of fishing towns generally, prove it to be sufficiently nourishing for all practical purposes.

These statements are the result of experience. Have they a foundation in fact? As regards the *time* required for the digestion of fish, there is great variation, owing to difference in the texture of the flesh of different species. Langworthy, in "Fish as a Food," considers that it should be classed with roast chicken or lamb, and he quotes the experiments of a German investigator, whereby he showed that—

(*a*) White fish, oysters, and shellfish, when eaten in a moderate quantity, leave the stomach in two or three hours, and should therefore be classed with eggs, milk, and white bread.

(*b*) Caviare was found to leave the stomach in three or four hours, as did chicken, boiled ham, lean beef, coarse bread, etc.

(*c*) Salt herrings left the stomach in four or five hours—that is, in the same time as roast beef, roast goose, smoked tongue, lentil or peas porridge.

The conclusion drawn from the investigation was that *fish in general is more rapidly digested than meat*, and this corresponds with experience. As regards completeness of digestion, it was found that fish and meat are equal; in each case 95 per cent. of the total dry matter, 97 per cent. of the protein, and 90 per cent. of the fat, were retained in the body. Experiments show that lean meat is more completely digested that fat meat; and similar experiments showed that fish containing little fat, such as cod, flounder, haddock, perch, pike, blue-fish, are more completely digested than the varieties which contain more fat, such as salmon, mackerel, herring, butter-fish, shad, or tunny.

As regards the economy of fish when compared with meat, the table[1] on p. 194 by Langworthy is sufficiently instructive.

This table shows that fish alone is deficient in energy-producing power, like lean meat of all kinds; when, however, fish is supplemented by bread, potatoes, and butter or some other fat, it furnishes a complete dietary. As a source of protein, codfish, mackerel, and canned salmon, are cheaper than beefsteak, mutton chop, or ham, at the prices stated. As a source of energy, fish is dearer than meat, owing to the deficiency in fat, which can be rectified by the addition of fat or butter.

The nature and texture of fish, from its not exacting laborious work on the part of the stomach, renders it an admirable diet for most people during convalescence, for all sufferers from diabetes, and for most people who require a highly nitrogenous food. Among those most easily digested are whiting, sole, plaice, fresh haddock, weak-fish, brill, turbot, flounder, and cod. These varieties, consequently, are the most suitable for invalids and others whose digestion is feeble, as well as for those who require an unstimulating diet. Most fresh-water fish may also be included in the list of unstimulating foods. Turbot may be taken as a type; it is an excellent fish and well adapted to a weak stomach, unless it is eaten with lobster

[1] "Fish as Food," Bull. No. 85, U.S. Department of Agriculture.

COMPARATIVE VALUE OF FISH AND MEAT.

	Refuse.	Nutrients per Cent.		Calories per Pound.	Cost per Pound.	Cost of Protein per Pound.	Cost of 1,000 Calories of Energy.
		Protein.	Fat.				
					Cents.	Dollars.	Cents.
Codfish steak	9·2	17·0	·5	327	12	·71	38
Blue-fish	48·6	10·0	·6	204	12	1.20	58
Halibut	17·7	15·3	4·0	454	18	1.18	40
Codfish (salt-dried)	24·9	19·0	·4	363	7	·44	23
Mackerel ,, ...	19·7	13·9	21·4	1,107	10	.61	10
Salmon (canned)	14·2	19·5	7·5	658	12	.62	18
Beef: Sirloin steak	—	25·0	3·5	615	20	1.52	21
Round ,, ...	—	24·6	4·5	605	14	·74	16
Mutton chop	13·0	16·0	33·0	1,695	20	1.48	14
Pork: Loin	—	20·3	19·0	1,180	12	.90	10
Smoked ham.. ..	—	19·8	20·8	1,245	22	1.55	14

sauce or other condiments which would render it difficult of digestion. The flakiness of its flesh, and its opaqueness after being cooked, are indications of its freshness and goodness. When the fish is in its best condition, there is a layer of white curdy matter (*coagulated albumin*) between the flakes. The absence of such material and a bluish transparent appearance of the flesh after cooking shows that it is not in condition, and it should be rejected as of inferior value or as not in season. The same remarks apply to many kinds of fish. Brill is similar to turbot, but inferior in flavour. Whiting is well adapted for a weak stomach ; it is one of the lightest fishes, on account of the laxity of its fibres ; it is at the same time delicate, white, and tender, and conveys sufficient nutriment to the invalid's stomach without producing undue stimulation of the body. The American weak-fish has smiliar properties, but contains a little more fat. Sole and plaice are also very tender, and are not only admirable food for invalids, but are highly esteemed by all who desire their food to possess lightness and ease of digestion. Haddock and cod are much firmer in texture, and the latter contains more glutinous matter. *Fresh* haddock only should be taken by invalids, and this is better when only of a middle size. Cod is somewhat denser, and not so digestible as whiting or haddock ; it is usually preferred when moderately large, its flesh being then firmer, but coarser. For invalids the smaller fish should be chosen.

The heavier kinds of fish, as those of the salmon, mackerel, and herring families, are richer in fat and require longer time for their digestion ; these varieties, therefore, are as a general rule not suitable for invalids or convalescents. Salmon is not very digestible ; it is heating and oily, and even persons having a good digestion usually eat it with a condiment, such as vinegar, while the addition of lobster sauce makes it even more difficult to digest. Salmon-trout is not so rich and oily as salmon, and therefore it is more digestible but less nutritive and heat-producing. Some kinds of fish do not agree with healthy people: *e.g.*, mackerel, even when quite fresh, has been known to make the consumer ill for several days. Eels are extremely objectionable to some people on account of the large amount of oil in their tissues.

It should be observed that various circumstances influence the character, condition, and flavour, of the fish. Fresh-water fishes are best when taken from deep lakes or ponds with clear water. The delicate flavour of the fish from Alpine lakes is well known. Fish caught in clear rivers and fairly rapid streams are better than those whose habitat is sluggish streams and muddy waters. Sea-fishes vary in their disposition, but the flavour of those which inhabit the deep waters off rocky headlands is better than that of fishes dwelling in shallow bays. Most fishes cannot be cooked too soon after being caught ; but in a few cases—*e.g.*, turbot—the flavour and tenderness improve by keeping the fish a short time ; skate and other rays also improve by keeping, and their flesh, which is normally firm and resistant, becomes tender. Fishes that have no scales are

generally regarded as unwholesome and indigestible. The season of the year has an influence upon the flavour and condition of fish. Fish is said to be *in season* some time before spawning ; it is then in its highest perfection, its flesh being firm and delicious ; but for some time after spawning they are thinner and out of condition, and are considered to be unfit for food.

Fish which has been pickled, cured, salted, or smoked and dried, is less easily digested than when fresh. The mode of cooking is another circumstance which influences its digestibility. Frying it in lard or oil is objectionable, because the fat renders it more difficult to digest, while the oil itself often becomes empyreumatic and is a cause of gastric disturbances. Boiled or steamed fish is better, providing it is not eaten with a rich sauce. Vinegar, lemon-juice, white sauce, or other simple sauce, along with salt, form the best condiments. Fish which is cooked in an oven in its own juice, in a confined space (*e.g.*, between two plates or in a paper bag), is free from the objections usually raised to frying ; it retains its normal flavour better than fried or boiled fish.

Some people consider fish to be essentially a brain food. But it is probable that its reputation in this respect is due to its general lightness and ease of digestion, and consequently less disturbance of the nerve centres. The quality of being a brain food is usually referred to its containing a large proportion of phosphorus. It is also credited with being an aphrodisiac, which has some foundation in experience. And this property, like the former, is also attributed to some excess of phosphorus in the composition of fish. Unfortunately for those who uphold this view, the statement that fish contains much phosphorus is not supported by chemical analysis. The percentage of phosphorus in the fishes analyzed is not larger than in the flesh of other animals used for food. Even if it were shown that fish contains more phosphorus, there is no experimental evidence to prove that it is more valuable than meat as a brain food ; but that fish is a desirable food for persons of sedentary habits, as most brain-workers are, appears to have a basis in experience, which is due to its general lightness and ease of digestion.

Whether fish is or is not a cause of skin diseases has been much debated. Disturbances of the skin undoubtedly follow the consumption of certain kinds of fish, and may follow the use of any fish which is not fresh. It is said that people who live a long time upon fish as their principal food secrete sweat of a rancid odour ; it is also a well-known fact that the flesh of birds which live largely upon fish has a distinctly peculiar flavour. It is therefore possible that some skin diseases may be caused and others aggravated by a prolonged fish diet. The prevalence of leprosy in certain districts where fish is a common article of food has caused men of note to conclude that the consumption of fish in large quantities is the *fons et origo mali*. Other people as stoutly urge that eating fish has nothing whatever to do with it, because leprosy occurs in places where fish is not a common article of food, and even in places where

fish is difficult of access. The cause of this disease is undoubtedly a specific microbe, and it is a contagious disease spread amongst the people by dirty habits and unhygienic surroundings. The inhabitants of the shores of Great Britain have always been large fish-eaters, but leprosy (once a common disease in the island) was never confined to the coasts, whose inhabitants were naturally the largest consumers of fish, as is shown by the remains of leper or lazar houses in inland towns and country districts.

It must not be considered, however, that fish are themselves immune to disease, or that they never convey disease to human beings. Fish are subject to the attacks of ectoparasites and endoparasites, the latter including bacteria and sporozoa. Certain *crustaceæ* become attached to the gills, fins, eyes, etc. *Worms* are found in the intestines and muscular planes. Fish are the means of distributing tapeworms ; they are the intermediate host for their development, and consequently the consumption of imperfectly cooked fish is responsible for tapeworms in man, especially the variety *Bothriocephalus latus*. *Sporozoa* attack various fishes—*e.g.*, flounder—causing blotches and swellings upon their skin. The salmon disease, formerly thought to be due to a fungus, *Saprolegnia*, is due to bacteria.

But whatever disadvantages are attached to fish, it is eaten by the inhabitants of all countries which have an extensive coast. From time immemorial it was highly esteemed by the Greeks, and the Romans placed an extravagant value upon certain varieties. The inhabitants of Britain have always had an abundance around their shores, and have eaten largely of the best kinds. Modern Britons who desire light and nourishing food have plenty of fish at their command, most of which are valuable as a source of nitrogen and phosphorus, and are light and easy of digestion.

Recent data collected by the United States Fish Commission show that the total weight of fish consumed annually in America amounts to 2,169,000,000 pounds, and is of the value of 58,000,000 dollars. The greater part of this is consumed in the United States, although a considerable quantity of canned, salted, and otherwise preserved fish is exported. It does not include the thousands of fish caught by sportsmen, but is the total produce of the industries in the fisheries of the east coast, the large rivers and lakes, and the Pacific coast as far north as Alaska.

The market value of fish is affected by various circumstances, such as locality from which they come, season, condition, their food, and the mode of capture. Fish caught in nets and allowed to die by slow degrees in or out of the water undergo decomposition more rapidly than fish killed in a proper manner directly it is taken out of the water. The flesh of the latter is firmer, and bears transportation better. Great importance therefore attaches to the handling of fish for the market. Care must also be exercised during its transportation to insure its arrival at distant markets in a good condition. This object is best attained by keeping them during transit in cold

storage, and, when sent long distances, by chilling or freezing them. The preservation of fish by cold storage has the effect of checking the activity of micro-organisms. Recent observations have shown that, when meat is stored at a temperature of 32° F., the activity of micro-organisms is checked, but the action of the ferments normally present in the meat still continues. While, therefore, the meat ripens in storage, it does not decay. But with regard to fish, the conclusion was reached that, although a temperature of 32° F. checks the action of micro-organisms and prevents putrefaction the *enzymes normally present in the flesh of fish act prejudicially and produce bodies of unpleasant flavour, so that, although the fish is not decayed, it becomes unpalatable.* The only way to check the action of both ferments and micro-organisms is to reduce the temperature of the fish *below* 32° F.—that is, it is necessary that it should be frozen. It is therefore a commercial custom to *freeze fresh fish*, and maintain its temperature at 25° to 30° F.; and *dried* fish should be kept at 25° F. Accordingly, a large industry has sprung up in various parts of the world, and notably in the United States, for dealing with the preservation and transport of fresh fish. As the boats come to land, the fish are sorted, graded as to size and quality, packed in vessels about 2 feet long, and frozen by keeping them for twenty-four hours in an atmosphere as low as 16° below zero. The fish thus form a solid cake, in which condition they can be stored for months or transported to distant markets. Such fish are packed in boxes or barrels with broken ice, in such a manner that water from the melting ice can readily escape.

Large quantities of fish are also salted, dried, and smoked. These methods secure the preservation of the fish, but at the same time modify its flavour. The Chinese are experts at drying fish; and large quantities of dried fish form an important part of the food of the Japanese, who powder it and make it into a cake or bread. The Scandinavians also make a number of articles of food from fish preserved in such a way that it is partly fermented. The industry of canning fish has developed enormously. The fish is partly cooked by heat, in order to destroy micro-organisms; it is then placed in glass or tin boxes, being afterwards "processed" and hermetically sealed to prevent the access of air and micro-organisms. It is thus preserved from oxidation and decomposition.

1. The Salmon Family and Allied Fishes.

Salmon (*Salmo salar*) is the most important fresh-water fish. It also inhabits the sea from the Arctic regions down to the northern and western coasts of Europe, and along the American coasts as far as Massachusetts, and to a still lower latitude in the Pacific waters.

Salmon is one of the most highly prized fishes, being firm yet delicious. It forms an important article of commerce. The Romans sent large quantities of salmon, preserved in snow, all over their empire. It was an important article of food even in

England and Wales in ancient times, for both England and Scotland sent salmon all over Europe. The fish is abundant now in Scotch rivers, but much less numerous in English rivers than formerly, having been exterminated from the Thames, Avon, and some other streams, owing to drainage of the land, pollution of the rivers, etc. The principal American fisheries are in Nova Scotia, New Brunswick, and Maine. The fish ascend the rivers for the purpose of spawning. In Canada they ascend the St. Lawrence and penetrate as far as Niagara. They do not extend in the east farther south than the Delaware, where they are now only occasionally found, but were formerly abundant. On the Pacific shores, "Californian salmon" extends from Behring Straits to California, and ascends the great rivers, such as Fraser, Columbia, and Sacramento Rivers.

The spawning season extends from autumn to spring, the eggs being deposited in a furrow in the bed of the river. The young fish, or larva, emerges from the egg in 80 to 140 days, when it is $\frac{5}{8}$ inch long, and not unlike a tadpole in appearance. It is called an "alevin" until it is two or three weeks old, during which period it grows to the length of $1\frac{1}{2}$ inches, and is then a fish of dark olive colour, and is called a "parr" or "samlet." It remains in the shallows of its native stream until the next spring, when, having attained a length of 3 or 4 inches, and considerable vigour, it descends to the lower reaches of the river or into brackish water. They are now called "smolts," or salmon-fry, and at the age of about fifteen months or thereabouts they congregate in shoals, which proceed leisurely towards the sea, remaining for some time in the brackish water of the estuary, and then proceed to the open sea.

They are lost to sight from the age of fifteen or sixteen months until they are two and a half years old. Of their life in the interval very little is known. They go to sea weighing only 2 or 3 ounces; they return weighing 8 or 10 pounds. When they return they are nearly full-grown, and are called "grilse." At two years and eight months it is a salmon, weighing 15 to 25 pounds, and may continue to increase in size and weight until it is 75 or 80 pounds. During their growth these fish undergo various changes in colour. When a "parr" becomes a "smolt," its coat assumes a silvery-white colour, owing to the presence of guanidin. When it comes back to the river, it still has a silvery whiteness; but as the spawning season advances its lustre becomes dimmed and of a brown colour, and the fish are very emaciated. They are now called "kelts." After spawning, the discoloration begins to pass away quickly, and the fish soon drop down into the sea.

Land-Locked Salmon (*Salmo Sebago*).—This is a fresh-water variety of the fish in America, which has probably become land-locked by the drying up of a river after the entrance of salmon from the sea. The Ouananiche (*S. ouananiche*) is a variety peculiar to the Lake of St. John in Quebec.

Californian Salmon.—The salmon of the Pacific waters belong to the genus Oncorhynchus, of which there are five species, allied to the Salmonidæ:

(*a*) Blue-back, Sockeye, or Red Alaska Salmon (*O. nerka*) is very abundant in the Columbia and Fraser Rivers of Canada. It has a rich salmon-coloured flesh, which is very attractive in appearance and palatable. It is the most important variety from a commercial point of view, being canned in enormous quantities.

(*b*) Chinook Salmon (*O. tschawytscha*), also called the Quinnat, or Columbia and Sacramento Rivers Salmon, because it is most frequently found there. It is the largest Pacific salmon ; it is also the best, and next in commercial importance to the Blue-back. Columbian salmon average 22 pounds, and Sacramento fish 16 pounds, but specimens are sometimes landed weighing 60 or even 90 pounds.

(*c*) Hunchback Salmon (*O. gorbuscha*). It exists in great abundance from Alaska to California, and is particularly numerous in the rivers of Alaska, which it ascends for spawning. It is one of the best fishes for eating fresh, being palatable and nutritious, but its flesh is pale and unsuitable for canning. It is known commercially as " pink salmon."

(*d*) Silver Salmon (*O. kisutch*) is like the former in appearance, but it is smaller, and its average weight is 5 pounds. In point of nutriment it is equal to Blue-back and Chinook, and is known to the trade as Coho or " medium red " salmon.

(*e*) Dog Salmon is also found in great numbers from Alaska to San Francisco. It is known in commerce as Chum, and is canned and sometimes sold for the superior varieties. But it is chiefly eaten fresh, being frozen and sent to the interior of the continent for that purpose.

All varieties of salmon, and the allied forms, are highly prized as food, being firm, delicious, and very palatable. They have a high nutritive value, their chief content being nitrogenous matter.

Composition of Salmon.

	Refuse.	Nutrients per Cent.				Calories per Pound.
		Water.	Protein.	Fat.	Ash.	
Whole fish	34·9	40·90	15·30	8·90	·90	660
Entrails removed	29·5	48·10	13·80	8·10	·80	600
Edible portion only	—	77·70	17·80	3·30	1·20	470
Atlantic salmon, edible part	—	63·61	21·60	13·38	1·41	—
Pacific salmon, edible part ..	—	63·61	17·46	17·87	1·06	1,080
Land-locked salmon, edible	—	78·54	17·24	2·98	1·24	—
Canned salmon	—	63·50	21·80	12·10	2·60[1]	915
Water-free substance :						
Atlantic species	—	—	61·45	36·88	3·81	—
Pacific species	—	—	52·91	49·05	2·92	—
Canned salmon	—	—	53·52	40·52	6·25	—

Canned Salmon.—The enormous distance of the Pacific salmon fisheries from the great centres of manufacture, and the plentiful supply of the fish, has led to the development of a considerable industry in canning the fish. It is, indeed, probable that the trade in Pacific or Californian salmon is one of the most impor-

[1] Including salt.

tant industries connected with fisheries, being only surpassed by that of manufacturing cod-liver oil. The method adopted is that of canning other foods—viz., careful sterilization and hermetically sealing the tins to preserve the fish and prevent the formation of amino-acids, leucomaines, and ptomaines. The fish is scaled, gutted, beheaded, and washed, placed in nets and three-parts cooked. It is then divided into "cutlets" which fit into the tins, and a little *alum* is added, with salt water and oil. The alum makes the flesh firm. The tins are then "processed" and sealed.

Trout is the common name of fishes allied to salmon. There are in Europe twenty-four species of fresh-water trout, besides five migratory species, belonging to the Salmonidæ. Those most numerous in Britain are—(*a*) The Common or Brown Trout (*S. fario*), found in streams of quick-running water, and a great favourite with sportsmen. (*b*) The Bull-Trout (*S. eriox*), sometimes called the "sea-trout," ranks near to salmon, and averages 8 to 15 pounds, but sometimes weighs as much as 40 pounds. The young is called a *whitling*. (*c*) The Grey or Lake Trout (*S. ferox*), which weighs from 20 to 30 pounds. A distinct species is that of Loch Leven (*S. levenenis*). (*d*) Salmon-Trout (*S. trutta*), also called "white salmon," ranks next to salmon in value, which it resembles in form and colour. It ascends the rivers to spawn. It is sometimes called "sea-trout."

The American species belong to the genus Salvelinus. (*e*) Brook-Trout (*S. fontalis*) exists in the quick-running streams from Labrador to Saskatchewan, and southwards as far as Georgia and Alabama. It weighs 2 or 3 pounds. On the Pacific slopes various other species of brook-trout exist—*e.g.*, rainbow trout (*Salmo iridens*), steel-head (*S. gairdneri*), cut-throat (*S. clarkii*), etc. (*f*) Lake-Trout: *S. confinis* is the common form, but there are several others, the chief being the Namaycush (*S. amethystus*), which is found in the great lakes from Maine to the Pacific. The latter is of great commercial importance, and ranks next to white-fish. Its average weight is 15 to 20 pounds, but specimens are caught weighing 100 pounds.

Composition of Trout—Percentages.

Edible Part only.	Water.	Protein.	Fat.	Ash.
Salmon-trout	70·80	17·80	10·30	1·20
Lake-trout, fresh	69·05	18·29	11·62	1·14
,, dry	—	60·13	36·01	3·86
Brook-trout, fresh	77·73	19·27	2·10	1·21
,, dry	—	86·62	9·16	5·39

Smelt, or **Sparling** (*Osmerus eperlanus*), also allied to salmon, inhabits salt waters about the mouths of rivers, which it ascends to spawn from August to May. There are numerous species in Europe and other countries. The Canadian smelt (*O. mordax*)

inhabits the Atlantic waters, is very abundant from New York northwards, and is also numerous in the lakes of New England and Canada. It has the following percentages of composition:

Edible Portion.	Water.	Protein.	Fat.	Ash.
Fresh	78·99	17·48	1·81	1·72
Dry	—	83·25	8·63	8·12

Powan, or **Gwyniad** (*Coregonus clupeides*), is a species of Coregonus of the family Salmonidæ. It is also called the "fresh-water herring." The genus Coregonus also includes **Pollan** (*C. pollan*), a small fresh-water fish of the Irish lakes, but much larger in American lakes; **Vendace** (*C. vendesius*), nearly allied to pollan, almost confined to Loch Maben in Scotland, but more common in the lakes and rivers of Sweden; **White-fish** (*C. sapidus vel clupeiformis*)—several varieties of fish in American lakes, having average weight of 3 pounds, and of following composition:

Composition of White-Fish—Percentages.

Edible Portion.	Water.	Protein.	Fat.	Ash.
Fresh	69·74	22·69	5·90	1·60
Dry	—	74·20	20·44	5·36

Ciscoe (*C. tullibee*), also called lake-herring, green-back, blue-back, etc. It inhabits all great lakes of America, and weighs about a pound.

Sisco (*C. artedi*) is a subspecies, smaller than the former, and inhabits smaller lakes.

Composition of Ciscoe.—Fresh edible portion: Water, 73·0 per cent.; protein, 18·5 per cent.; fat, 6·8 per cent.; ash, 1·7 per cent.

Grayling (*Thymallus vulgaris*), also called "umber," is a fish 16 or 18 inches long, occupying clear, rapid streams of Northern Europe. It is an excellent food, but is prized more highly as an ornamental fish for lakes, etc.

2. The Carp Family and Allies.

Carp (*Cyprinus carpio*).—The carps are not indigenous to Britain, but are natives of Chinese waters which have become naturalized all over Europe. Their diet is chiefly vegetarian, and their growth is more rapid than that of other fresh-water fishes. Their weight has no normal limit; they are often caught weighing 10 or 15 pounds in British, and heavier than that in German, waters. They may

attain a length of 4 feet. The carp, like many other members of this family, is not regarded very highly as food ; their flesh is coarser and not so pleasing to the palate or the eye, although in point of nutriment they are quite equal to most fresh-water fishes.

Gobel (*Carpassus vulgaris*) has a similar dietetic value to the carp.

Barbel (*Barbus vulgaris* and species).—The barbels form a branch of the family of carps, and comprise 200 species, which range from the tropics to the temperate regions of the Eastern Hemisphere ; but they are not represented in America. They run up to 100 pounds in weight, and may have scales as large as the palm of the hand. In England the common barbel is confined to the Thames, Trent, and other eastern rivers. It abounds in the Rhine, Danube, and other rivers of Central Europe. Its flesh is coarse and unsavoury.

Gudgeon (*Gobio fluviatilis*) : a small fish about 6 inches in length in British waters ; little used for food.

Roach (*Leuciscus rutilus*) : lives in lakes, ponds, and slow streams ; its weight averages 1 pound, and rarely exceeds 2 pounds. Its distribution is wide : from the Danube to Ireland, and from Scandinavia to the Alps. It is a great favourite with anglers, but not much esteemed for food.

Rudd, or **Red-Eye** (*L. erythrophthalmus*) : is found in the Thames, Cam, and other rivers in England, and is very common on the Continent.

Chub, or **Pollard** (*L. cephalus*) : distributed over the temperate zone in Europe and Asia Minor. Its weight is usually 2 or 3 pounds, and rarely exceeds 5 pounds ; it is indifferent food.

Dace, or **Dart** (*L. vulgaris*) : seldom exceeds a pound in weight. It inhabits the waters of quiet streams, and its activity affords sport to anglers.

Tench (*Tinca vulgaris*) : a small fish living in ponds and sluggish streams ; weight 3 or 4 pounds ; flesh coarse and insipid.

Bream, or **Carp-Bream** (*Abramis brama*) : weighs 12 or 14 pounds ; flesh insipid, and not much esteemed for food. White-bream, or bream-flat (*A. blicca*), has similar flesh.

Loach (*Nemachulus barbatulus*) : has flesh which is considered dainty food. Spine-loach (*Cobitis tænia*) is similar.

Bleak, or **Blay** (*Alburnus lucidus*).

3. The Pike Family and their Allies.

Pike or **Pickerel-Pike** (*Esox lucius*).—This is the common pike, also called luce, jack, gedd, etc. It inhabits the deep fresh waters, rivers and lakes, of Europe, Asia, and North America. There is only one European species of pike, but America has six species. In America the smaller species are usually called " pickerel-pike " (*E. estor*), and the larger ones which inhabit the great lakes of America are called **Muskellunge** (*E. masquinongy*). The latter is a large fish, which often attains a length of 7 or 8 feet and weight of 80 to 100 pounds, and is considered a prize by the angler. Another species (*E. ohiensis*) is found principally in Lake Chautauqua and the basin of the Ohio River ; while still another (*E. immaculatus*) exists in the small lakes of Minnesota and Wisconsin.

The **Pickerel** (*E. reticulatus*) is a species of pike of very large size, often attaining a length of 4 feet and a weight of 45 to 50 pounds. It lives in the fresh-water streams of North America and in the sea along the Atlantic coast.

The **Perch-Pike,** or **Wall-Eyed Pike** (*Stizostedion vitreum*), inhabits the great lakes of America, and the smaller lakes and stream of the Mississippi Valley. It is sometimes erroneously called "jack-salmon."

Mormyri are fishes allied to the pikes which inhabit the Nile and rivers of Senegal.

Composition of Pike—Percentages.

Edible Portion.	Water.	Protein.	Fat.	Ash.
Pike, or pickerel-pike	75·70	19·30	2·50	1·10
Pickerel, fresh	79·19	18·41	·50	1·10
,, water-free	—	92·05	2·28	5·72
Perch-pike	79·60	18·40	·50	1·50
Muskellunge, fresh	76·31	20·27	2·73	1·69
,, water-free	—	82·69	10·70	6·63

4. The Herring Family.

Herring (*Clupea harengus*), or common herring, lives in the cool waters of the northern seas, from Kamschatka downwards as far as New England or Cape Hatteras on the American shores, and corresponding latitudes in European waters. In Europe the principal herring fisheries are in the North Sea, especially off the British northern coasts, Denmark, Norway, Belgium, and France.

Anatomically the herrings have a close relation with the Salmonidæ, though they are widely separated by many writers. In British waters their average length is about 12 inches, but in some parts of the North Sea they measure 16 or 17 inches; *e.g.*, British herrings are smaller than those caught off Iceland. This fish, in fact, is a cold-water fish, which moves to lower latitudes chiefly in search of food. They are of great economic importance, being among the common articles of human food. In the remote and Middle Ages the herring fishery was the most important in Western Europe, the principal centres being Southern Sweden and the east coast of Britain, the latter being the chief seat of the great Dutch fishery, which was in part the source of the wealth of the Hanseatic towns.

Herrings are nutritious, being rich in fat as well as protein. The composition is as follows: *Edible portion*—Water, 71·51 per cent.; protein, 19·49 per cent.; fat, 7·59 per cent.; ash, 1·41 per cent. They are eaten fresh, pickled, salted, and smoked, and are esteemed most highly at the spawning season, although they are fattest at the beginning of winter.

Besides the common herring there are other varieties—*e.g.*, *C. leachii*, which are shorter; *C. pallasia*, which are abundant in the Pacific, especially in the region of Alaska, and are sold in great numbers in the markets of San Francisco.

Herrings are preserved in various ways. *Bloaters*, which are intended for speedy consumption, are unsplit herrings, dry-salted for six to twenty-four hours as soon as caught, and afterwards smoked. *Pickled herrings* are eviscerated and salted in brine. *Red herrings* are prepared in the same way, being salted in brine for two or three days, and afterwards smoked with hardwood sawdust for a fortnight. *Kippers* are eviscerated herrings, soaked in brine for fifteen to sixty minutes, and subsequently smoked over hardwood shavings. The time of smoking varies in different districts, being longer at Yarmouth than Aberdeen.

Sardines and Pilchards (*Clupea pilchardus*).—There are several species of this fish, which are of economic importance. Sardines and pilchards were formerly considered to be different species. This, however, is incorrect; they are one and the same fish, but pilchards are called sardines when one year old.

1. The European Sardine (*Sardinia pilcharda*) exists in great numbers along the west coast of France and the Mediterranean Sea. Their migrations are less extensive than those of the herring. They appear early in the spring in the waters off the Spanish coast, and a little later off the French shores. The young forms appear off the western coast of France from May to November, and these constitute the sardines of commerce. The French sardine fishery is chiefly carried on from Brest to La Rochelle, Concarneau in Brittany being the chief centre of the industry. There are other fisheries off Portugal and in the Mediterranean. The pilchards of British waters are larger than the foregoing, being more fully grown, and the chief fishery is carried on in Devon and Cornwall from August to April.

At Concarneau the fish are brought ashore and taken to a canning establishment, where they are selected, cleaned, and otherwise prepared, being afterwards soaked in brine for half to one hour, boiled and dipped in oil, and finally packed in tins, which are hermetically sealed. The oil is usually olive-oil, although the use of other kinds is not unknown. It is also known that tinned sprats and herring fry have been sold for the genuine article. Several species of sardines are canned in America, which are not the same as the European variety—*e.g.*:

2. The Spanish Sardine (*S. pseudohispanica*), which is abundant in Cuban waters, also occurs in the sea along the American east coasts as far north as Cape Cod. It is very much like the European species, and attains a length of 7 or 8 inches.

3. The Californian Sardine (*S. cerulea*) also very much resembles the European fish.

Sardines are salted, smoke-dried, and preserved in oil. They are most in demand in the latter form, being carefully selected, cleaned, boiled in oil, and hermetically sealed in tins. Although olive-oil is preferable, peanut-oil, cottonseed and sesame oils, are used, because they are cheaper. It is sometimes claimed that the fish boiled in peanut-oil have a better flavour than those cooked in

olive-oil. They are often cooked in a combination of the above-mentioned oils, and afterwards packed in olive-oil. When sprats or herringlets are packed as a substitute, they ought to be labelled accordingly. The edible portion of tinned sardines has the following composition : Water, 56·3 per cent. ; protein, 24·87 per cent. ; fat and oil, 12·71 per cent. ; salt, 0·61 per cent. ; ash, 5 per cent.

Canned Sardines.—Preparation : As soon as the fish are landed, they are sprinkled with salt, or, if sufficient time is allowed for their preparation on the same day, the sardines are placed in brine for thirty to sixty minutes, after which they are decapitated, gutted, and allowed to drain, or are dried in a current of warm air. They are then cooked in a vessel of oil, being placed upon wire trays. As soon as the fish begin to rise to the surface of the oil they are considered to be sufficiently cooked. The tray is then removed from the bath, and placed on an inclined surface so that the fish may drain. The fish are then packed in tins or glass boxes with oil which has been heated, with spices such as cloves, pepper, thyme, or bay-leaf. The oil-bath was formerly heated by direct heat from a fire, but it is now usually heated by steam-pipes, so that it does not boil and does not become discoloured. In some factories, however, the fish are not cooked in oil, but in super-heated or dry steam. This is a much quicker process. Trays of medium-sized fish are run from the drying chamber into the steam apparatus, where they remain about one and a half minutes—large ones longer in proportion to size. The exhaust is then opened, the steam dispersed, the fish canned in oil and spices, sealed up, and sterilized by boiling in water for two hours. The French authorities naturally support the former method, as they consider cooking in oil to be the only proper mode of producing a superior quality of sardines. The same authorities assert that most of the steam-cooked brands of fish consist only of sprats or inferior sardines or herring fry. Olive or cottonseed oils are chiefly used.

The **Sprat** (*Clupea sprattus*, variety *Harengulus sprattus*) is a small fish in European waters ; it is a delicious, well-flavoured, and wholesome fish.

Anchovy (*Engraulis Encrasicholus*).—There are several species which inhabit the Mediterranean and all tropical seas. They vary from 2 to 7 inches in length. Small-sized ones are often sold as whitebait ; the medium-sized ones are used chiefly for pickles, paste, and sauce. The genuine anchovy has a thin, round-backed body, of bluish-brown colour externally ; the head is sharp-pointed, the scales silvery, the ventral fin nearer to the head than the dorsal fin ; the flesh of a salmon colour. This description is necessary to assist in detecting the fraudulent substitution of sprats and small sardines. The anchovies are commonly gutted, decapitated, washed, and packed in barrels between layers of salt mingled with red ochre. When they arrive in England they are bottled in brine. Anchovy sauce is made by pounding the fish in water, simmering with cayenne pepper, mace, salt, and other seasonings, and rubbing it

through a sieve. Paste is made in a similar manner. Such sauce or paste is sometimes made from sprats and the fry of other fishes, sufficient anchovies being added to give flavour ; it is then seasoned, coloured, and sometimes mixed with red clay. According to Wiley, preserved anchovies have the following composition : Water, 57·8 per cent. ; protein, 22·3 per cent. ; fat, 2·2 per cent. ; ash (chiefly salt), 23·7 per cent.

The **Whitebait** (*Clupea alba*) is a small fish, 2 or 3 inches long, which abounds in large rivers, such as the Thames and Humber, and for a long time was regarded as the fry of the shad. They are highly prized for food.

Shad.—There are several species of shad belonging to the Clupeidæ : (1) *Clupea alosa* (allis-shad, or alewife) ; (2) *C. finta* (twaite-shad) ; (3) *C. sapidissima ;* (4) *C. alosa menhaden.*

They are sea-fishes which ascend the rivers to spawn in April and May, and they prefer a temperature between 55° and 65° F. Both the allis and twaite shad ascend the Severn and Wye in England ; the allis-shad runs up the Danube as far as Dresden, and the twaite as far as Hamburg. The twaite ascends every river on the Atlantic seaboard of Morocco ; but on the American Atlantic seaboard of the same latitude it is replaced chiefly by *C. sapidissima*, which is plentiful in the Hudson and Delaware Rivers, and is propagated artificially on a large scale in the Chesapeake and St. Lawrence Rivers, is highly esteemed for food, and consumed in a fresh state in large quantities. These fishes were introduced to the Pacific by placing shad fry in the Sacramento and Columbia Rivers, and, finding the waters congenial, have spread all along the Pacific coast.

Twaite-shad is small, and seldom exceeds 16 inches ; allis-shad grows to 4 feet in length, and American specimens sometimes exceed it. They form a highly nutritious food, the protein and fat being well balanced.

Composition of Shad—Percentages.

Edible Portion.	Water.	Protein.	Fat.	Ash.
Fresh	70·62	18·56	9·47	1·35
Water-free	—	64·36	31·93	4·63

The high nutritive value of this fish has placed it the third in rank of food fishes, only salmon and cod being more important. This reason led the United States Bureau of Fisheries to cultivate it, and disperse it by placing young shad in all the coast streams of America. In 1900 they planted 240 millions of fry. The number of grown shad annually caught off the Atlantic coasts of America is estimated at from 10 to 20 millions. The female or roe shad is considered more palatable, and obtains a better price. The males

and females go in separate "schools"; the males precede the females by a week or two, and therefore form the greater part of the earlier supply; later in the season the females predominate, and form the greater part of the catch.

Shad roe contains numbers of eggs, is considered a highly valuable food, and weight for weight fetches a higher price than the fish itself. It is eaten fresh, and is not cured or prepared like caviare. It contains a high proportion of proteins, especially basic proteins—*e.g.*, protamin and histidin, and much organic phosphorus in the form of nuclein and lecithin. It is suggested as a source of the latter substances for commercial purposes. Composition of shad roe: Water 71·2, protein 20·9, fat 3·8, carbohydrates 2·6, ash 1·5, per cent.

The **Menhaden** (*Alosa menhaden vel Brevortia tyrannus*) is allied to shad, and belongs to the same family. It abounds in the Atlantic waters off the coast of New England. It is not much consumed as a fresh fish, but it is eaten largely after being salted and dried. Wiley gives its composition as follows: Water 77·15, fat 3·91, protein (by difference) 18·94, per cent. It is one of the chief sources of fish oil, and the refuse, which contains the nitrogenous matters and a large amount of phosphates, is converted into artificial manure.

The **Alewives** are also allied to the shad, but belong to the genus Pomolobus. Various fishes—*e.g.*, allis-shad—have been called by this name. They are American fishes; Jordan and Evermann classify them as follows: (1) The real alewife, or branch herring (*Pomolobus pseudoharengus*), which inhabits the Atlantic waters off the coast of America as far as Charlestown. It enters the rivers to spawn. It also exists in some of the lakes. (2) The summer herring (*P. æstivalis*), along the same coast. (3) The tailor herring, also along the same coast from Florida to Cape Cod; when found in rivers, it is called the "fresh-water tailor." (4) The hickory shad. (5) The blue herring, or fresh-water skipjack (*P. chrysochloris*), which exists in Lakes Erie and Michigan, and tributaries of the Mississippi River. They are in season before shad, and are all highly esteemed.

Composition of Alewives—Percentages.

Edible Portion.	Water.	Protein.	Fat.	Ash.
Fresh fish	74·41	19·17	4·92	1·47
Water-free	—	-·87	10·08	5·78

5. The Eel Family.

Eels (*Anguilla vulgaris*) are both fresh and salt water fish; they are common throughout the rivers of Europe and America. They are carnivorous fish, very destructive to young shad, herrings, and other fry; they also consume all kinds of animal refuse. Some authorities assert that they are fresh-water fish which descend to the

sea to spawn ; others, that they are sea-fish which ascend the rivers for that purpose. Their flesh is firm and oily, and they make a substantial and nutritious meal. The composition of the fresh fish is as follows : Water 71·60, protein 18·68, fat 9·11, ash 1·01, per cent. The fat sometimes reaches 28 per cent., and protein is then lower.

Conger-Eel (*Conger vulgaris*).—These consist of a large variety of sea-eels very common in European and West Indian waters. They are more rare in American waters. They grow to a length of 10 feet and 100 pounds in weight. Their flesh is coarse and somewhat solid, and is not very highly esteemed. They contain 70 to 73 per cent. of water, 10 or 15 per cent. of fat, and 16 to 19 per cent. of protein.

Other species of eel are the sharp-nosed eel (*A. acutirostris*), the broad-nosed eel (*A. latirostris*), and the snig (*A. mediorostris*), which are found in the waters of Great Britain.

6. The Cod Family.

Cod (*Gadus morrhua vel Morrhua vulgaris*).—The cod inhabits northern seas from the Arctic to temperate regions ; they are absent from the Mediterranean and other waters of Southern Europe. They are most abundant between 45° and 66° latitude, especially in the seas of Norway and Iceland, the North of Scotland (especially about the Orkney Isles), and the banks of Newfoundland and New England. They are omnivorous feeders, living upon the vegetables, small fish, molluscs, and crustaceans, close to the bottom of the sea. They move about in schools, and their locality is determined by their search for food and the temperature of the water. Their colour is greenish or brown, and is subject to variations, being sometimes of yellowish or reddish tints. They are an important article of human food. The best are caught from February to May. They grow to a length of 4 feet and weight of 60, or even 100, pounds. In Grimsby Market they are called by different names, according to their size—thus, codling up to 20 inches ; sprag from 20 to 30 inches. Half-cod is an indefinite size, and cod is the full-grown fish. The chief fisheries are in Great Britain, Norway, Canada, Newfoundland, and North America.

As a food they are chiefly nitrogenous, the proportion of fat being very small. They are eaten fresh, salted, dried, and shredded.

Composition of Codfish—Percentages.

Edible Portion.	Water.	Protein.	Fat.	Ash.	Salt.
Fresh fish, whole ..	82·64	15·77	·36	1·23	—
,, ,, water-free ..	—	95·13	2·07	7·08	—
Cod steak	79·70	18·70	·50	·20	—
Shredded cod	46·52	30·87	·33	—	22·81
Salted dried cod.. ..	—	45·65	·53	—	53·82

The tongue, either fresh or salted, is considered a great delicacy. The liver is also eaten.

Cod is cured by salting it in brine and smoke-drying it; a delicious flavour is thus produced. Such fish is largely used for making fish balls, by mixing it with breadcrumbs and cooking it in fat. Codfish balls have the following composition, according to Wiley: Water 65·4, solids 34·57 (including nitrogen 1·05, phosphoric acid 0·25, sulphur 0·1), or protein 6·58, fat 7·84, carbohydrates, etc., 16·10, ash 4·05, per cent.

The ovaries are sometimes consumed; like shad roe, they contain a large amount of nucleo-protein, protamin, and histidin, owing to the large amount of ova therein. It is estimated that the ovaries of a 21-pound cod contain 2·7 millions, and those of a 75-pound cod 9·5 millions, of eggs.

A brief account of the Norwegian fisheries will not be out of place. Cod forms 60 per cent. of all fish caught off the Norwegian coasts. The fishing is periodic. The spawning fishery, or *gydefiske*, takes place in the winter season all along the coast of Norway, but chiefly near the entrance of the Moldefiord and at Lofoten (Lofot Islands), where immense shoals of codfish resort to spawn. They appear early in January, spawn in March, and disappear in April. The *loddefiske* takes place off the coast of Finmarken from April to the end of June, where the fish go in search of the caplin, or lodde (*Mallotus arcticus*), a fish of about 5 or 7 inches, and the smallest of the Salmonidæ. The fish are caught with lines and nets, the bait being fresh herring, caplin, and mussels. The average catch of fish at the Lofoten Islands is 25 millions, and at Finmarken 15 millions per annum. The *got*, or spawning fishery, at Finmark occurs from January to April; the *lodde* fishery from April to June; the summer fishery from June to September; and there is also an autumn fishery. The cod that appear with the caplin are not the same fish which came there to swarm; they are smaller, and are called "caplin-cod," or "lodde-torsk." When spawning, the males are separated from the females, in obedience to a natural law. The ova of the female are lighter than the sea-water, and rise to the surface; the male fishes therefore float at a higher level, and there discharge the milt by which the ova are impregnated as they rise nearer the surface. The spawning season of each fish only occupies a few days, but the quantity of ova and milt discharged is so enormous that at the height of the season the sea for miles around is quite milky in appearance.

The fish being hauled into the boat, are killed by an incision behind the gills, the body slit up, the liver and roe removed and placed in separate barrels. On arriving in the harbour, most of the fish is sold at once to buyers. A large proportion of the fish is split, salted, dried, and sold as *klipfisk*, chiefly to Spain. Some of the men, however, simply dry the fish by hanging it for months upon rods, when it is sent to Bergen, to be exported as dried fish (*torfisk*), chiefly to Sweden, Holland, and Italy.

Cod-Liver Oil.—The **liver** averages ½ pound in weight, and, when young, healthy, and fat, is of a cream colour, and so soft that the finger can be pushed through it. The primitive method of obtaining the oil is as follows: The cleaned livers are put into casks, covered down, exposed to the rays of the sun, and allowed to *putrefy*. In the disintegration which results the hepatic cells are broken up, and allow a clear pale yellow oil to exude and collect upon the surface; this is drawn off by means of a siphon, and constitutes the finest quality of *raw* medicinal oil. The substance

in the casks is then subjected to light pressure by means of stones, and, after further putrefaction or contraction of the tissues, a "clear brown" cod-liver oil is drawn off by means of a tap near the bottom of the barrel. The residue is then boiled in water, and yields a "brown oil," which is removed by skimming. In each case the oil requires to be clarified.

The modern process, however, is very different, the oil being obtained from the livers by a combination of heat and pressure, or by heating it with steam. The **hot-pressure** method is that adopted by the Scotch manufacturers. The cleaned livers are reduced to a pulp, heated, put into bags, and strained, the residue being subjected to pressure while hot. The **steam process** is that employed in Norway, Newfoundland, and Labrador. It was introduced by Möller in 1853, the apparatus consisting of a pan, surrounded by a steam-heated jacket wherein the cleaned livers are heated for three or four hours by steam at 100° C., or even by superheated steam. By this means a colourless and tasteless oil is obtained, free from decomposition products. A still further proportion of oil, of a light brown colour and somewhat unpleasant odour, is obtained from the residue by pressure. The finest oil, however, is that obtained from livers heated in a steam-jacketed pan at 70° C. for forty-five minutes only, after which it is cooled to −5° C., and the frozen mass put into canvas bags and submitted to pressure to remove the "stearin" and débris.

Three qualities of oil are put on the market: **Pale or clear pale cod-liver oil,** of a pale yellow colour, slight fishy odour and taste, and slightly acid reaction. **Light brown** or "clear brown" oil, of a chestnut-brown colour, rather strong fishy taste and smell, perhaps slightly bitter and irritating to the throat. **Brown** or "dark brown" oil, which is too unpleasant for food or medicine, and is chiefly used for leather-dressing.

Composition of Cod-Liver Oil.—The chief constituents are 20 per cent. of **jecolein** and 20 per cent. of **therapin**, the glycerides of jecoleic acid ($C_{19}H_{36}O_2$) and therapic acid ($C_{17}H_{26}O_2$) together with palmitin, glycerides of one or more unknown fatty acids, traces of cholesterin, lecithin, lipochrome, volatile fatty acids, alkaloids such as gadinin, asselin, and morrhuin, bile acids, iodine (never more than 0·002 per cent.), iron, manganese, magnesium, etc. It has S.G. = 0·922 at 15° C.; iodine number, 150 to 180; and refractive index, 1·47.

Adulteration.—Cod-liver oil is adulterated with other fish and vegetable oils. The oil from other fish is difficult to detect, and is not objectionable when derived from the liver of haddock, hake, ling, or even coalfish. Shark-liver oil (the basking shark), which is sometimes used as an adulterant, is a very light oil—S.G. = 0·875—or lower than that of cod-liver oil. Japanese fish oil and African fish oils, which are similar to those of the seal, and even whale oil, are occasionally used.

Cod-liver oil should be regarded as a food rather than a medicine.

It is absorbable and digested fairly easily, because the tension of the fat is low and permits the oil to spread out into thin films and become readily emulsified and saponified. It is for this reason it is well borne by patients who are unable to digest other fats. It increases the general nutrition and weight of the consumer, and is therefore of high value in all wasting diseases, such as tuberculosis, scrofula, rickets, diabetes, and the malnutrition of infants. It should be given only during the cold months, and intermitted during the heat of summer.

Tomcod, poor-cod, or power (*Gadus tomcodus vel minutus*) : a small variety of cod common on the American coasts, and widely distributed. It is much used for food. Composition of the edible portion : Water 81·5, protein 17·2, fat 0·4, salts 1·2, per cent.

Pout, or burbot (*Gadus luscus*), also called "eel-pout."

Whiting (*Gadus merlangus*).—This fish abounds in British seas ; it is small, but excels all other members of the family in delicacy and lightness. It seldom exceeds 20 inches in length or 4 or 5 pounds in weight. It feeds on the fry of other fishes. It attains maturity when about 9 inches long, and spawns from February to March. As a foodstuff it is chiefly nitrogenous, being poor in fat, having same composition as cod ; it is chiefly valued for its lightness and tenderness. *Couch's whiting,* or pontassan (*G. pontassan*), is a small rare fish, seldom exceeding 15 inches in length.

Haddock (*G. æglefinus*) is smaller than cod, but is a well-known member of the family, which breeds in immense numbers in Northern seas. The young haddock grows very rapidly, and may attain a length of 3 feet and weight of 24 pounds. The fish are very abundant in American waters, especially off Massachusetts in the summer season. They form an important article of commerce, for which the medium-sized fish are preferred. They are eaten fresh, or after being cured by salting and smoking. As an article of food, fresh haddock is exceedingly light, the flesh being lax and tender, and forms an easily digested food. Salted and smoked fish are not so easily digested.

Composition of Haddock—Percentages.

Edible Portion.	Water.	Protein.	Fat.	Ash.
Fresh fish	81·4	17·2	·30	1·10
,, ,, water-free	—	91·9	1·34	6·76
Smoked fish	72·4	23·7	·30	3·60
,, ,, cooked	68·7	22·3	2·30	6·70

"Finnan haddies" are haddocks preserved by being decapitated, opened, and eviscerated ; they are soaked in strong brine for half an hour, drained, and dried by exposure to the smoke from peat for four to six hours.

Pollack, or Lythe (*G. pollachus*).—This is a British fish familiar to sportsmen, but not often seen at the fish-shop. It extends from Norway to the Mediterranean. It is common off the Cornish coats, and around Scotland and Ireland. When cooked at once it forms excellent food ; but it loses freshness so rapidly that it never gets to market. The edible portion contains—Water 76·0, protein 21·6, fat 0·8, ash 1·5, per cent.

Hake (*Merluccius vulgaris*).—The common hake of the British seas is generally regarded as a surface fish, but its habitat extends to a depth of 300 fathoms. It has a long body, growing to 4 feet, and weighing 24 pounds. It ranges cold and warm seas alike, being abundant from Norway to Madeira. It spawns early in the year and late in the summer. It is caught in numbers along the east coast of Scotland. There is a periodicity about its appearance : it is scarce in some years, and abundant in others ; it comes and goes without apparent rule, although it follows the herrings, mackerel, and sprats, on which it preys. There are two species in the American waters : *Merluccius productus*, which occurs chiefly off the Pacific shores, and has rather coarse flesh ; and *M. bilinearis*, off the New England coasts northwards along the east of Canada, whose flesh resembles that of cod, and is sometimes sold for it.

Composition of Hake—Percentages.

Edible Portion.	Water.	Protein.	Fat.	Ash.
Fresh fish	83·25	15·29	·71	1·00
,, ,, water-free	—	91·10	3·88	5·02

Ling (*Molva molva*, or *M. vulgaris*) extends from Spitzbergen to Gibraltar, and is one of the most prolific fishes in British waters. It is most rapacious, consuming herrings, whiting, sprats, dragonets, and even cod and halibut. It grows to a length of 7 feet and weight of 120 pounds. It is eaten either fresh or salted ; the dried fish forms a considerable article of commerce.

Rockling, or sea-loach : There are three species in British waters—*Motella tricirrata, M. ambria, M. mustella*, of which the former is the most numerous.

Torsk, or tusk (*Brosmius brosme*), is very plentiful off the North of Scotland ; it is salted and dried, and forms a savoury fish of considerable commercial importance.

The **Ophidiidæ** have an affinity with cod. The **Launce** (*Amnodytes lanceolatus*) and **Sand-eel** (*A. tobianus*) are found in British waters or in the sands at low-tide. They vary from 4 to 12 inches in length, and are delicate-flavoured food, but are chiefly used for bait by anglers.

7. The Flat Fishes.

The flat fishes have the peculiarity that they are coloured on the right side, and white on the left side ; the eyes also become altered in position, so that both appear on the right side soon after they are hatched. The exterior of these fishes also varies in other ways.

(1) *Pleuronectidæ.*

Plaice (*Pleuronectes platessa*) has an unmistakable form. It is of a deep brown colour, with orange-red spots, which are not found upon any other flat fish in British waters. The scales are very small, and a newly-caught plaice feels slimy. It is distributed throughout European seas from the cold waters of the North to the warm waters of Southern Spain. It is abundant all around the British Isles ; it occurs in the Bay of Biscay, but not in the Mediterranean Sea. Like all flat fishes, the adults lie close to the bottom, often lying in sand or gravel, which affords them protection. They feed on molluscs, crustaceans, and worms. They spawn, in the English Channel, from January to April, and in all seas at a considerable distance from land. The eggs float near to the surface, and are a prey to herrings, whitings, etc. The males are mature when about 15 inches in length, and are smaller than the females. The fish are generally distributed around Great Britain, but the largest fish keep in deep waters, up to about 100 fathoms deep. As a food they are exceedingly light, and chiefly nitrogenous, The edible portion has the following composition : Water 87, protein 11·86, fat 0·53, salts 0·71, per cent.

Dab.—There are several species—*e.g.*, dab (*P. limanda*), lemon-dab (*P. microcephalus*), pole-dab or witch (*P. cynoglossus*), the long rough dab (*Hippoglossoides limandoides*). Most of the remarks about plaice apply to these fishes. Dab is a light brown fish with dull brown spots ; it ranges up to 10 inches in length, and occupies the sea from Iceland to the Bay of Biscay. Lemon-dab, sometimes called "lemon-sole," only attains a length of 6 or 8 inches, but it is much preferred to the former for food. Pole-dab is a pale brown fish on one side, and has rough scales ; it grows to 20 inches in length, and is plentiful in the North Sea, off the west coast of Scotland, and around Ireland. The long rough dab is similar in shape to halibut, but has a lighter colour, and rarely any spots. It has the same area of distribution as halibut, but is rarely seen in the English Channel.

Flounder (*Pleuronectes vel Platessa flessus*).—The flounder is one of the most important flat fishes, and has a wide range of distribution. They live in the sea as well as in fresh or brackish waters, and have been transferred from one to the other without injury. They mostly live where the bottom consists of soft sand or mud, and feed on small fish, crustaceans, worms, water-insects, infusoria, etc. The fish descend the large rivers to the sea, where they spawn, the ova floating on the surface. The adult weighs about 4 pounds. The British flounder has rough scales, those of the Baltic Sea being even rougher ; but the Mediterranean species has smooth scales. There are several species of flounder in the American waters : (1) The summer flounder (*Paralicthys dentatus*), which exists in abundance off the Atlantic coast from Cape Cod to Carolina, but especially in the neighbourhood of New England and Long

Island. It attains a length of 2 or 3 feet and weight up to 15 pounds (2) The wide flounder, or common flat fish (*P. americanus*) extends from Labrador to Carolina. It is smaller than the former, averaging 15 inches in length and a weight of 2 or 3 pounds. (3) The southern flounder (*P. lethostigmus*) replaces the former in southern waters, extending from Carolina to Central America. (4) The Gulf flounder (*P. albiguttus*) is a species special to the Gulf coast.

Composition of Flounder—Percentages.

Edible Portion.	Water.	Protein.	Fat.	Ash.
British species	83·80	14·26	·63	1·31
Summer flounder	84·21	13·82	·69	1·28
,, ,, water-free ..	—	89·03	4·46	8·15

Halibut (*Hippoglossus vulgaris vel H. hippoglossus*).—This is the largest flat fish; it attains a great size, specimens being caught which exceed 8 feet in length and 200 to 500 pounds in weight. The best and most palatable fish do not exceed 80 pounds in weight. The upper side of the fish is dark green or mottled brown, the underside being pure white. It inhabits the seas of high latitudes, about Greenland and Iceland, but also occurs as far south as the English Channel, and in the Pacific as far south as Columbia and Oregon. It prefers water having a temperature of about 45° F. and a depth of 120 fathoms, but is often caught in more shallow waters, and temperature at about freezing-point. It spawns in April and August, the eggs being of the floating kind, but are not actually seen on the surface. The species are several.

Halibut is a common article of food, halibut steak being highly esteemed; the flesh is mostly firm, but some parts are tender and delicious. It is one of the best food fishes, containing protein and fat in a moderate ratio.

Composition of Halibut Steak—Percentages.

Edible Portion.	Water.	Protein.	Fat.	Salts.
Fresh fish	74·83	18·47	5·30	1·40
Water-free substance	—	76·87	18·53	4·06

Turbot (*Rhombus maximus*) is the largest flat fish next to halibut. It is a broad fish, of light brown colour, without spots, and has tubercles instead of scales. The largest specimens are 2 or 3 feet long, and weigh 60 or 70 pounds. It feeds on fish, and spawns from April to June. The American turbot (*R. maculatus*) is spotted, and not so large. Turbot is an excellent food, being light and highly esteemed. The edible portion has the following composition: Water, 71·4; protein, 14·8; fat, 14·4; ash, 1·3—per cent.

Brill (*Rhombus lævis vel Pleuronectes rhombus*) resembles turbot, being somewhat smaller, of light brown colour, and mottled; it has small scales, but no tubercles. In size it varies from 22 to 26 inches. Its distribution is from the Mediterranean Sea to Scotland, but no farther north. It is inferior to turbot in quality, and is not so highly esteemed as a food.

Scald and Megrim.—The scald (*Arnoglossus laterna et grohmanni*) is a fish of British waters, whose skin is fragile and comes off when roughly handled—hence its name. The megrim, or rough scald (*Lepidorhombus megastoma*), also called "whiff" and "sail-fluke," is another thin-skinned fish, yellow above, and about 2 feet long. It is plentiful off the coasts of Devon and Cornwall, less abundant in the North Sea, and absent from the Mediterranean.

Topknot.—Several British species of Pleuronectes—viz., *Zeugopterus punctatus, Z. unimaculatus, Z. norvegicus*—are known by this name. They also inhabit Scandinavian waters, but are not numerous in the Mediterranean. They are small, 5 to 7 inches long, and are not important food fishes.

(2) *Soleidæ.*

Sole (*Solea vulgaris*).—The sole is an oblong flat fish, growing to a weight of 6 or 7 pounds, abundant in deep waters around the coasts of Europe, except where the bottom is sandy. They come to shallow water in the summer time, and sometimes ascend the rivers and thrive therein. They form a light, wholesome, and delicious food, which is chiefly nitrogenous and highly esteemed. The composition is as follows: Water, 86·14; protein, 11·94; fat, 0·25; ash, 1·67—per cent.

The name of "sole" is in America applied to *Eopsetta jordani*, a species of flounder, which inhabits the Pacific from Puget to Mountesey, and is an estimable food fish. Great numbers are cured and dried by the Chinese. **Lemon soles** or **French soles** (*S. lascaris*), inhabit the sea from the North of Scotland to the Mediterranean, but are most abundant in the English Channel. They are smaller that *Solea vulgaris*, the largest on record being 14 inches long. Lemon-dab is sometimes incorrectly called "lemon-sole." **Solonette**, or **little sole** (*S. lutea*), is only about 3 or 3½ inches long; it is abundant from Scotland to the Mediterranean Sea. **Bastard sole**, or **thick-back** (*S. variegata*), averages 8 or 9 inches in length, and is found from the English Channel to the Mediterranean Sea. It is excellent eating.

8. The Perches.

Perch (*Perca fluviatilis*).—The perch family consists of numerous genera and species which inhabit fresh and salt water throughout the temperate and tropical regions. The English or yellow perch varies in weight from 1 to 3 pounds. They spawn in sluggish waters from March to May. They grow slowly, a fish of six years being only 16 inches long and 1½ pounds in weight. They are, however, excellent food, and have the following composition:[1]

[1] Bulletin 28, U.S. Department of Agriculture.

Composition of Perch—Percentages.

Edible Portion.	Water.	Protein.	Fat.	Ash.
Yellow perch	79·3	18·7	·8	1·2
White perch	75·7	19·3	4·0	1·2
Perch-pike	79·7	18·6	·5	1·4

In North America the place of common perch is taken to a great extent by **Black Bass,** which the naturalists consider to be a separate species. There are several varieties: (*a*) Large-mouthed black bass (*Micropterus salmoides*); (*b*) small-mouthed black bass (*M. dolomieu*)—both abundant in the rivers of America; (*c*) rock bass (*Ambloplites rupestris*), one of the most common fishes of the rivers in the Central States, averages a pound in weight, and is conducive to the pleasure of anglers; (*d*) striped bass (*Roccus lineatus*), a common fish of the Atlantic coasts from New England to Carolina, and abundant in the markets; (*e*) red bass (*Sciena ocellata*).

Sea Perch or **Bass** (*Labrax lupus*) is a handsome fish which appears in shoals in the shallow seas or estuaries of the South of England and Ireland from June to September. In the autumn a few fish are taken in the rivers, but most are caught off Dover, Brighton, and Bournemouth, good specimens weighing 10 to 20 pounds. At the present day they are not much in repute, but the Greeks and Romans esteemed it highly. The American species is *Centropristus nigricanus*. The red grouper (*Epinephalus morio*), an American fish, and the ruffe, or pope (*Acerinus cornua*), are allied.

Composition of Bass—Percentages.

Edible Portion.	Water.	Protein.	Fat.	Ash.
Black bass	76·7	20·6	1·7	1·2
Striped bass	77·7	18·6	2·8	1·2
Red bass	81·6	16·9	·5	1·2
Sea bass	79·3	19·8	·5	1·4
Red grouper	79·5	19·3	·6	1·1

9. **The Sea-Breams** (*Sparidæ*).

These should not be confused with the cyprinoid breams of our lakes and rivers. There are a number of species around the British coasts. The following belong to the family: Common sea-bream (*Pagellus centrodontus*), axillary bream (*P. owenii*), pandora (*P. erythrinus*), Spanish bream (*P. bogoraveo* or *P. acarne*), Couch's sea-bream (*P. vulgaris*), gilt-head (*P. auratus*), old-wife (*Cantharus lineatus*), bogue (*Box vulgaris*).

Bream is called by different names in different parts of the world. Thus, at Plymouth (Australia) small red bream are called "chad," intermediate sizes are "ballard," and the mature fish "bream." At Sydney the same fish are respectively called "red-brim," "squire," and "snapper." The common sea-bream of America is a wrasse.

Red Snapper.—Several members of the genus *Sparidæ* are called "snapper" in America—*e.g.*, red snapper and grey snapper. Red snapper (*Lutjanus*

blackfordi) is the principal one. It is found chiefly in the deep waters of the Gulf of Mexico, where it attains a length of 1½ to 3 feet and a weight of 10 to 30 pounds. According to U.S. Bulletin No. 28, the edible portion has the following composition:

Edible Portion.	Water.	Protein.	Fat.	Ash.
Fresh fish	78·50	19·70	1·0	1·31
,, ,, water-free	—	91·75	4·7	6·05

Porgy (*Stenotomus chrysops*), also belonging to the Sparidæ, occurs in large numbers off the Atlantic coasts of America in summer and autumn, and is largely consumed and much esteemed. The edible portion of the fresh fish has the following composition: Water 74·99, protein 18·52, fat 5·11, ash 1·38, per cent.

Sheepshead (*Diplodus probatocephalus*), allied to the former, is also abundant along the American shores of the Atlantic from Cape Cod to Texas. It ascends fresh-water streams, and is particularly abundant in the Indian River. Individual fish may attain a weight of 10 or 12 pounds, but the average weight is only 3 or 4 pounds. It is very destructive to young oysters, and its gluttony is a source of much trouble to proprietors of oyster-beds. Its composition shows it to be a nutritious food, the edible portion containing—

Edible Portion.	Water.	Protein.	Fat.	Ash.
Fresh fish	75·6	20·10	3·71	1·20
,, ,, water-free	—	83·47	13·59	5·14

Weak-fish (*Cynoscion regale*) is one of the Scienidæ, or Croakers. It is one of the most valued fishes of America, highly esteemed for its palatability and the extreme tenderness when young. It inhabits the Atlantic Ocean along the coast as far south as the Gulf of Mexico, and congregates at the mouth of tidal rivers, which it sometimes ascends. Its composition is as follows:

Edible Portion.	Water.	Protein.	Fat.	Ash.
Fresh fish	78·69	17·67	2·42	1·22
,, ,, water-free	—	83·73	11·43	4·82

King-fish (*Menticirrus saxatilis*) is another of the Scienidæ much esteemed in America. The edible portion has the following composition: Fresh fish—Water 79·2, protein 18·9, fat 0·9, ash 1·2, per cent.

Maigre (*Sciena aquila*) is a fish of the same family common in the Mediterranean Sea, and often taken along our shores; it is an excellent food. **Red Bass** (*S. ocellata*) occupies the same regions.

10. The Mullets.

Mullet.—(*a*) Red mullet, surmullet (*Mullus surmuletus*), inhabits the Mediterranean Sea. It is a small fish, averaging about 1 foot in length. It has always been esteemed a delicacy by epicures, and was extravagantly prized by the Romans. (*b*) The gray or thick-lipped mullet (*Mugil chelo*) is a common fish off many parts of the British coasts, especially in southern waters, near harbours and estuaries. It ascends the rivers or seeks shallow waters in the spring. It grows to 18 or 20 inches long, and weighs from 12 to 15 pounds. (*c*) The common or striped mullet (*M. cephalus vel albula*) has its habitat over a large oceanic area in the Atlantic Ocean, along the coasts of America, where it is especially abundant about Florida, and throughout the Southern Seas, attaining its maximum numbers, apparently, about the islands of Hawaii. This fish is about 2 feet long ; it feeds upon mud and the small organisms and refuse contained therein. Although a scavenger, it does not eat other fishes, but is itself attacked and consumed by carnivorous fishes. It is highly esteemed for food, and the edible portion has the following composition :

Edible Portion.	Water.	Protein.	Fat.	Ash.
Fresh fish	74·88	19·42	4·53	1·17
Water-free substance ..	—	77·47	18·28	4·25

11. The Gurnards and their Allies.

These fishes belong to the Cottidæ. There are several species of **Gurnard** in British seas which are considered good eating. The commonest is the red gurnard (*Trigla cuculus*), caught off the south coasts ; its length averages about 18 inches. The grey gurnard (*T. gurnardus*) occupies more northern waters, and is a larger fish, specimens of the length of 30 inches being caught. They come to the coasts to spawn in summer, but return to deep waters in the autumn. The piper (*T. lyra*) is the largest English gurnard, and averages 24 inches in length. The armed gurnard (*Peristhetus cataphractum*) is a wanderer from the Mediterranean Sea.

The **Bullheads** (*Cottus gobio, C. norvegicus,* and *Agonus cataphractus*), found in British waters, are unimportant as a food.

The **Gobies** (*Gobius* and species) are also unimportant, and are not seen at the fishmonger's.

The **Blennies** (*Blennius* and species) are also seldom or never seen at the fishmonger's ; nevertheless, they are a somewhat important food in North Britain. They are rich in fat.

The **Butter-fish**, or spotted gunnel (*Murænoides guttatus*), an American fish, is allied to the blennies, and like them is rich in fat, in consequence of which it has attained the name of " butter-fish."

The edible portion has the following composition: Fresh fish—Water 69·8, protein 18·0, fat 11·0, ash 1·2, per cent.

12. The Mackerels and their Allies.

Mackerel (*Scomber scombrus*).—This is a well-known fish of excellent qualities which inhabits all European seas, and the whole of the North Atlantic Ocean, extending from Norway to the Mediterranean and Adriatic Seas, and the American waters as far south as Cape Hatteras. It is found all round the British Isles, but is especially abundant in the English Channel and off the south and south-west coasts of Ireland. The fishing seasons are from March to June and July to November. As the fish is a popular article of diet in Britain, the mackerel-fishing is an important industry, which is supported by the extraordinary fecundity of the fish. Like herrings, they are caught when they approach the shores or shallow waters for spawning. In the English Channel the spawning season is in the summer-time. The eggs, of which a female may contain half a million, float separately in the water. As they develop the larvæ resemble bullheads. A year-old mackerel is about 3 inches long, at two years it measures 8 inches, and at three years, when it attains sexual maturity, it measures 11 inches. Shoals of mackerel appear in January off the west coast of France, and later in the English Channel; in April shoals of larger fish from the North Atlantic approach the south and south-west coasts of Ireland; in May they are caught in great numbers off Cornwall and Devon. The fishing lasts through June and July; there is a falling-off in August, and a revival in October, but by the middle of November practically all the great body of mackerel have left the waters around Great Britain.

A fish so abundant, so palatable and nutritious, as mackerel could not fail to be duty appreciated; consequently the demand equals the supply. It is not only eaten in fresh condition, but it is preserved by being pickled, salted, or smoked and dried. Its value as an article of food is shown by the composition of the edible portion:

Edible Portion.	Water.	Protein.	Fat.	Ash.
Fresh fish	77·78	18·52	7·43	1·27
Water-free substance ..	—	70·65	25·17	4·28

The **Spanish Mackerel** (*Scomber colias*) inhabits chiefly the Mediterranean Sea, but is sometimes caught off the British, French, and American shores, where it has wandered from its natural habitat. Its flesh is highly esteemed by epicures, and its comparative rarity causes it to be expensive. A good-sized fish weighs from 5 to 8 pounds. Unfortunately, it speedily becomes unfit for food after its

removal from the water, and in consequence this species is of little commercial value. It is, however, highly nutritious, as shown from analyses of the edible portion, the composition being as follows :

Edible Portion.	Water.	Protein.	Fat.	Ash.
Fresh fish	68·10	20·97	9·43	1·50
Water-free substance ..	—	67·25	29·56	4·71

Horse-Mackerel, or **Scad** (*Caranx trachurus*), resembles the ordinary mackerel, but belongs to the Carangidæ. It inhabits southern waters, but finds its way northward along European coasts. It attains a length of 20 inches, and weighs as much as 3 pounds ; but the flesh is rank and oily, and therefore not much esteemed.

Boar-fish (*Capras aper*) is a small fish of about 7 inches long, very plentiful off the British south-west coasts during the summer, which spawns off the coasts of Cornwall in July. It is of no commercial importance.

Tunny.—Several of the Scomberoidei are called "tunny"—*e.g.*, *Thynnus vulgaris* (common tunny), *Orcynnus thynnus* (short-finned tunny), *Orcynnus germo* (long-finned tunny)—while *Thynnus palamys* (bonito), *Palamys sarda* (belted bonito), and *Auxis rochii* (plain bonito), are closely allied.

The common tunny is the largest fish of the mackerel family, and is also called the "great albacore," and sometimes the "horse-mackerel." Like mackerel, it lives in shoals, and inhabits the seas of all temperate warm regions of the earth. It may grow to 20 feet in length and attain a weight of half a ton. In American waters fish are frequently caught measuring 10 feet in length and 1,500 pounds in weight ; but those caught in European waters and in the Pacific Ocean seldom exceed half that size. The flesh of tunny is considered a delicacy, somewhat resembling veal in flavour, and is highly esteemed. The composition of the edible portion is as follows : Fresh fish—Water 72·7, protein 20·3, fat 4·1, ash 1·7, per cent.

Pompano (*Trachynotus carolinus*), like horse-mackerel, belongs to the allied group of Carangidæ. It is an important food fish in the Southern States of America, especially in Florida and New Orleans. It is abundant in the Gulf of Mexico, and occurs along the Atlantic coast as far north as Cape Cod. It is a comparatively small fish, averaging only 2 or 3 pounds in weight ; but it is highly nutritious, containing well-proportioned fat and protein, as shown by the composition of the edible portion. It is, however, not obtainable in sufficient quantities to make it of economic importance. Composition of the edible portion :

Edible Portion.	Water.	Protein.	Fat.	Ash.
Fresh fish	72·81	18·68	7·45	1·06
Water-free substance ..	—	73·16	23·32	3·52

John Dory (*Zeus faber*) belongs to the Cyttidæ. It is found in British waters, measuring from 15 to 22 inches in length, and weighing as much as 18 pounds. Its flesh is esteemed very delicate eating, but its grotesque appearance may cause it to be unpopular as a food. In any case, it is not caught in sufficient numbers to bring it into commercial prominence.

Blue-fish (*Temnadon saltatrix*), a carnivorous fish of the order Pomatomidæ allied to the mackerel. It is commonly caught along the Atlantic shores of America, and is particularly abundant off the New England coast. Its usual weight is from 3 to 5 pounds. It is much esteemed as a food, and runs the pompano and Spanish mackerel for favour pretty close. It, however, contains less fat than either of the latter, as shown by the following calculation of the composition of the edible portion :

Edible Portion.	Water.	Protein.	Fat.	Ash.
Fresh fish	78·52	19·10	1·17	1·27
Water-free substance ..	—	89·33	5·96	4·71

Garfish (*Belone vulgaris*) and **Saury-Pike** (*Scomberesox saurus*) belong to the Scomberescoidæ—that is to say, they resemble mackerel in form, but are larger, being from 2 to 3 feet long, and have flesh which resembles that of mackerel. They, however, possess a long snout-like beak and other characteristics which place them in the subdivision Pharyngonathi. They are plentiful off the British coasts, and appear in great numbers before the usual time of mackerel.

13. The Wrasses.

The **Wrasses** (*Labridæ*) are a large family of bony fish. They are among the least important of our food fishes, and are sometimes said to be unfit for human food. But opinions differ on this matter, and some members of the family are largely consumed in various parts of the world.

The British wrasses are the striped wrasse (*Labrus mixtus*), the ballan (*L. maculatus*), connor (*Crenilabrus melops*), Jago's goldsinny (*Ctenolabrus rupestris*), scale-eyed wrasse (*Acanthalabrus pallori*), rock-cook (*Centrolabrus exoletus*), and the rainbow wrasse (*Coris julis*). The wrasses dwell under weed-covered rocks in shallow or moderately deep water. The ballan, or comber, is one of the largest ; it attains a length of 16 inches and a weight of 6 or 7 pounds. It feeds on worms and molluscs. The connor is similar to it, but rarely exceeds 9 inches in length. The scale-eyed wrasse is a southern form which wanders into British waters, and is one of the largest caught there, some of the specimens being 20 inches long. A wrasse of North America, the **Tantog,** or **Black-fish** (*Tantago vel Hiatula ornitis*), extends from New Brunswick to Carolina, and especially about the rocky coasts of New England. It is esteemed good food, the edible portion containing 18·5 per cent. of protein and 1·4 per cent. of fat. The **Hog-fish** (*Lachnolaimus maximus*) is another wrasse inhabiting the seas round the West Indies and the southern coasts of America. It is much esteemed for food. Its common name is derived from the shape of its head, resembling that of a hog.

The **Chromides,** allied to the wrasses, inhabit the fresh-water streams of

hot climates. They usually have ctenoid scales, and are considered very good eating. One of the chromides in the Nile, having cycloid scales, is reckoned to be the best edible fish in that river.

14. Catfishes, or Sheatfishes.

The **Catfishes** belong to the Siluridæ, an extensive family of fish which for the most part inhabit the fresh waters of warm climates. The only known European species is *Siluris glanis*, a fish of very large size inhabiting the lakes of Switzerland, the Danube, Elbe, and all the rivers of Hungary. Its flesh is very fat, and is sometimes used in place of lard. In North America there are many species, some of which are localized—*e.g.*, the **Schuylkill Cat** (*Ameirus nebulosus*) of the streams and small lakes of Maine and Pennsylvania. The **Blue Catfish** (*Ictaleurus furcatus*) is an important species of large size, sometimes weighing 150 pounds, which inhabits the Mississippi and its large tributaries. Many species of catfish occupy the smaller rivers and streams of America, where they do not attain a great size, but average only 1 or 2 pounds. This is a notable instance of the influence of environment on development. Compensation for the small size is, however, shown in the superior edible quality of the small varieties for food over that of the large-sized species. The average composition of the edible portion of catfish is as follows: Water 64·1, protein 14·4, fat 20·6, ash 0·9, per cent.

15. The Dogfishes: Flake.

Sharks have no commercial value on the British coasts, although they are consumed in the East, where certain parts of them are highly appreciated for food. But some members of their natural order or subdivision are consumed for food in Britain. The common dogfish, or pickled dog (*Acanthius vulgaris*, family *Spinacidæ*), and flake, or spotted dog (*Scyllium canicula*, family *Scyllidæ*), are commonly consumed, being wholesome food and highly nutritious. These species grow to 3 or 5 feet in length, and are much used for food in the Orkneys, and also find a ready market at Hastings, Brighton, and elsewhere on our southern coasts. Their flesh is somewhat dry and hard, and requires soaking in water for a long time before cooking it in order to make it palatable. The liver contains a considerable proportion of oil. The consumption of this organ is apt to be followed by unpleasant symptoms, such as general malaise, heaviness, or stupor, which may last several days, and an erythematous rash followed by desquamation.

16. The Rays: Skate.

Skate.—The common or grey skate (*Raia batis*) is the variety most often used for food. Its flesh is gelatinous and highly nutritious. It varies much in size, some specimens only being 15 inches long and a few pounds in weight; others caught off the Scotch and Irish coasts weigh as much as 224 pounds, and have a corresponding

size. The edible portion has the following composition: Water 80·2, protein 18·18, fat 1·42, ash 1·1, per cent.

The thornback (*Raia clavata*) is also caught in great numbers along the British and Irish coasts. It grows to about 2 feet long. The female is called in Scotland the "maiden skate." It feeds upon crustaceans, herring fry, small flounders, and other fish. Its flesh is considered excellent food.

The homelyn (*Raia maculata vel miraletus*), also called the "spotted ray," is plentiful in British waters, and sold abundantly in the London markets.

Other rays found in the markets are the Burton skate (*R. marginata*) and shagreen skate (*R. fullonica*). There are fourteen British rays in all, besides the eagle ray and ox ray, which sometimes find their way from the warm waters of Florida and Mexico. Most of them are good food—that is to say, nourishing; others can only be classed among the coarser varieties of fish.

Subclass: Cyclostomata; Order: Marsipobranchii.

Lamprey (*Petromyzon*).—There are several species of these eel-like fishes. The marine or sea lamprey (*P. marinus*) often weighs 4 or 5 pounds; the river lamprey, or lampern (*P. fluviatilis*), a smaller variety which abounds in the rivers and fresh-water lakes of Europe and other countries; and the mud lamprey (*P. branchialis*). They are much appreciated as a food by some people.

Subclass: Palæicthys; Order: Ganoidei.

Sturgeon (*Accipenser*) is one of the largest edible fishes of the Northern Hemisphere. The body is long, nearly cylindrical, and covered with bony plates, or scutes. The framework of the body and head is cartilaginous. Its food consists of infusoria, crustacea, and other low-formed organisms. It ascends the rivers to spawn in the spring and early summer, when thousands are caught daily. Their flesh is wholesome, and resembles a "compound of eel and veal with a flavouring of salmon."

Composition of Sturgeon—Percentages.

Edible Portion.	Water.	Protein.	Fat.	Ash.
Fresh fish	78·71	17·96	1·9	1·43
Water-free substance ..	—	85·17	8·9	6·72
Dried Russian sturgeon	50·60	31·80	9·6	7·60

There are about twenty species. Those of most importance industrially are as follows: Redfish, or belooga (*A. huso*), common sturgeon (*A. sturio*), sturgeon (*A. guldenstädtii*) stellated sturgeon (*A. stellatus*), smaller sturgeon (*A. schypa*), sterlet (*A. ruthenus*).

The common sturgeon (*A. sturio*) is found in most of the large rivers of Europe, and is sometimes caught in the Thames, Severn,

Wye, and other British rivers. It is, however, especially in Northern Europe where this fish abounds, and where its wholesome, agreeable, and delicate veal-like flesh is most easily obtained and appreciated. **Sterlet** (*A. ruthenus*) is a small species of sturgeon abundant in Russian rivers, highly esteemed for the flavour of its flesh and the superior isinglass obtained from the swim-bladder (see Isinglass). The great **White Sturgeon** (*A. rusa*) inhabits the Danube, Volga, and other rivers running into the Black and Caspian Seas. It frequently measures 12 to 15 feet in length, and weighs 1,500 pounds. Its flesh is not so highly esteemed as that of the foregoing and some other varieties, but very fine isinglass is made from its air-bladder. Some species of sturgeon are peculiar to North America—*e.g.*, *A. sturio oxyrhynchus*.

Caviare is the preserved roe of sturgeons. Its preparation was formerly almost confined to Russia, but it is now also preserved in Norway, Germany, and America. There are several varieties of caviare. "Red or belooga" fish is the source of most, while sterlet yields the finest quality of caviare on the market. There are two chief kinds—pressed and granulated caviare. The roe is so treated that the surrounding membrane is broken up and the eggs liberated. "Granulated" caviare is made thus: The roes are rubbed through a sieve, the meshes of which are small enough to allow the eggs alone to go through it, while the membranous sheath is detained. The liberated eggs are then mixed with salt, and allowed to remain for some time. The salt extracts some moisture from the eggs, and forms a brine in which they are pickled. The superfluous liquid is then drained away, and the remnant constitutes granulated caviare, which is canned. "Pressed caviare" is made by washing the fresh roe in vinegar, and afterwards pickling it in brine, care being taken that the eggs do not become too salt or shrunken by abstraction of moisture. After being removed from the brine they are drained, put into bags, and submitted to pressure in a screw-press. "Dried caviare" consists of the roes pickled in the foregoing manner, and afterwards dried in the sun.

Caviare is a very rich food, usually eaten on hot toast with pepper and lemon-juice or vinegar. It contains a high proportion of proteins, especially basic proteins (protamin, arginin, and histidin), phosphorized fat (*e.g.*, lecithin and nuclein), besides ordinary fat. Its composition is as follows:

	Water.	Protein.	Fat.	Ash.
Caviare, fresh	56·97	27·87	12·85	2·31
,, pickled or canned	50·92	27·92	13·59	7·55
,, dried	38·10	30·00	19·70	4·60

The corresponding male organ, called the "milt," resembles the roe very closely in its composition and nutritive value.

The Mollusca.

(*a*) Lamellibranchiata.

Oysters.

Oysters are the well-known edible molluscs, *Ostreidæ*. The species are numerous, and are found in shallow salt waters or at the mouths of rivers, and in the seas of all warm and temperate climates. As a source of food they are in season from September to May.

1. The only British species is the *Ostrea edulis*, which has an extensive range of distribution along the coastline of Europe, but is chiefly raised for commercial purposes in vast artificial beds in certain localities. Oysters grown in artificial beds are known as **Natives,** and are considered to be of a quality superior to those dredged from the natural beds. They thrive best in a mixture of salt and fresh water. The breeding season is April and May, and the fertilized eggs, or *fay*, are collectively termed *spat*. Oysters are edible at the age of a year and a half, but they are in their prime at three years. There are many varieties, some of which rank as distinct species. Oysters, however, are subject to great variation, owing to their environment and the effects of cultivation and domestication. The market value of oysters also varies according to their quality and condition. Deep-sea and Channel oysters are usually large and coarse compared with the more delicate *natives*. In consequence of this and the injury to natural beds from various causes, more than 60 per cent. of oysters consumed in England are derived from sources where their cultivation is carried out as an industry. They are reared from spat in artificial "parks," and laid down for a time in shallow waters at or near the mouths of rivers to increase in size and quality. *Whitstable natives* are among the best oysters, the beds being at the entrance of the Thames. The oysters from the Kent and Essex coasts, from Colchester, and from Medina in the Isle of Wight, are also in high favour with connoisseurs. Their chief food consists of the minute animalculæ present in large quantities in the organic matter accumulated at the mouths of rivers, which is an explanation of the fact that such situations are very favourable for fattening them and improving their quality. Many rivers receive enormous quantities of organic matter from the sewers of large towns and cities, which provides a field for the growth of an incalculable number of diatoms, infusoria, and other low-formed organisms. The majority of our natives are raised on such beds.

2. Portuguese oysters (*O. angulata*) are also consumed in considerable quantities in Great Britain. They are larger and coarser than *O. edulis*. The shell is rough and more or less angular, but well filled. They are more adaptable to their environment than the former, and accommodate themselves to such water and conditions that other European and American oysters would scarcely survive.

3. The Marennes oyster, or Groenbarden, is a green oyster much

esteemed on the Continent. The colour is due to the pigment of infusoria and diatoms, especially *Naviculare ostreariæ*. To meet the demand for them, an imitation is produced by keeping those from other sources in sea-water, and feeding them for months upon seaweed, the pigment of which imparts a green coloration to the gills. A similar coloration is also produced by sulphate of copper.

4. American oysters (*O. virginata*) inhabit the salt or brackish waters along almost the entire coasts of North America. On the Atlantic coast they are most abundant about the sound of Long Island, and on the coast of Norfolk, Virginia, and the Gulf of Mexico. On the Pacific shores they extend from British Columbia to California. There are several varieties, which are larger than the European species, and the shell varies from 2 to 4 inches in width and 2 to 6 inches in length.

(*a*) *Blue Point Oysters*.—This species belongs to Long Island. The shell does not exceed 2 by 2·5 inches, and is characterized by the *patch of blue colour on the inside of the shell*. Other small varieties of oysters, which neither have this characteristic coloration nor come from Long Island, are frequently sold as "Blue Points."

(*b*) *Saddle-Rock Oysters* are a variety of larger molluscs. Commercially, all large oysters are sold under this name.

(*c*) *Rockaway Oysters* come from Rockaway, in Long Island; *Shrewsbury Oysters* from Shrewsbury, in New Jersey; and so on with others bearing special names, like those of Colchester and Whitstable in England.

(*d*) The *Long-Hinged Oyster* (*O. canadensis*) of North America is a much elongated species, the shell being about 2 by 6 inches in size.

The Nutritive Value of Oysters.—An oyster consists of a soft part formed by the liver, containing fat and carbohydrate (glycogen), which is very digestible; and a harder portion, formed chiefly by the muscular tissues, containing most of the protein, which is not nearly so quickly digested, but is, when cooked, nearly as firm as a hard-boiled egg. The smaller varieties, especially natives, when eaten raw and in season, are very digestible; but large oysters are more suitable for cooking than for consumption in their natural condition. It has been found that three or four raw oysters leave the stomach in 90 to 100 minutes. Cooked oysters are not nearly so easily or quickly digested. The nutritive value of oysters is not great. It is about equal to the same bulk of milk; in fact, they contain the same amount of nutriment, but the constituents are not in the same proportion.

Composition of Oysters—Percentages.

	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.
Minimum	77·9	4·2	·6	1·80	1·2
Maximum	91·4	10·5	2·6	7·25	2·8

When properly stored, oysters can be kept *fresh* for six weeks. It is scarcely necessary to " chill " them, as they can be kept alive for a period of ten to fourteen days after removal from the water by keeping them at a temperature of 40° to 50° F., sprinkling them occasionally with brine or sea-water, and protecting them from the sunlight. Oysters are transported long distances—*e.g.*, from America to Europe. Some of them are afterwards laid in oyster-beds, or " parks," for a longer or shorter period in order to fatten them and improve their flavour before being sold. It is, moreover, a common practice to " freshen," " fatten," or " float " the oysters by placing them in brackish water for forty-eight hours after their arrival. This, however, is not a good practice. The oyster acquires greater plumpness and rotundity, which the oysterman calls " fattening," under the supposition that it is due to an actual gain of fat or flesh. But the change is due to **osmosis.** The tissues of the mollusc contain diffusible salts. When brought into contact with water of less density than the tissue juices, the salts diffuse out, water passes into the cells of the tissues and swells the oyster. Some water and salts (chiefly sodium chloride) pass out, but more water passes in than goes out—hence the increase in bulk. The average increase of weight is 10 per cent. The loss of sodium chloride causes a loss of flavour. Warmth is favourable to the process, and fresh water fattens them quicker than brackish. If they are left too long in the " floats," they become " lean " again, and analyses have shown that there is always an actual loss of solids, the " floated oysters " containing 4 or 5 per cent. less solids than those taken from the beds. This difference is well shown in the following analysis taken from the Report of the United States Bureau of Fisheries:

COMPOSITION OF FRESH AND FLOATED OYSTERS COMPARED—PERCENTAGES

	James River Oysters.		Potomac River Oysters.	
	From Beds.	From Floats.	From Beds.	From Floats.
Flesh only:				
Water	77·99	82·77	77·90	82·06
Water-free substance	22·01	17·23	22·10	17·94
Water-free substance:				
Protein	10·63	8·79	10·31	9·09
Fat	2·61	1·91	2·33	1·93
Ash	2·21	1·55	2·17	1·58
Carbohydrate (by difference) ..	6·56	4·98	7·29	5·34
Total	22·01	17·23	22·10	17·94

It is thereby shown that floating, " fattening," or freshening the molluscs reduces their nutritive value; but it also weakens them:

they die and decay in less than half the time oysters do which are taken directly from their source. It should also be observed that they are liable to contamination unless great care be taken that they are put into water which is free from any possible danger from this source.

The Colour of Oysters.—Reference has already been made to the "greening" of the molluscs, under the paragraph on Marennes oysters, which is due to their food—seaweeds, diatoms, infusoria, and other low-formed organisms. Such colouring matter is quite harmless, and may be removed, if desired, by placing the molluscs for a time in perfectly fresh water which is free from green plants and diatoms. But the colouring matter of oysters is not always, it is argued, so innocent as that which is derived from the foregoing sources. On the other hand, green-coloured oysters are said to be injurious if consumed for food, and the colouring matter is the cause of the toxic symptoms which sometimes follow the ingestion of the molluscs. It has further been asserted that the colouring matter consists of **copper.** There may be a very slender foundation for the statement that oysters absorb copper from the water in regions where that metal abounds, and that they may obtain it from the copper sheathing of ships. At any rate, Ray Lankester[1] found that oysters normally contain a minute trace of copper in their blood in the form of a protein known as "hæmocyanin," but it has never been found in sufficient quantity to account for the production of poisonous symptoms. It has, in fact, been satisfactorily determined that the colour of oysters only causes trouble when the coloration is artificially induced. In the much-prized Marennes oysters, the colour or "greening" arises from their food including the diatom *Naviculare ostreariæ.* The demand for this special variety of mollusc sometimes exceeds the supply. The common oyster is then stained green by the salesman with sulphate of copper to simulate the natural colour of its more highly esteemed relative, whose place in the market it is made to occupy by this fictitious colour. Symptoms of acute poisoning have followed the consumption of such oysters. It is possible to distinguish Marennes and artificially coloured oysters from each other. In the real Marennes oyster the colour is of a dark green tint, and derived from vegetable matters. In the fictitious kind the colour is due to copper, which stains the molluscs a grass-green tint, and causes a slimy secretion of a verdigris colour to appear on the folds of the mantle. Moreover, if a little vinegar be poured over the copper-containing oysters, and a steel fork is afterwards stuck into them, the metal will become coated with copper; or if a little ammonia is added to such oysters, they will become dark blue.

Micro-Organisms in Oysters.—Until recently the oyster was considered to be unable to cause disturbances of the human organism similar to the mytilism which follows the consumption of mussels.

[1] *Journal of Micro-Sciences*, 1885.

But disturbances of the alimentary canal, similar to those following mussels, do sometimes occur even after eating oysters from deep-sea beds, if they have, subsequent to their removal from this source, been kept in the water of harbours or near the outfall of sewers, etc. It is agreed that certain gastric symptoms are due to the consumption of oysters, but it is undecided whether they are due to the toxins of bacteria present in the oysters at the time of consumption or to toxins produced after consumption by bacteria in the alimentary canal. One factor which requires to be further studied is the influence of the seasons upon the molluscs. It is usually in the summer months when oysters cause the disturbances referred to. At this period they are **out of season,** and changes are observed in their appearance. The flesh becomes more or less milky-looking, and the liver is enlarged, soft, and grey. The cause of these changes is unknown.

Oysters are liable to contamination by micro-organisms and various parasites. They have been ascertained to be the cause of enteric fever in numerous instances. This cannot surprise us when we consider that the finest "natives" come from beds, or "parks," situated in the neighbourhood of sewage effluents. Their chief food consists of the minute organisms which thrive best in water containing enormous quantities of organic matter, such as that at the mouths of rivers or where the stream receives the effluent of sewers. This explains the fact that such places have a reputation for fattening and improving the flavour of oysters. It is therefore necessary to remember that the majority of natives are reared in such vicinities, and that American and Portuguese oysters are usually relaid for a time in such places to fatten them and improve their appearance before they are placed on the market.

It has been shown that the bacteria of enteric fever and cholera can live in sea-water for a period of two months, and that they probably retain their infectiveness and virulence during most of that time. The contamination of the water in the neighbourhood of the "parks" may therefore lead to the molluscs becoming infected with these pathogenic organisms, and the risk to the consumer of such oysters cannot be over-estimated.

Mussels.

Mussels are bivalve molluscs forming the order Mytilidæ. The common mussel (*Mytilus edulis*) is very abundant in the North Sea, especially along the shores of Britain, and in the Mediterranean. There are several species, some of which inhabit fresh-water streams. In North America mussels are found in the fresh waters of nearly all parts. Although used as a food to a considerable extent, they do not, like oysters, form a dainty dish, and economically are of more value for the pearls found in them than for their flesh. The composition of the edible portion is as follows: Water, 78·57; protein, 12·62; fat, 1·68; carbohydrate, 5·29; ash, 1·84—per cent.

The protein varies in amount, and may be as low as 6 per cent. The carbohydrate is also variable, and exists chiefly in the liver.

Mytilism, or "musselling," is an affection of the human organism due to the consumption of mussels containing mytilo-toxin, a poisonous alkaloid which produces symptoms similar to those of **botulism,** with an additional acute urticaria. The mytilo-toxin, according to Wolff,[1] is produced chiefly in the liver by a special micro-organism. This alkaloid can be extracted from the liver by alcohol. Salkowski showed that it is rendered inactive when heated with carbonate of soda, and mussels lose their toxicity when they are cooked for ten minutes in a solution of this alkali. As with oysters and other mollusca, their consumption has been associated with the outbreak of enteric fever and other epidemic diseases.

Clams.

There are several genera and many species of these bivalves—*e.g.*, common clam (*Mya arenaria*), giant clam (*Tridacna gigas*), yellow clam (*T. crocea*), and thorny clam (*Chama Lazarus*). The chief kinds of clam in America, where they are much used for food, are as follows:

1. The long, soft clam (*Mya arenaria*). This kind is abundant along the New England shores, where it is used both fresh and canned, and is the chief feature of the "clam-bakes" of that region.

2. The round, hard clam (*Venus myenarea*), which is more common off the coasts of America below New York, and especially abundant off the shores of the Southern States.

3. There is also a smaller round clam, which is very palatable, and replaces oysters during the closed season of the latter molluscs.

Clams are eaten raw, cooked, and in soup. Opinions differ about their digestibility, the information on this point being variable, probably because they agree with some people and not with others. Their nutritive value is well established.

Composition of Edible Portion—Percentages.

	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.
Long clam	85·8	8·6	1·0	2·0	2·6
Round clam	86·2	6·5	·4	4·2	2·7
,, ,, out of shell 36 hours	80·8	10·6	1·1	5·2	2·3
,, ,, canned	82·9	10·5	·8	3·0	2·8
Long clam, canned	84·5	9·0	1·3	·8	2·3
Clam chowder	88·7	1·8	·8	6·7	2·0

The **Scallop** (*Pecten irradiens* and others), commonly called a "clam," belongs to the family of oysters (Ostreidæ), genus Pecten.

[1] *Archiv f. Pathol. Anat.*, 1886, ciii. 187.

There are numerous species consumed for food ; they are found along the shores of Great Britain, and some of them in the seas of most climates. Their flesh is nutritious, and has the following composition : Edible portion—Water 79·6 to 80·3, protein 14·8 to 15·04, fat 0·1 to 1·0, carbohydrate 1·95 to 3·4, ash 1·4, per cent.

Cockles (*Carduum edule*) are also found along the sandy shores of Great Britain ; they are much used for foods, and have a similar composition to scallops.

Abalone is a large mollusc abundant on the Pacific shores of America, especially abundant about California. Originally consumed by the Chinese, it has since become more commonly known, and is highly relished by those who use it. The fresh and canned products correspond fairly well with those of oyster and clam. Mendel found that they are especially rich in glycogen. The flesh is very nutritious, being cut into strips of a suitable size, and eaten in the fresh, dried, or canned form.

Composition of Edible Portion—Percentages.[1]

	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.
Fresh	72·8	22·2	·3	3·3	1·4
Dried	39·7	36·0	·5	20·9	2·9
Canned	73·2	21·7	·1	3·7	1·3

(*b*) Gasteropoda.

The **Whelk** (*Buccinium undatum*), periwinkle (*Littorina littorea*), and limpet (*Patella vulgata*) are all consumed as food. The red whelk (*Fusus*), or spindle-shell, is more highly esteemed than the common whelk. These molluscs are common on the shores of Great Britain, and are prized by the poor as tasty morsels. They have about the same composition and nutritive value as mussels, and, like other shellfish, have been associated with outbreaks of epidemic fever.

Snails, especially the escargot or vineyard snail (*Helix pomatia*), are largely cultivated in France and elsewhere for food, and are highly esteemed by many persons. They are specially cultivated in snail-nurseries, "escargotoires," or in the vineyards of Burgundy, Champagne, Franché-Comte, and Lorraine. Those found on elevated lands are the best, the soil being free from decomposing materials. The molluscs, moreover, are most delicate at the end of the winter season—that is, after a period of partial fasting. As they feed upon plants of the Solanaceous Order amongst others, they should be kept a few days after their removal from these plants, in order that any deleterious substances in their organism may be excreted. Raw snails are soft and easily digested, but

[1] Langworthy, Bulletin 85, U.S. Department of Agriculture.

their flesh is rendered firm and compact by cooking, and not very easily digested. They are, however, undoubtedly nutritious, and enjoy a reputation among Parisians, which renders them one of their greatest luxuries.

(*c*) Cephalopoda.

Squid, or Sea-Pen (*Teuthidæ*).—The tentacles are eaten and considered palatable by the inhabitants of Cuba and other localities. They have a similar composition to the mollusca.

The Crustacea.

Lobster (*Homarus vulgaris*).—The common lobster is found abundantly along many European shores. They are generally in season from October to May. The American lobster (*H. americanus*) is very similar, and closely allied to it. These occur all along the Atlantic coast, but the chief fisheries are off the coast of Maine. Their length varies from 10 to 15 inches. Their colour is greenish-black, but changes to red on being boiled. They are esteemed a rich and nourishing aliment when fresh, but are dangerous when not fresh or when out of season.

Canned Lobster comes chiefly from Canada, especially Nova Scotia, Newfoundland, and New Brunswick; but about 20 per cent. of the American supply is obtained from the neighbouring coasts of Maine. The live animals are put into brine and boiled until they are cooked. They are rapidly cooled, shelled, and canned, the cans being filled with salt water, and they are sterilized by "processing" in hot water or steam. The best brands have the interior of the tin lined with parchment paper, to prevent the action of phosphorus from the lobster upon the metal.

Spiny Lobster, or sea-crayfish (*Palinurus vulgaris*), which occurs in Europe and America, is preferred by some people to the foregoing.

Crayfish, "écrevisse," or fresh-water lobster (*Astacus fluviatilis*), which also inhabits the streams of Europe and America, is more delicate than common lobster, but is usually eaten hot, and is used in making bisque soup.

The **Norway Lobster** (*Nethrops norvegicus*), common in Norway and parts of Britain, is orange-yellow, and smaller than ordinary lobster.

Composition of Edible Portion—Percentages.

	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.
Crayfish, abdomen	81·20	16·00	·50	1·0	1·30
Lobster, fresh	79·40	16·20	1·70	·5	2·20
,, ,, ...	76·71	19·17	1·17	1·0	2·75
,, water-free.. ..	—	81·60	4·60	2·7	11·30
,, canned	77·40	18·10	1·10	·6	2·80

Crabs (*Cancer esculenta*).—Several species of crabs are very common along European shores, and the fisheries along British coasts form an important industry. There are also several species of hard- and soft-shelled crabs along the Atlantic and Pacific shores of America ; but the most highly esteemed is *Callinectes hastatus*, which is abundant along the middle and southern Atlantic shores. The flesh of the crab is neither so delicate nor so digestible as that of the lobster. Its composition is as follows :

	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.
Fresh crab, hard-shell variety ..	77·6	16·8	2·2	1·2	2·1
Canned crab	79·4	16·1	1·5	1·0	2·0

Shrimps and Prawns.—Shrimps (*Crangon vulgaris*) are abundant along all our sandy shores ; prawns (*Palæmon serratus*) are somewhat larger, and inhabit deeper waters near land—and in the vicinity of rocks. **Caramotes** (*Penæus caramote*), which are larger shrimps, common along the Mediterranean shores, are tasty morsels or relishes of fairly high nutritive value, and sometimes a useful aid to appetite. Caramotes are caught in great numbers, and salted for exportation. Some fresh-water prawns reach a great size. The composition of fresh shrimps, which are typical of the group, is as follows : Water 70·8, protein 25·4, fat 1·0, carbohydrate 0·2, ash 2·6, per cent.

Potted Shrimps are boiled, shelled, tinned, and "processed." *Shrimp Paste* consists of boiled shrimps, shelled, reduced to a paste, and combined with lard, margarine, anchovy, salt, and spices such as cloves, mace, and cayene.

Echinodermata.

The Holothurians, sea-slugs or sea-cucumbers, are much used as articles of food in China. The best-known example is the **Trepang,** or bêche-de-mer (*Holothuria edulis*), found on coral-reefs in the Pacific and waters of the East Indies and Northern Australia. It resembles a cucumber in shape and size, being from 6 to 24 inches long. They are caught in great numbers, boiled, cut open, gutted, and dried in the sun or over a wooden fire. There are important fisheries in the Indian Ocean, and the whole produce goes to China, where they are in much demand for making soup. They are also used fresh, being cooked in their own juice, and served in thin, "quivering" slices, the flavour of which is said to possess something of the piquancy of the snail and the richness of the turtle.

Reptilia and Batrachia.

Turtle.—The green turtle (*Chelonia mydas*), so called because the fat is of a greenish colour, is the chief member of the reptilian group used for food. They are found in the seas of all warm

climates, especially the Mediterranean, Atlantic and Indian Oceans, where they feed on marine plants. They come to land to deposit their eggs several times a year. The size and weight of the animal varies: they may attain a length of 5 feet and weight of 500 to 600 pounds. They are generally put on the market alive, but their flesh is also cut into slices and dried in the sun. They are consumed chiefly as "turtle soup," which is made from fresh or dried flesh, is esteemed a luxury, and is highly stimulating and nutritious.

PERCENTAGE COMPOSITION.

	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.
Turtle flesh	79·8	19·8	·5	—	1·2
,, soup	86·6	6·1	1·9	5·6	1·5

Terrapins, or fresh-water tortoises, constitute the family of Emydæ, and are natives of warm and tropical climates, many inhabiting North America, where their flesh is highly esteemed. The chicken tortoise (*Emys reticulata*), so called from its flesh having the flavour of chicken, is very nutritious, and a luxury highly esteemed, which is now accentuated by the growing scarcity of the reptile in America. Another terrapin (*Malachlemys concentrata*), which occupies the bays and lagoons from New Jersey to Texas, and especially the salt-marshes about Charlestown and Chesapeake Bay, was formerly brought to market in immense numbers in the spring and summer. Attempts at artificial production have only been partially successful. The composition of their flesh is—Water 74·5, protein 21·2, fat 3·5, ash 1·0, per cent.

The *Iguana delectissima* and Agama are eaten in South America and Africa, and considered excellent and delicate food.

Frogs (*Rana esculenta*).—The hind-quarters of frogs are eaten in France, Germany, and America, at all seasons, but are in their best condition in autumn and winter. They are cultivated in France and Minnesota, being marketed alive or dressed. The edible portion has the following composition: Frogs' legs—Water 83·7, protein 15·5, fat 0·2, ash 1·0, per cent.

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CHAPTER IX

MILK

Milk is the secretion of the mammary gland, and is therefore confined to the mammalia, and is designed for the nourishment of the young animal whose parent secretes the fluid. There is no other fluid exactly like it, although certain other animals have a secretion comparable with it, and the juice of some plants is similar in appearance.

Although cow's milk is that most commonly used in civilized countries, where the animals are bred chiefly for their flesh and milk, the milk of other animals is also used. Goat's milk is commonly used in the rough, hilly districts of Europe ; sheep's milk is also used in Europe and elsewhere for making cheese and for other purposes ; llama's milk is used in South America ; that of the buffalo in India and Hungary ; of the mare in the steppes of Russia and Tartary ; and of the reindeer in the cold northern and Arctic regions. The preference for cow's milk is the result of habit and taste rather than any intrinsic superiority of the fluid over that of other mammals. This, however, has been fostered by the adaptability of cattle to the needs of mankind, and the excellent results which have followed the care exercised in breeding and feeding the animals.

The Secretion of Milk.—Milk consists of water, casein, various other proteins, fat, milk-sugar, and minerals salts. These are not filtered from the blood by the mammary gland, for milk-sugar and casein do not exist in the blood. They are products of metabolism in the cells of the mammary gland. These cells are rich in proteins and nucleo-proteins, one of the latter yielding pentose and guanine. Casein arises by the union of the nucleic acid from the cell nucleus with serum-albumin, thereby forming a nucleo-albumin,[1] or, according to recent classifications, a phospho-protein. Fat is a normal constituent of the protoplasm of the cells. During the period of lactation the cells undergo a speedy fatty metamorphosis, and the globules of the milk are derived in this manner, being set free by destruction of the cells. Whether all the fat of milk arises in this way is unknown. It is probable that fats which have been assimilated from the food are taken up by the cells. But cattle

[1] Basch ; *cf.* Hammarsten, " Physiol. Chem.," p. 457.

secrete more fat than is contained in the food consumed by them ; it must therefore be produced from proteins or carbohydrates, or both. Such fat may or may not be first transformed into body fat ; it may be taken up from the blood or lymph by the galactiferous cells, which rapidly increase in size, become overgrown, burst, and discharge their contents into the ducts in the same or a similar manner to muciparous cells.

Neither is the origin of milk-sugar exactly known. Lactose is a disaccharide consisting of a molecule of dextrose and galactose, and is probably formed in the glands by a synthetic process. A large number of vegetable substances contain both these sugars. The animal body, moreover, is capable of transforming one kind of carbohydrate into another, and it is thought by Hammarsten that some of the lactose may arise by the transformation of dextrose into galactose. Lactose is formed by the linking together of the molecules of two monosaccharides : dextrose + galactose = lactose + water ; *i.e.*, one molecule drops H, the other OH, and they are joined in regular ether fashion.

The salts are derived from the blood.

The milk of every species of animal differs somewhat in composition from that of every other kind of animal. But inasmuch as the secretion of the cow is the substance, for obvious reasons, commonly referred to as "milk," and is one of the standard and most important foodstuffs of the human race, the following remarks upon this secretion must be considered to refer especially to cow's milk, unless qualified by the name of the animal from which it is derived.

The Characters of Milk.—Milk is an opaque fluid of a white or yellowish-white colour, or somewhat bluish-white in a thin layer. Under the microscope its appearance is that of a fluid containing innumerable globules. It has a faint odour and sweetish taste. The specific gravity is 1·028 to 1·0345 at 15° C. It freezes at 0·56° C., and boils at 100·9° C. (213·5° F.). The reaction of milk varies. When tested immediately after being drawn, it is amphoteric—*i.e.*, it has a double reaction, being alkaline towards *blue lacmoid*, and acid towards phenolphthaleïn ; 100 c.c. of fresh milk gives the same reaction as 41 c.c. of a decinormal solution of caustic soda, and also the same reaction as 19·5 c.c. of a decinormal solution of sulphuric acid. The acid reaction of fresh milk, although feeble, is seen on the application of litmus, which it turns red ; while, on the other hand, it turns turmeric brown, the acidity being probably due to acid-phosphate of the alkaline salts. The reaction becomes more and more acid on exposure to the air, which is due to the transformation of lactose into lactic acid by micro-organisms.

The Composition of Milk.—Probably no food has been more often analyzed and studied than milk and the preparations made from it. A large amount of information is in consequence available respecting the composition and general properties of this fluid and its products.

Milk is a fluid containing fat, proteins, carbohydrates, salts, and water. These are partly in suspension and partly in solution, the dissolved substances being lactose, casein, albumin, peptones, lactochrome, salts, and minute proportions of other substances. The suspended matters are milk-fat and a small proportion of casein in particles too fine to be arrested, except by filtration through earthernware. The adjoining table gives the composition of the milk of various animals; it is derived chiefly from König,[1] with additions from other sources.

The Food Value of Milk.—The milk of the cow is an important foodstuff, being of a superior nutritive character, and adaptable for combination with many other articles of food. Its fluidity and easiness of digestion render it a very suitable article of diet for children and invalids. Its importance to all classes of people, and the ease with which it can be mingled with other liquids or polluted by many kinds of materials, necessitates that a standard of purity be set up by the State, and its condition, when sold, carefully watched on behalf of the consumer. This is especially desirable when we consider the enormous quantity annually used as food for children and sick persons, and the extreme liability of the liquid to become contaminated, adulterated, and otherwise sophisticated.

Absorption of Milk.—Milk yields 400 to 450 calories per pint, according to its quality. Its protein, fat, and carbohydrate, are almost completely absorbed. Rubner found that, if 2 litres be consumed daily, the loss of dry substance amounts to only 5·7 to 7·8 per cent.; if 3 litres be taken, the loss amounts to 10·2 to 11·16 per cent. Wait[2] found that the absorption of milk is more complete as a mixed food than when taken alone:

	Milk digested as Exclusive Food.	Milk digested as Bread and Milk.
Protein	92·1 per cent.	97·1 per cent.
Carbohydrates ..	86·3 „	98·7 „

The protein and fat are absorbed equally well; the protein is absorbed better than that of meat. It has been found by Camerer, Rubner, Uffelmann, etc., that children absorb milk better than adults do. Prausnitz[3] says that up to four years of age the loss of nitrogen is only 4·4 per cent. against a loss of 11 per cent. in adults; that in the case of babies the absorption is even more complete.

The table on p. 240 shows the composition of cow's milk according to various authorities of high standing. The mean of these findings is assumed by the writer as representing the average composition of the fluid.

1 "Chemie der Menschlichen Nahrungs- und Genussmittel."
2 Bulletin 53, U.S. Department of Agriculture.
3 *Zeit. f. Biol.*, 1889, Bd. xxv., 553.

THE COMPOSITION OF MILK—NUTRIENTS PER CENT.

Source.	Water.	Casein.	Albumin.	Fat.	Milk-Sugar.	Ash.	Authority.
Woman	87·41	1·03	1·26	3·78	6·21	·31	König.
Cow	87·17	3·02	·53	3·69	4·88	·71	,,
Goat	85·71	3·20	1·09	4·78	4·46	·76	,,
Sheep	80·82	4·97	1·55	6·86	4·91	·89	,,
Mare	90·78	1·24	·07	1·21	5·67	·35	,,
Ass	89·64	·67	1·55	1·64	5·99	·51	,,
Sow	84·04	7·23		4·55	3·13	1·05	,,
Rabbit	—	15·50		10·50	2·00	2·60	Pozzi.
Guinea-pig	—	11·20		45·80	1·30	·60	,,
Bitch	75·44	6·10	5·05	9·57	3·08	·73	Pröscher.
Cat	81·63	3·12	6·00	3·33	4·91	·61	,,
Buffalo	81·41	5·85	·25	7·47	4·15	·87	König.
,, Indian ..	82·16	4·26	·46	7·51	4·77	·84	,,
,, Egyptian ..	84·10	3·26	·60	5·56	?	1·03	Richmond.
Reindeer	—	8·40	2·00	17·10	2·80	1·50	Werenskield.
Llama	86·55	3·00	·90	3·20	5·60	·80	König.
Camel	86·57	4·00		3·07	5·59	·77	,,
Elephant	67·85	3·09		19·57	8·84	6·50	,,
Porpoise	41·11	7·60		43·80	?	·50	Frankland.
Whale	47·87	7·58		43·76	—	·46	,,

COMPOSITION OF COW'S MILK—NUTRIENTS PER CENT.

	Richmond: Average.	Vieth: Average.	Experiment Station: U.S. Records, vol. v., 10.		Fleischmann.		Kirchner.		Long.		
			Average.	Variation.	Average.	Variation.	Average.	Variation.	Average.	Low Quality.	High Quality.
Solids-not-fat :											
Casein ..	3·37	3·30	3·30	2·0 to 4·5	3·50	3·0 to 4·0	3·9	2·28 to 5·73	3·45	3·04	3·48
Milk-sugar	4·45	4·77	4·95	4·0 ,, 5·5	4·60	3·6 ,, 5·5	4·5	3·00 ,, 6·00	4·83	4·90	5·02
Ash ..	·73	·73	·75	·6 ,, ·9	·75	·6 ,, ·9	·7	·60 ,, ·90	·72	·66	·72
Total ..	8·55	8·80	9·00	6·6 ,, 10·9	8·85	7·2 ,, 11·4	9·1	5·80 ,, 12·60	9·00	8·60	9·22
Fat	4·07	4·10	4·00	2·0 ,, 8·0	3·40	2·7 ,, 4·3	3·4	·80 ,, 8·00	3·35	2·50	6·91
Total solids	12·62	12·90	13·00	8·6 ,, 18·9	12·25	9·9 ,, 14·7	12·5	7·20 ,, 12·63	12·35	11·10	16·13
Water ..	87·38	87·10	87·00	81·1 ,, 91·4	87·75	87·5 ,, 89·5	87·5	83·00 ,, 90·00	—	—	—
Total ..	100·00	100·00	100·00	—	100·00	—	100·0	—	—	—	—

The average composition of milk, being a mean of the foregoing, is—Water 87·35; solids-not-fat 8·93—including casein and albumin 3·595, milk-sugar 4·615, and ash 0·73; fat 3·72—per cent. The specific gravity at 15° C. = 1·030 or 1·033, but varies from 1·028 to 1·035.

THE CONSTITUENTS OF MILK.

(*a*) *Bodies in suspension :*
- (1) Fat globules.
- (2) Form elements—*e.g.*, colostrum corpuscles, or a few nucleated cells of little importance.

(*b*) *Bodies in solution :*
- (1) **Proteins** : Casein, nuclein, lactalbumin, lactoglobulin, peptone, hemialbumose.
- (2) **Carbohydrates** : Lactose and (?) dextrin.
- (3) **Extractives** : Urea, creatin, creatinin, hypoxanthin, lecithin, and cholesterin.
- (4) Other organic bodies : Alcohol, lactochrome, and a bitter principle.
- (5) **Organic Acids** : Free citric, lactic, and acetic acids.
- (6) **Inorganic Acids** (in combination) : Phosphoric, sulphuric, hydrochloric, and, according to Musso, sulpho-cyanic acid.
- (7) **Bases** : Potash, soda, lime, magnesia, ammonia, and ferric oxide.
- (8) Gases in solution : Carbonic anhydride, nitrogen, and oxygen.

The Fat Globules ; Milk-Fat.—In the microscopic examination of milk, the milk-fat is the most striking and, to an ordinary observer, the only visible substance. It appears in the form of an immense number of globules, the quantity of which varies with the richness of the milk, but averages 3·75, and varies from 1·06 to 5·75, millions per cubic millimetre. The largest globules are about $\frac{1}{1500}$ and the smallest $\frac{1}{12000}$ inch in diameter, or an average of 0·0037 millimetre. All the fat is contained in globules. The milk of some cows contains larger globules than that of others, to which fact is attributed differences in the texture of butter.

It is usually stated that each fat globule is surrounded by a membrane or pellicle of extreme thinness. According to Ascherson, this membrane is an albuminous envelope. An argument in support of the membrane theory is based on the behaviour of milk towards ether. If milk be shaken up with ether, the fat is not dissolved out of the globules, and there is no diminution in the opacity of the milk. If, however, a solution of soda or potash be added, the ether speedily dissolves the fat, and the milk is clarified. The supporters of the theory believe that the caustic alkali dissolves the membrane, and permits the ether to act upon the fat. But the presence of a true membrane was considered to be not proven, and the theory was given up by most authorities. It was then stated by Quincke[1] that each fat globule was surrounded by a stratum of casein, consisting of fine particles held together by molecular attraction, which prevented the globules from coalescing. Storch,[2] on the other hand, said it was not casein, but a slimy substance, probably identical with the stroma substance of cells, which surrounds the globules. He further states that this substance is a gluco-protein containing 14·5 per cent. of nitrogen, and yielding sugar on boiling with hydrochloric acid. In any case the surrounding pellicle can amount to nothing more than an extremely thin film, such as

[1] *Pfluger's Archiv*, 19. [2] *Maly's Jahresber.*, 27.

that forming a soap-bubble. But there are other authorities who assert that there is no pellicle at all around the fat globules—that the fat is merely in the form of an emulsion, and is probably maintained in that condition by the salts of the plasma.

Milk-Fat consists of 30 to 40 per cent. of olein, rather more of palmitin, and a very little stearin, which together make up the chief portion of the substance. It also contains some volatile fatty acids, which average 7·3 per cent., but vary, according to Duclaux, from 5·77 to 7·95 per cent. of the total fat; these include 3·7 to 6·1 per cent., or an average of 4·58 per cent., of butyric acid, and from 2·0 to 3·3 per cent. of caproic acid, with an average of 2·7 per cent. According to Hehner and Mitchell, 100 grammes of butter yields the following amount of fatty acids:[1]

Composition of Milk-Fat.

Stearic acid	1·83 per cent.
Distearic acid	1·00 ,,
Oleic acid	32·50 ,,
Palmitic acid	38·50 ,,
Myristic acid	8·89 ,,
Lauric acid	2·57 ,,
Capric acid	·32 ,,
Caprylic acid	·49 ,,
Caproic acid	2·09 ,,
Butyric acid	5·45 ,,

Milk also contains some lecithin, cholesterin, and lactochrome. The lecithin varies from 0·49 to 0·58 per 1,000 parts of milk. Pure dry milk-fat is solid at ordinary temperatures, varies in colour from white to yellow (according to the amount of lactochrome), has S.G. of 0·914 at blood heat; the melting-point is usually given as 35·8° C., but varies from 29° to 41° C.

Milk-Sugar.—The chief normal situation of lactose, $C_{12}H_{22}O_{11}+H_2O$, is milk. It has the following percentage composition: C 40·0, H 6·11, O 48·9; and water of crystallization 5 per cent. Lactose crystallizes in colourless rhombic crystals with a molecule of water. It has a sweetish taste, but is not so sweet as cane-sugar; it dissolves in 6 parts of cold or 2·5 parts of boiling water; but it is insoluble in ether and alcohol. It is dextro-rotatory. Being transformed into lactic acid, it forms combinations with alkalies and bases, which are insoluble in alcohol. On hydrolysis it splits into dextrose and galactose; dilute nitric acid transforms it into *mucic acid*, and strong acids into lævulinic and formic acids and *humin* substances.

The Proteins.—Casein, so far as is known, occurs only in milk, although there are certain so-called "vegetable caseins." It belongs to the phospho-proteins, does not contain true nuclein, but para- o pseudo-nuclein, and has the following composition, according to Kirchner: C 53·0, H 7·1, N 15·7, S 0·8, P 0·85, O 22·65, per cent. Pure dry casein is a fine white powder, insoluble in pure water, but soluble

1 Abstracts, *Journal of the Chemical Society*, 1899, 55

in ordinary neutral salt solutions and in 1 per cent. solution of ammonium or potassium oxalate. *It is a tetrabasic acid,*[1] and forms salts with sodium bicarbonate, calcium carbonate, and other alkatine earths. It is dissolved in water by their aid—*e.g.*, calcium carbonate, from which it displaces CO_2. Such combinations are easily split by hydrolysis. Casein is precipitated from milk or neutral salt solutions by sodium chloride and magnesium sulphate without changing its properties. It is likewise completely precipitated from neutral solutions by metallic salts such as alum, zinc, and copper sulphates.

The Effects of Heat.—A solution of casein, like milk, does not coagulate on boiling, but it becomes covered with a skin. The skin formed upon milk by heating it is commonly said to consist of coagulated albumin. It is true that the lactalbumin is coagulated at a low temperature—50° C. (122° F.)—and forms a skin upon the surface of the milk. But the removal of one skin is followed by the formation of another, and so on indefinitely. Each skin, therefore, cannot consist of lactalbumin, because the proportion of that protein is very small. Later investigators, having found casein and lime salts in the skin, consider that the heat liberates casein from its combination with the salt, by which it is held in solution, and the liberated casein is thrown out of solution, rises to the surface, where it rapidly becomes dried by evaporation. That the amount of material removed is not great was shown by Solomin, who examined the skin removed from 100 c.c. of milk, which, after boiling fifteen minutes, contained only 0·27 gramme of protein.[2] Jamison and Hertz[3] found that the formation of a skin or film on milk is not the peculiar property of casein or albumin, for a skin can be produced by warming any protein solution which contains emulsified fat ; but drying is an essential condition to their formation. They concluded that the film formed on milk and other protein solutions is composed of dried protein with fat entangled in it.

The extent to which coagulation of these bodies takes place, and the relative effect of different coagulating reagents, are influenced by the temperature and other conditions. The higher the temperature, the smaller is the amount of a precipitating agent required to produce coagulation. The coagulation is also greater the sooner the milk is boiled after milking ; and therefore the amount of the precipitant to be used will depend upon how soon after milking and the temperature—a point of considerable importance in cheese-making.

The application of heat affects the flavour of milk, a change which is not agreeable to some people. Thus if the milk be heated to 158° F. for fifteen or twenty minutes, it acquires a *cooked* flavour, which it loses again more or less on cooling. It is possible that

[1] Hammarsten, " Physiol. Chem.," p. 441.
[2] *Arch. Hyg.*, 1897, p. 43.
[3] *Journal of Physiology*, 1901, p. 26.

this change in flavour is due to the presence of a small quantity of sulphuretted hydrogen arising from the decomposition of casein or albumin. The application of heat to milk also causes some of the fine fatty globules to coalesce and form larger globules; and a slight change in colour, due to the formation of *lacto-caramel.*

The Action of Rennin.—The most remarkable property of casein is that of forming a coagulum of paracasein under the influence of rennet and in the presence of lime salts. In the absence of lime salts the casein will not coagulate, but it is so altered by the enzyme that the solution will coagulate on the addition of lime salts, even after the destruction of the enzyme by heat.

The curd of milk always contains a large amount of calcium phosphate. This is remarkable, for, according to Soxhlet and Söldner, only the soluble lime salts are essential for coagulation, the calcium phosphate being without importance. There is a fairly definite ratio between the amount of lime and casein required to produce the curd, and as the result of observations it has been ascertained to be as follows: Casein : lime : : 100 : 1·55.

The changes in the curd during coagulation are not quite clearly understood. It is unknown to what extent the cleavage of casein occurs, but the chief portion is separated in the form of **paracasein,** which is no longer affected by rennin, and is not able to hold the calcium phosphate in solution to the same extent as the casein did. It should be observed that Hammarsten, Bunge, and other foreign and American chemists, adhere to the name **casein** for the chief protein of milk, and **paracasein** for that of the curd. Halliburton and others call the former "caseinogen" and the latter "casein."

The digestion of casein is attended by further changes. The action of pepsin results in the formation of proteoses and peptones. A phosphorized proteose is formed from which the pseudo-nuclein is split off; as digestion proceeds, and the pepsin-hydrochloric acid increases, the amount of pseudo-nuclein produced diminishes; there is therefore a relation between the amount split off and the proportion of the gastric constituents. In the intestinal canal still further changes are produced, and amino-acids appear.

The **lactoglobulin** in milk is small in amount; it has the characteristics of serum globulin, and coagulates at 70° to 76° C. (156° to 167° F.).

The **lactalbumin** averages 0·6 per cent., and, according to Kirchner, varies from 0·2 to 0·8 per cent. It has the properties of serum albumin, and, according to Sébelien, the following composition: C 52·19, H 7·18, N 15·77, S 1·73, O 23·13, per cent.

Other nitrogenous bodies in milk are **lactoprotein,** which Hammarsten considers to be merely a laboratory product consisting of a mixture of casein and proteose. Babcock considers that milk always contains about 0·1 per cent. of **fibrin.** The occurrence of peptones and proteoses is also asserted, but their presence has not definitely been proved.

Various **enzymes** are found in milk, such as catalase, lipase or fat-splitting ferment, and galactase, which is allied to trypsin.

The **extractives** include urea, creatin, creatinin, hypoxanthin, leucin, and tyrosin.

The **salts** in milk are as follows :

	Parts per 1,000 (Söldner).
Potash, K_2O	1·72 grammes.
Soda, Na_2O	·51 ,,
Lime, CaO	1·98 ,,
Magnesia, MgO	·20 ,,
Ferric oxide	—
Phosphoric acid, P_2O_5	1·82 ,,
Sulphuric acid, SO_3	—
Chlorine	·98 ,,

Composition of the Ash (Schrodt).

Potash, K_2O	25·42 per cent.
Soda, Na_2O	10·94 ,,
Lime, CaO	21·45 ,,
Magnesia, MgO	2·54 ,,
Ferric oxide	·11 ,,
Phosphoric acid, P_2O_5	24·11 ,,
Sulphuric acid, SO_3	4·11 ,,
Chlorine	14·60 ,,

The potash, soda, and chlorine, in the total milk are the same as in the milk plasma ; but part of the lime is combined with casein, and is said to keep it in solution. The remainder is phosphate of lime, which in turn is kept dissolved or suspended by the casein. Milk contains a small amount of iron. According to Bunge,[1] it consists of 0·0035 parts of oxide of iron (Fe_2O_3) per 1,000 parts of milk, and is combined with the pseudo-nuclein. It should be observed that the mineral constituents of milk are present not merely as salts ; some portion is combined with the other contents. Thus, the sulphuric anhydride in the ash is derived from sulphur, which forms a part of the casein and albumin ; a portion of the phosphoric acid is likewise formed by the oxidation of phosphorus contained in casein and phosphorized fats ; and a portion of the lime was also combined with the casein. Milk also contains a small amount of **citric acid,** which averages 0·1 per cent. of milk, according to Henkel and Soxhlet, and is chiefly combined with potash and magnesia. Other organic acids are acetic and lactic, and, according to the same authority, the *total organic acidity* is equivalent to 0·24 per cent. of citric acid.

The composition of the milk of various animals differs considerably, as shown by the table given at the beginning of this article. No satisfactory explanation of this difference is given, unless we regard that of Bunge[2] as being so. He bases his explanation on the rate of growth of the young animal for which the milk is designed. Thus, the infant grows more slowly than the foal, the foal than the calf, the calf than the dog. Pröscher gives the rapidity

[1] *Zeit. f. Biol.*, x. [2] *Pfluger's Archiv*, 2.

with which these animals double their weight after birth, and Bunge finds the time occupied in this increase of weight is correlative with the proportion of protein and salts in the milk, which he shows in the following table, and from which he concludes that the composition of the milk of an animal varies with the rate of growth of its young :

	Number of Days in which a New-born Animal doubled its Weight.	Milk contains—			
		Protein per Cent.	Ash per Cent.	Lime per 1,000 Parts of Ash.	Phosphoric Acid per 1,000 Parts of Ash.
Man	180	1·6	·2	·328	·473
Horse	60	2·0	·4	1·240	1·310
Cow	47	3·5	·7	1·600	1·970
Goat	19	4·3	·8	2·100	3·220
Pig	18	5·9	—	—	—
Sheep	10	6·5	·9	2·720	4·120
Dog	8	7·1	1·3	4·530	4·930
Cat	7	9·5	—	—	—

Variations in the Composition of Cow's Milk.—The proportion of each article in milk varies with the breed of the animal, and even in the different individuals in the same herd. It is influenced by many circumstances, such as the food, time of day, time of year, period of lactation, and the housing of the animals. The proportion of fat varies from 0·8 to 8·0 per cent., the proteins from 2·25 to 5·75 per cent., and the lactose from 3 to 6 per cent. The mineral substances are fairly constant.

The influence of the **breed** on the composition of milk is shown well in the first table on p. 247 :[1]

It is generally considered that cows which give a large amount yield milk of poor quality, but this does not always follow. It is possible to have a large yield of milk of a good quality. The above table throws some light upon this matter. The table also shows a difference of 3 per cent. in total solids and 2·15 per cent. of fat between the highest and the lowest.

The Time of Milking exercises an influence upon the quality of the secretion. If a cow is milked twice a day, with equal intervals of time, there will be no difference in the quality of the secretion ; but if one interval be longer than the other, the milk obtained after the longer interval will be greater in quantity but poorer in quality than that obtained after the shorter interval. It is interesting to observe that, when a cow is milked three or four times instead of twice a day, she not only yields 20 per cent. more

[1] Records of Experiment Stations, vol. v., 10, 945, U.S. Department of Agriculture.

COMPOSITION OF MILK.

Breed of Cattle.	Number of Analyses.	Total Solids per Cent.	Solids-not-Fat per Cent.	Fat per Cent.	Casein per Cent.	Milk-sugar per Cent.	Ash per Cent.	Nitrogen per Cent.	Water per Cent.	Amount secreted Daily (Pounds).
Jersey	238	15·40	9·80	5·61	3·91	5·15	·743	·618	86·40	14·07
Guernsey	112	14·60	9·46	5·12	3·61	5·11	·753	·570	85·39	16·00
Devon	72	13·77	9·60	4·15	3·76	5·07	·760	·595	86·36	12·65
Ayrshire	252	13·06	9·35	3·57	3·43	5·33	·698	·543	86·95	18·40
American Holderness ..	124	12·63	9·08	3·55	3·39	5·01	·698	·535	87·37	13·40
Holstein Friesian	132	12·39	9·07	3·46	3·39	4·84	·735	·540	87·62	22·65

FRACTIONAL COMPOSITION OF MILK.

	Stages of Milking.						First Milk.	Strippings.	First Quart.	Last Quart.
	First.	Second.	Third.	Fourth.	Fifth.	Sixth.				
Total solids	10·47	10·77	10·85	11·23	11·63	12·67	13·15	28·81	12·04	25·72
Fat	1·70	1·76	2·10	2·54	3·14	4·08	1·32	9·63	1·22	8·48
Solids-not-fat ..	8·77	8·99	8·75	8·69	8·49	8·59	11·83	19·18	10·82	17·24

milk, but the amount of fat is 25 per cent. more than when she is milked only twice a day. Milk secreted under pressure, such as that of a full udder, is poorer in quality than when there is a lower resistance to its secretion. Thus, it is always found that the "strippings," or *the last-drawn milk, is the richest.* The proportions of *total solids* and of *fat* increase as the milking proceeds, and the final secretion is far richer than that obtained in the first part of the milking. This point has to be observed when milk is taken for analysis; in fact, it should be taken from the entire milk of the animal after the milking is finished. Boussingault divided the milk into six parts, obtained at different stages of the same milking. The result of his analyses is given in the second table on p. 247, side by side with similar observations by Long ("Elements of Dairy Farming").

The Period of Lactation.—The duration of lactation varies, but averages about 300 days. The first milk, or colostrum, contains from 15 to 30 per cent. of solids, but sinks to the composition of ordinary milk in three or four days. Eugling found the average composition of the colostrum of twenty-two cows to be as follows. This estimate differs very little from that given by König and other authorities.

COMPOSITION OF COLOSTRUM.

Water	71·69 per cent.
Total solids	28·31 ,,
Fat	3·37 ,,
Solids-not-fat	24·94 ,,
Casein	4·83 ,,
Albumin	15·85 ,,
Sugar	2·48 ,,
Ash	1·78 ,,

The colostrum is a turbid liquid of a viscous or slimy nature, yellow colour, strong peculiar odour, somewhat saltish to the taste, and usually of a weak acid reaction. Rennet does not coagulate it, or only incompletely; but it coagulates on boiling, owing to the presence of a large percentage of albumin. While the amount of casein present is little more than that in average milk, there is 15 or 16 per cent. of other proteins, including, according to Emmerling, 8·3 per cent. of globulin. Nuclein, lecithin, cholesterin, and urea, occur in traces. The fat of colostrum has a higher melting-point than that of normal milk, and is distinguished by a peculiar flavour and odour. Colostrum also contains numerous granular nucleated cells, called "colostrum corpuscles." The lactose is replaced by other sugars—*e.g.*, dextrose. The mineral substances are more abundant than in ordinary milk, and 41·43 per cent. of it consists of phosphoric acid, against 27 per cent. or so in normal milk. While providing an easily digested food of a highly nutritive character especially suited to calves, it is unsuitable for butter or cheese making. For this reason it is usual for the milk of newly-

COMPOSITION OF THE COLOSTRUM OF A COW, OR BIESTINGS—PERCENTAGES.

	Dry Matter.	Ash.	Fat.	Lactose.	Total Albumin.	Casein.	Globulin.	Albumin.	Specific Gravity.
Milking No. 1	22·878	1·034	2·302	2·742	12·236	4·858	5·3206	1·454	1·068
,, 2	16·232	·874	2·490	2·850	6·970	3·350	2·0400	1·010	1·037
,, 3	15·158	·866	3·410	3·370	5·820	3·090	1·4500	·750	1·035
,, 4	15·902	·824	4·740	3·620	4·650	2·700	·6600	·780	1·030
,, 5	15·738	·820	5·100	3·630	4·010	2·610	·5500	·520	1·030
,, 6	15·748	·818	4·550	3·860	4·040	2·560	·4800	·490	1·029
,, 7	15·718	·804	5·490	3·920	3·460	2·210	·3100	·620	1·029
,, 8	15·624	·802	5·470	4·570	3·360	2·170	·2700	·610	1·030
,, 9	15·476	·824	5·620	4·220	3·350	2·150	·2500	·590	1·030
,, 11	15·970	·846	5·040	3·820	3·520	2·520	·2200	·590	1·031
,, 14	16·550	·844	5·150	5·000	5·210	2·200	·2000	·560	1·031
,, 16	16·280	·836	4·900	5·010	3·320	2·340	·1900	·550	1·031
,, 20	16·058	·814	4·790	4·870	3·240	2·250	·1900	·560	1·030

delivered cows not to be mixed with that of the herd. It is not used for churning for four to seven days, nor for cheese-making for two entire weeks. It is used for making puddings and custards. Sutherst analyzed the milk drawn from a newly-delivered cow at the Cheshire Agricultural College. The milk was taken at 6 a.m. and 4.30 p.m. Equilibrium was reached after the ninth milking, and the fluid was then suitable for ordinary usage. The results are shown in the table on p. 249.[1] As a general rule the milk is mixed with that of the herd after six milkings, its freedom from albumin being established by boiling. Care should be taken that the cow is in condition, for the consumption of the milk too soon after delivery has been associated with an outbreak of epidemic disease of the nature of scarlatina.

It is therefore established that the milk is fairly normal in character and composition by the fourth or fifth day. It is also established that cows give the poorest quality of milk just after calving, that it increases in quality during the first two weeks, after which it remains fairly uniform for four or five months, when it again gradually *increases in quality* until about the ninth month of lactation, at which time it is one-seventh richer in solids than it was during the earlier months.[2] During the latter part of the period of lactation there is also a gradual *decline in the quantity* of the secretion. The difference in quality is almost entirely due to an increase in the proportion of fat, the solids-not-fat remaining nearly constant throughout the whole period. By dividing lactation into three periods, Dean found that in the second period the fat was increased by 17 per cent. and in the third period it was increased to 46 per cent. more than in the first period.

The Food.—In the spring and summer, when cows are turned out to grass, and their food is more succulent, the flow of milk increases. This, however, is not attended by an increase of solids. On the contrary, the percentage of solids may decrease. But in the winter, especially when the cattle are generously fed, they yield milk which is richer in solids. The composition of pasture grass, reckoned on an average of a large number of analyses, is—Water 80·00, protein (N × 6·25, plus a small amount of extractives) 3·50, fat 0·80, carbohydrates 9·70, fibre 4·00, salts 2·00, per cent. An animal living entirely on such grass would consume 16 tons per year. The most important ingredient in the food, as far as the milk is concerned, is the protein. Out of this the cell substance of the mammary gland is built up; and the more abundant the cellular protoplasm is made, the more abundant will be the secretion of milk, and *vice versa*. On the other hand, the amount of fat in the food appears to have little influence upon the secretion of milk. The following interesting table, by Becquerel and Vernois, illustrates the influence of the food on the composition of the milk:

[1] *Chemical News*, 1902, ii. 2.
[2] Cook, "Agricultural Science," 1893, vii. 253-265.

MILK: PARTS PER 1,000.

Character of the Food.	Water.	Casein and Extractives.	Sugar.	Fat.	Salts.
(*a*) *Winter feed:* Trefoil, lucern, oat-straw and beetroots	871·26	47·81	33·47	42·07	5·34
(*b*) *Summer feed:* Green trefoil, lucern and grass, maize and barley ..	859·56	54·70	36·38	42·76	6·80

In another series of experiments, shorthorn cows were fed upon clover and corn fodder. *In addition*, (1) one set of cows had a mixture of corn and corn-cob meal of the following composition: Fat 2·81, carbohydrate 65·9, protein 8·37, per cent.; (2) another set of cows had sugar-meal, a product of glucose manufacture having the following composition: Fat 11·16, carbohydrate 52·06, and protein 20·27, per cent. The cattle were fed for twenty-one days upon these substances, and the result of the experiment was formulated in the ratio of the fat to the solids-not-fat in the milk, of each set of animals. It was as follows:

Nature of Food.	Ratio of Fat to Solids-not-Fat.
(1) Corn and cob-meal	380 : 1,000
(2) Sugar-meal	469 : 1,000

The influence of an increase of protein in the food is thus observed. In every instance the milk showed a corresponding increase in the proportion of fat, and to a less extent of the other solids also, after feeding on the sugar-meal, which is obviously richer in protein.

The milk of cows fed on grass and potatoes is abundant, but watery and comparatively poor in solids; that from cows fed on cabbage and swede-turnips may have a disagreeable odour. Cows fed on overkept or sour rations give a milk of acid reaction, which speedily turns sour and coagulates. The refuse of sugar-factories and breweries (grains) which have been kept too long, and ensilage which has been put up too green, acts in the same way upon the milk.

Influence of Excitement on the Milk.—It would be manifestly unfair to judge the *quality* of an animal's milk by analysis of a sample taken immediately after a period of excitement. It has been found that when an animal has been driven to a market or fair, and subjected to the influence of noise and bustle, the composition of its milk may for a short time be materially altered in quality and very deficient in fat. The following are examples of the amount of fat and total solids which have been found in the milk under such circumstances:[1]

MILK DURING EXCITEMENT.

1. Fat	1·85 per cent.	Total solids ..	10·75 per cent.
2. ,, ...	7·37 ,,	,, ,, ..	16·00 ,,
3. ,, ...	11·06 ,,	,, ,, ..	19·50 ,,

[1] Aikman's "Milk Analysis," p. 52.

The Environment.—In like manner, the environment of the cows is of importance, especially the cleanliness of the byres, the temperature, and the ventilation. It is universally affirmed by farmers that the cattle must be warm, but it is essential that protection from vicissitudes of temperature and good ventilation should go together. The cubic space per animal is of importance. If they are crowded together they do not thrive so well, and their milk is liable to deteriorate. A visit to some byres reveals a close and stuffy atmosphere; others are draughty. In properly-erected byres, constructed with due regard to ventilation, the animals are warmer in winter and cooler in summer than in the outside air. The byres should be regularly inspected, and limewashed twice a year. The animals themselves ought to be periodically inspected by a veterinary inspector, and every care taken to eliminate the tuberculous. The danger arising to the community from tuberculous milk is such as to warrant State control of the milk-supply. Finally, the udders of the cows should be cleansed before milking, the men's hands should be clean, and the milk immediately strained and cooled in a refrigerator to 50° F. or less, and stored so as to avoid contamination.

The Legal Limit.—The regulation of the Board of Agriculture of Great Britain is that pure milk should contain not less than 3 per cent. of fat and 8·5 per cent. of solids-not-fat, which is established as the legal standard in England. But inasmuch as there are differences of opinion as to the *minimum* which should be set as the standard for pure milk in different countries, so also the legal limit varies. In the United States of America a different standard is fixed in some States, and, as seen by the table on p. 253, the legal limit for fat varies from 3·0 to 3·5 per cent., and for total solids from 12·0 to 13·13 per cent.

Examination of Milk.—The variations in the composition of milk are determined by analysis. Some of the methods adopted for this purpose ought now to be considered.

The *Physical Characters* are determined in the usual manner.

Appearance.—When placed in a narrow glass tube, the milk should be white and opaque; if it is more or less transparent and of bluish colour, it has probably been watered. The milk may be thick and viscid—that is, having a consistence akin to that of mucus. Such milk has the property of imparting its own peculiar characteristics to a large quantity of ordinary milk (see Ropy Milk). Milk which coagulates on boiling is probably colostrum; but other milk may also coagulate on heating immediately after it is drawn, owing to some febrile condition of the cow or inflammatory condition of the udder.

Colour.—Good milk is usually white, with a faint yellow tinge; but the consumption of mangolds, yellow turnips, and buttercups, etc., may give it a decidedly yellow colour. A very decided yellow colour, however, should create a suspicion as to its origin: it may be due to a large number of colostrum corpuscles, to inflammatory congestion of the udder, or to the addition of colouring matter, such as annatto or turmeric. A purplish hue may be due to the presence of blood; a reddish-brown, blue, or green colour, to micro-organisms. When the colour develops slowly *after milking*, it is almost certain that it is due to micro-organisms (see Blue Milk, etc.).

Taste and Odour.—The normal taste and odour of milk is characteristic. The cause of any departure from it should be sought for. Milk has the power of *absorbing* odorous gases. But the milk of animals kept in dirty byres or supplied with dirty water gives evidence of the same in the odour of the secretion. The taste of milk may be altered by the food of the animal —*e.g.*, turnips may give a marked flavour, vine or chestnut leaves a bitter flavour. The latter may also be due to some affection of the cow's liver or to medicines which have been administered to it, and, after being drawn, to micro-organisms.

The *Reaction* of milk should be neutral or alkaline. If markedly acid, the reaction is probably due to lactic fermentation. If markedly alkaline, it

STANDARD MILK IN AMERICA.

State, City, etc.	Percentage of Solids by Weight.		
	Solids-not-Fat.	Fat.	Total Solids.
Baltimore	—	—	12·00
Columbus, Ohio..	9·37	3·12	12·50
Des Moines, Iowa	—	3·50	13·13
Denver, Colorado	—	—	12·00
Iowa, Law of 1892	—	3·00	—
Lansing, Michigan	—	3·00	12·50
Maine, Law of 1893	9·00	3·00	12·00
Madison, Wisconsin	—	3·00	—
Massachusetts, Law of 1896	9·30	3·70	13·00
,, excepting May and June ..	—	—	12·00
Michigan, Law of 1889	9·50	3·00	12·50
Minnesota, Law of 1889	9·50	3·50	13·00
New Hampshire, Law of 1893	—	—	13·00
New Jersey, Law of 1882	9·00	3·00	12·00
New York, Law of 1893	9·00	3·00	12·00
Ohio, Law of 1889	9·38	3·12	12·50
Oregon, Law of 1893	—	3·00	—
Pennsylvania, Law of 1890	8·50	3·50	12·00
U.S. Treasury Department	9·50	3·50	13·00
Vermont, Law of 1888..	9·25	3·25	12·50
Wisconsin, Law of 1889	—	3·00	—

is probably due to the addition of sodium bicarbonate. But either acidity or alkalinity may be due to fungoid growths in the milk.

Sediment.—Milk throws down more or less sediment, which can be collected in a glass tube or by centrifugalizing it, and may be found to contain chalk or starch, used as an adulterant.

The further examination of milk does not admit of full treatment here, although an outline is given ; and the reader is referred to the works of Wanklyn, Fleischmann, Aikmann, Hehner and Richmond, etc., for fuller details.

Estimation of the Cream.—A " cream-tube " may be used for this purpose. This is divided into ten equal parts, and these again into ten parts, thus showing a scale of tenths and hundredths. The tube is filled to the highest mark with milk, and allowed to stand for nine or twelve hours ; the separated cream is then read off by the markings on the tube. The average milk will show about 10 per cent. of cream, but that of Alderney or Guernsey cows may yield 30 to 40 per cent. The estimation of the cream, when considered

with the specific gravity of the milk, is of value in showing whether the milk has been watered.

Specific Gravity is taken by a *lactometer*, an instrument similar to that used in urinalysis, the S.G. being shown upon the stem. The S.G. varies with the temperature, and a correction for temperature may therefore be necessary. The lactometer is graduated by water at 60° F., and the necessary correction for temperature is made by *adding* one to the S.G. for every 10° below 60° F., or *subtracting* one for every 10° above 60° F. The S.G. of water at 60° F. is 1000; that of milk is about 1030 at the same temperature. If the S.G. of milk is increased, the temperature being the same, it is due to the greater amount of solids which it contains. The fat of milk, however, is lighter than the other solids, and counteracts the effects of the latter on the S.G. An abundance of cream will therefore reduce the S.G. of milk. On the same principle a removal of the cream or a natural low percentage of cream would cause a higher S.G. Now, S.G. of 1032 is sufficient to raise a suspicion that some of the cream has been removed. But the dairyman may be aware of this fact, and also capable of using a lactometer. In this case he will probably use something which will again lower the S.G. The most handy thing is water; and the more water he adds to the milk, the nearer he will bring the S.G. to 1000. *A low S.G.*, therefore means either an abundance of cream or an addition of water to the milk. Hence the value of taking an estimate of the S.G. as well as the percentage of cream. This will be referred to again under Addition of Water to Milk.

According to Wanklyn, the points to be estimated in milk analysis are as follows:

IN 100 C.C. OF MILK.

1. Total solids .. .. = x grammes.
2. ,, fat .. .. = y ,,
3. ,, solids-not-fat .. .. = $x-y$,,
4. ,, ash .. .. = z ,,
5. Water by difference.

The Total Solids.—This may be estimated by taking a known quantity of milk—say 100 c.c.—and evaporating it over a water-bath until it is dry. The difference in weight in grammes gives the percentage of total solids. Or 5 grammes of milk should be dried in a small platinum dish, whose weight is known, over a water-bath for three hours at 100° C. The weight of the dish is then taken again, and the difference between the weight of dish before and after heating represents the loss of moisture or amount of water. The total solids are determined as follows: Let the dish weigh 7·215 grammes; pour into it 5 c.c. of milk; weigh again. The weight of the dish and milk will be 12·316; therefore the milk will weigh $12{\cdot}316 - 7{\cdot}215 = 5{\cdot}101$ grammes. When it has been dried, say—

The dish and dried solids weigh .. .. 7·914 grammes.
The dish weighs .. .. 7·215 ,,

Therefore total solids weigh 0·699 gramme in 5 c.c. of milk.

And $\frac{0{\cdot}699 \times 100}{5{\cdot}101} = 13{\cdot}7$ per cent. of total solids in the milk.

The **Mineral Substance** or ash is next determined by burning the total solids at a low red heat. We have thus the ash from 5 c.c. of milk, and the percentage of the ash in milk therefore $= \frac{\text{ash in 5 c.c.} \times 100}{5{\cdot}101}$. The percentage is always between 0·7 and 0·8 per cent. in genuine milk, and a *diminution* of the ash below 0·73 per cent. always indicates adulteration by the addition of water. An *excess* of ash, more than about 0·75 per cent., indicates the addition of mineral matters to the milk—*e.g.*, borax, boracic acid, sodium bicarbonate, etc. Some authorities consider the minimum of 0·73 per cent. of ash as being rather too high, and that there is a risk of injustice to salesmen if an arbitrary rule is set; they therefore prefer to make an estimate

of added water from the percentage of non-fatty solids. It should be observed that 0·73 per cent. of ash is the *average* amount. Fleischmann considers it may vary from 0·6 to 0·9 per cent. ; but the average is about 0·73, according to all other authorities.

The Fat in Milk.—There are various ways of determining the proportions[1] of fat.

1. Adam's coil process is probably the most satisfactory method. It consists of a coil of blotting-paper being used to absorb a known quantity of milk (say 100 grammes). The paper is afterwards dried, in the manner for obtaining the total solids, and the fat dissolved out of it by ether, which is in turn evaporated, and leaves the milk-fat. The proportion is then ascertained by weighing it.

2. Take the total solids, obtained as directed above, which together with the dish weighed 7·914 grammes ; pour in some ether, stir it with a glass rod, warm it in hot water until the ether boils gently, and filter it through paper into a *tared* platinum dish. The residue should be treated two or three times in the same manner until all the fat is removed. The ethereal solution is then placed over a water-bath until all the ether is evaporated. The fat is finally dried until the weight is constant. The weight of the dish then represents the weight of the dish plus the fat in 5 c.c. of milk.

The dish weighs	.. .. ..	7·215 grammes.
,, and total solids weigh	..	7·914 ,,
The dish and fat weigh	.. ..	7·393 ,,
,, alone weighs	.. ..	7·215 ,,
∴ Fat in 5 c.c. of milk weighs	..	0·178 gramme.

When multiplied by 20, this gives roughly the percentage of fat—$0{\cdot}178 \times 20 = 3{\cdot}56$; or, more accurately, if 5 c.c. of milk weighs 5·101 grammes, and the fat in the same 0·178 gramme, then the fat in 100 grammes of milk $= \frac{0{\cdot}178 \times 100}{5{\cdot}101} = 3{\cdot}5$ per cent.

3. Fleischmann recommends that the percentage of fat should be found from the S.G. and total solids, for which purpose he gives the following formula : Let T represent the total solids, F the fat, and G the specific gravity, of a quantity of milk at 15° C.

$$\text{Then } F = 0{\cdot}833\ T - 2{\cdot}222\ \frac{100\ G - 100}{G}.$$

Hehner and Richmond, having the same data, use the following formula : $F = 0{\cdot}859\ T - 0{\cdot}2186\ G$.

The *total solids* may also be ascertained by formulæ, providing the amount of fat and S.G. are known. Thus, Richmond uses the formula

$$T = \frac{G}{4} + \frac{6}{5} F + 0{\cdot}14 ;$$

and Fleischmann the following :

$$T = 1{\cdot}2\ F + 2{\cdot}665\ \frac{100\ G - 100}{G}.$$

The *specific gravity* is therefore of considerable importance in respect to these matters. But when taken alone it is apt to be misinterpreted. Thus, the fat of milk has a low S.G.—viz., 0·93—and has a tendency to counteract the high S.G. of the solids-not-fat, which equals 1·6. A low S.G. in milk might therefore, as already stated, have two meanings—viz., an unusual amount of fat, *or* the addition of water to the milk.

The **Solids-not-Fat** are *x-y*, the proportion of total solids *minus* fat; as in above example : Total solids = 13·7, and the fat 3·5 ; therefore solids-not-fat $= 13{\cdot}7 - 3{\cdot}5 = 10{\cdot}2$ per cent.

[1] *Journal of the Royal Institute of Public Health*, 1907, 756 : "Ten Methods of Estimating the Fat in Cream."

There remain the sugar and nitrogenous matters to be estimated. These are not usually calculated separately in an ordinary analysis.

The **Nitrogenous Matters** include casein, lactalbumin, etc. There are various methods of determining the amount.

Casein.—1. Take 100 c.c. of milk; precipitate the casein with acetic or sulphuric acid. Collect the precipitate, wash it successively with water, alcohol, and ether. The residue is practically pure casein. Dry and weigh it. The weight thus obtained represents the percentage of casein per 100 c.c.

2. Take the total solids obtained from 10 grammes of milk; extract the fat by ether. The residue consists of casein, milk-sugar, and salts. The sugar and soluble salts should now be removed by washing the precipitate in strong alcohol; filter it. Collect the residue, dry it over a water-bath, and *take its weight.* We have now the casein and insoluble salts, consisting chiefly of phosphate of calcium. Incinerate the residue; weigh the ash and subtract the figure from the former weight, and the remainder will be the weight of casein in 10 grammes of milk. Multiply the same by 10, and the figure will give the *percentage* of casein in the milk.

3. The quickest method, and that recommended by Wanklyn, is by determining the amount of albuminoid ammonia which can be obtained from it; 100 c.c. of genuine milk should yield 0·26 gramme of albuminoid ammonia, and 1 part of casein yields 0·065 part of ammonia.

4. The amount of protein can also be determined by Kjeldahl's method for ascertaining the nitrogen, and protein = N × 6·25.

The **Milk-Sugar** is ascertained in the following way: Take the total dry milk solids, wash with ether to remove the fat, and then treat the residue with alcohol and hot water; filter it. The liquid contains the lactose and some salts. Evaporate it to dryness, and weigh the residue (lactose + salts). Gently incinerate the residue and weigh again; only the insoluble salt remains. Subtract this from the former number, and the difference is the weight of the milk-sugar.

Various other points have now to be considered.

Addition of Water to the Milk.—According to the Board of Agriculture Regulations, should the proportion of non-fatty solids fall below 8·5 per cent., the presumption is to be raised that water has been added, unless the contrary can be proved. It has been found on analysis that at certain times cows do produce milk containing less than 8·5 per cent. of solids. But as a rule *this is only true of single cows, and not of entire herds.* Only very rarely, during a long dry season, the milk of an entire herd of cows may depreciate very rapidly, and, without any visible change, the proportion of non-fatty solids may sink below the standard. Faber,[1] as a result of 50,000 analyses, concluded that the non-fatty solids had an almost constant value of 8·7 or 8·8 per cent.; the fluctuations in the total solids were due chiefly to variations in the fat; evening milk contains more fat, and therefore more total solids, than morning milk; and the milk is richer in fat and total solids in October and November than in the rest of the year.

The detection of the fraudulent dilution of milk by water depends upon the proportion of total solids in the milk. Thus, supposing milk were found to contain only 9·9 per cent. of **total solids,** instead of 13 per cent., it would be a presumption that the milk had been diluted with 33·3 per cent. of added water "until the contrary is proved." In practice, however, it is customary to judge by the

[1] *Chemical News*, 1889, i. 253.

percentage of **non-fatty solids** present. Thus, if the milk contains only 6·37 per cent., instead of 8·5 per cent., of solids-not-fat—*i.e.*, 75 per cent. of the *minimum* recognized by the Board of Agriculture—it is considered to be a mixture of three parts of genuine milk and one part of water. The estimation and use of the non-fatty solids for this purpose is a good criterion, because the variation of these substances is less than the variation in the amount of fat, according to the evidence of Droop Richmond as the result of the analysis of the milk of 6,000 cows of different breeds :

Breed.	Percentage of Fat.	Solids-not-Fat.
Pedigree Shorthorn ..	4·0	8·8
Dairy Shorthorn	4·0	8·9
Red Poll	4·3	8·9
Montgomery	3·6	9·0
Kerry	4·7	9·0
Welsh	4·9	9·2
Jersey	5·7	9·2
Sussex	4·9	9·3

It has been shown by Vieth,[1] and confirmed by other authorities, that there is a definite ratio between the non-fatty solids of milk—viz., sugar 13, proteins 9, ash 2—which gives a milk having the following percentage of solids-not-fat :

Lactose	4·77 per cent.
Proteins	3·30 ,,
Ash	0·73 ,,
Total solids-not-fat ..	8·80 ,,

This is fairly representative of the average composition of milk, and it is obvious that the mere addition of water to the milk would not disturb that ratio. If genuine unadulterated milk is **deficient** in non-fatty solids, it is usually due to an abnormally low percentage of sugar. On the other hand, **an unusually high percentage** of non-fatty solids is almost always due to an increase of proteins, the sugar and ash remaining normal or only slightly increased. When the non-fatty solids are below 8·5 per cent., it is therefore advisable to make an estimation of the milk-sugar. This is strongly recommended by Revis,[2] who says : " If the proportion of sugar in the milk is below $\frac{13}{24}$ of the total non-fatty solids per cent., it affords strong evidence that *the deficiency is due to natural causes*. If, on the contrary, the percentage of sugar approximates to $\frac{13}{24}$ of the total percentage of non-fatty solids, it is very strong evidence that the deficiency of non-fatty solids *is due to adulteration with water*."

[1] *Cf.* Revis, *Journal of the Royal Institute of Public Health*, 1907, 39.
[2] *Journal of the Royal Institute of Public Health*, 1907, 39.

Adulteration by separated milk is not so easily detected as adulteration by water, and the case is usually treated as one in which there is a deficiency of cream.

The Removal of Cream.—The removal of cream from milk sold as genuine milk is one of the most serious offences against the Sale of Food and Drugs Act. The following Regulation with regard to fat in milk supplied to the public has also been made by the Board of Agriculture of Great Britain: "That any milk (other than skimmed, separated, or condensed milk) in which the amount of milk-fat is less than 3 per cent. shall be deemed to be so deficient in milk-fat as to raise a presumption, until the contrary is proved, that the milk is not genuine by reason of some portion of its normal content of milk-fat having been removed." In various tables already given it has been shown that the fat of milk varies in different breeds from 3·25 per cent. in Holstein cows to 6 or 7 per cent. in Alderney and Jersey cows. Respecting mixed milk from all sources, the proportion of fat also varies. The average of more than 30,000 analyses by Droop Richmond up to the year 1900 showed 4·07 per cent. of milk-fat. In the evidence given before the Departmental Committee on "Milk and Cream Regulations" in 1900, it was shown that the average of 120,540 samples of milk analyzed by Dr. Vieth was as follows:

Fat	4·1 per cent.
Solids-not-fat	8·8 ,,
Total solids	12·9 ,,

As the result of such evidence, and taking into consideration the variations, the Board of Agriculture laid down the rule that 3 per cent. of fat should be recognized as the *minimum* proportion in unadulterated and unskimmed milk. As the average milk of a herd of cows is appreciably more than 3 per cent., the evidence of such milk not having its fat removed or not being adulterated with water would have to be exceedingly strong. On the other hand, the knowledge that genuine milk rarely contains so small a proportion as 3 per cent. of fat is evidence of the removal of cream or adulteration by water when the percentage falls below this *minimum*. In the case of individual cows, however, an "appeal to the cow" can always be made, when the composition of the milk at different stages of the milking process must be borne in mind (*vide ante*). A sample was found which contained only 0·25 per cent. of fat,[1] and another which contained 11·06 per cent.,[2] so great are the variations in individual cases, and even at the milking of the same cow. It has been shown, however, that only 1 per cent. of cows yield milk containing less than 3 per cent. of fat, and only 3·5 per cent. yield milk containing less than 3·2 per cent. of fat. The proportion of fat varies little during the period of lactation, and as a rule only *decreases* when the food is insufficient. On the other hand, it *increases* proportionately with any increase of fat and

[1] *Milch-Zeitung*, 1903, xxii. 804. [2] *The Analyst*, 1893, pp. 1-12.

protein in the food, while an increase of carbohydrate increases all the solid constituents of the milk. An excess of watery food, such as fresh green crops, causes an increase in the amount of the secretion, but such milk may be correspondingly deficient in the total solids.

Mineral and Other Adulterations.—Various substances are added with the view of giving a fictitious character to the milk, and thereby deceiving the purchaser or analyst. (1) **Common salt** is added to increase the S.G. of the milk, the percentage of ash and of total solids. It is estimated by calculating the amount of chlorine in the ash. If this exceeds 0·14 per cent., according to Bell, we should suspect the addition of common salt. (2) **Carbonate of soda** is added for the same purposes. The normal ash gives no effervescence on the addition of hydrochloric acid ; but where sodium bicarbonate has been added to milk, its presence is revealed in the ash by its effervescence on the addition of a single drop of hydrochloric acid. (3) **Chalk** improves the colour, thickens the milk, and checks acidity ; but it is now a rare adulterant. The ash effervesces on the addition of a drop of acid. Its detection, however, is made by dissolving the ash and testing it with ammonium oxalate. Various antiseptics are used to preserve the milk. (4) **Boracic acid** is detected by Kretzschmar's method. Shake up the sample, evaporate 6 c.c. to one-fourth its volume, add one or two drops of hydrochloric acid, evaporate to dryness. As it dries up, apply a Bunsen burner over the dish, when a green flame will indicate the presence of boron. (5) **Salicylic acid** is indicated thus : The ash is dissolved in distilled water and a drop or two of perchloride of iron added, when the production of a purple colour shows the presence of salicylic acid. (6) **Formaldehyde, Formalin,** is detected thus—Make the following reagent :

Take Commercial hydrochloric acid (S.G. = 1·2)	..	500 c.c.
Solution of ferric chloride (10 per cent.)	..	1 ,,

Mix.

Mix together 10 c.c. of milk and 10 c.c. of the reagent in a porcelain vessel ; heat slowly until it boils, stirring occasionally to break up the curd. If formaldehyde be present, it will become violet-coloured, increasing on cooling. It is a delicate test. The colour appears if $\frac{1}{200000}$ part of formaldehyde is present in fresh milk, or $\frac{1}{500000}$ in sour milk, but the test cannot be used if the milk is flavoured with vanilla. (7) **Cane-sugar** is sometimes added to thicken and sweeten a poor milk. It is detected by titration with Fehling solution. Milk-sugar is naturally present. It is therefore necessary to apply a second test after inverting the sugar. Some of the milk is boiled with 5 c.c. of normal sulphuric acid, and the amount of sugar inverted is then estimated by Fehling's solution. A proportion of $\frac{2}{10}$ per cent. is added to that obtained in the first test as being due to inverted milk-sugar ; therefore any invert sugar beyond the $\frac{2}{10}$ arising from the inversion of lactose is considered to arise from cane-sugar. (8) **Starch** is occasionally added to thicken milk and increase the S.G. Its presence is shown by the microscope and testing with iodine. The proportion is estimated in the usual way. (9) **Glycerine** is also added to increase S.G. It is detected thus : Some whey is evaporated to dryness, and the residue freed from fat by ether. The residue is again digested with a mixture of alcohol and ether to dissolve out the glycerine. The liquids are poured off, the spirits evaporated therefrom, and the glycerine remains as a thick, sweetish liquid. Heated in a test-tube, it gives off the acrid fumes of acrolein.

The Milk of Diseased Cows.

Pathogenic Organisms in Milk.—In many diseases the secretion of milk stops during the febrile stage. But this is not a constant rule. The secretion may continue, although diminished in quantity.

To the naked eye such milk may appear normal, and is frequently mixed with that of the herd and sent out for human consumption. This has been known to occur when a cow has been suffering from anthrax, and such milk has been sold in the ordinary way, even when the fluid contained numbers of *B. anthracis*. Naturally, the whole of the milk is polluted when that of a diseased animal is mixed with the entire milk of the herd, and the danger to the consumer is obvious. In foot and mouth disease the milk contains pus and blood or mucus. If there are ulcers on the udder, the milk-corpuscles show a tendency to aggregate into grape-like clusters, and on being boiled the milk quickly separates into curds and bluish whey, which many authorities consider to be diagnostic. In an advanced stage of foot and mouth disease the milk contains large yellow granular bodies, and cells which resemble pus-corpuscles, but are larger, besides blood-corpuscles, vibriones, and bacteria, including the dumb-bell micrococci of Klein. In cattle plague, also, the milk contains blood and pus corpuscles, and the milk-corpuscles have the same tendency to form grape-like clusters as in foot and mouth disease. The milk shows a great diminution of sugar, but the proportion of fat is increased, and to a less extent the casein and salts. It is obvious that such milk should not be mixed with the milk of the herd.

Numerous epidemics of disease in mankind have been associated with milk. It is such a favourable medium for the growth of bacteria that chance infection by the microbes of disease soon renders it a powerful source of contagion.

Besides the bacteria which produce changes in the physical condition of milk, the following pathogenic and other micro-organisms are sometimes found:

B. coli communis.
B. enteritidis sporogenes.
B. tuberculosis.
B. pyocyaneus.
B. Klebs-Loeffler.
Streptococci.
Staphylococci.
Sarcinæ.
Fungi.

Scarlet fever epidemics have been traced to the milk-supply—*e.g.*, the Hendon epidemic. This may be due to the cow being milked by a person suffering from the disease, to the milker nursing some other person infected by it, or to the milk being stored in an infected house. The cows are themselves liable to a disease very closely resembling scarlet fever, and their milk has been the cause of the disease in the consumer. **Diphtheria** has been associated with the milk-supply in a similar manner. This disease has likewise been associated with the consumption of stringy or ropy milk. The cattle may also be affected with diphtheria or an allied disease. **Enteric fever** has many times been traced to polluted milk, and

especially to washing the milkcans with unboiled water from a contaminated source, or to the intentional adulteration of the milk with water. **Tuberculosis** has been somewhat fully considered in the chapter on Meat. It may now be considered settled that tuberculosis can be transmitted from cattle to human beings by means of the milk, and that milk is the source of a large percentage of the diseases of glands, bones, brain, and serous membranes, arising from *B. tuberculosis*, and also of general tuberculosis. This has been denied, and the denial was strongly supported by Koch; but the evidence given before the British Royal Commission on Tuberculosis, and that of independent observers, may be considered conclusive—viz., that milk is a source of tubercle to mankind, and is one of the causes of the high mortality from tubercular diseases, especially in children. **Thrush** is due to *Oïdium albicans*, a fungus which readily grows in milk. Gastro-intestinal catarrh is sometimes due to *Aspergillus*, *Penicillium*, and other fungi, growing in it.

There seems, moreover, to be a number of microbia which are quite harmless, if consumed by human beings under normal conditions, but which may be a cause of disease if consumed when the body is not in a normal condition. Such bacteria frequently occur in milk, and are doubtless the cause of the gastric and intestinal disturbances so common in young infants during the summer months. Some of these bacteria are capable of producing certain by-products which have a poisonous effect when taken into the susceptible digestive tract of the infant.

The Changes in Milk produced by Bacteria.

Various changes in the constitution and physical characters of milk are produced by bacteria which grow therein. These changes are the souring of milk or acid fermentation, alkaline fermentation, slimy or ropy milk, blue milk, bitter milk, and soapy milk.

The Souring of Milk.—Although the reaction of milk when fresh drawn is alkaline, it also has a slight acid reaction—in other words, it is amphoteric (*vide ante*). But the reaction becomes more and more acid on exposure of the milk to air, which is due to the transformation of lactose into lactic acid by Hueppe's lactic acid bacillus. Up to the present time about 200 dairy bacteria have been described, some of which are of extreme importance in dairying. Hueppe's lactic acid bacillus is 1·0 μ long and 0·004 μ broad. It develops rapidly, and multiplies freely at a temperature between 10° and 45° C. (50° and 113° F.). In the course of time the development of lactic acid is so great that the milk will coagulate on boiling, and a continuance of the bacterial development will produce enough lactic acid to induce spontaneous coagulation of the milk at ordinary atmospheric temperatures. The coagulation results in the formation of a solid mass of casein, which gradually contracts and squeezes out the whey in the form of a greenish-yellow fluid. As the acid

produced in sour milk is principally lactic acid, this process is spoken of as the **lactic fermentation.** Acetic, butyric, succinic, and other acids are also produced in milk by bacterial activity. But the coagulation of milk by these acids is not exactly the same thing as coagulation by rennet.

The lactic-acid-producing organisms do not as a rule produce spores ; they have a feeble resisting power, and are killed by a temperature of 70° C. (158° F.). Their rate of development is also influenced by the temperature. Rapid development occurs only at 10° C. (50° F.), so that if the milk is cooled, immediately after milking, to below this temperature, it may be kept sweet for a much longer time. The temperature of the milk should therefore be kept low. But just as a low temperature is unfavourable to the bacillus, so is a high one unfavourable to it ; in fact, the development of the bacillus is checked by heating the milk to 50° C. (122° F.), while at 70° C. (158° F.) it is destroyed.

But Hueppe's bacillus is not the only organism capable of souring the milk. The production of lactic acid from lactose is effected by quite a number of micro-organisms, which have been described by Hueppe, Weigmann, Krueger, Grotenfeldt, and Marpmann, including bacilli, micrococci, streptococci, and other bacteria. According to Warrington, milk is curdled by *Staphylococcus candidus*, *B. termo*, *B. fluorescens liquescens*, *M. gelatinosus*, and *M. ureæ*, which, however, do not all produce an appreciable acidity. It is doubtful if any two organisms which produce lactic acid act in the same manner. It was shown by Grotenfeldt that they can be cultivated in other media than milk, but they do not produce lactic acid except in the presence of sugar, and, furthermore, the production of the acid is in time fatal to the organisms, for when the proportion of acid exceeds a little more than 1 per cent., its production ceases. It is further observed that the curdling of milk only occurs when the proportion of acid reaches a certain amount. The action of the organism is due to an enzyme or enzymes, one of which splits a molecule of lactose into four molecules of lactic acid, the action being attended by the liberation of carbonic anhydride, while at the same time other enzymes produce a small amount of by-products, one of which is alcohol. The most important application of the lactic fermentation is in cheese and butter making, and, as it is known that all lactic-acid-producing bacteria are not equally active, attempts have been made (more or less successful) to produce a pure culture of those which are of the greatest practical use, and which produce in butter the finest aroma. Thus, butter is made from ripened cream, and Weigmann has been successful in isolating and cultivating a micrococcus which sets up normal lactic acid fermentation, and is now used as a cream-ripening ferment. But while the souring of milk is an almost universal phenomenon, it is not always produced by the same, or even by allied, organisms. "Occasionally the milk in a large number of dairies in one locality will be found to be soured by the same species of bacteria, while in

others the spontaneous souring may be produced by different species in dairies at no great distance from each other. Sometimes this spontaneous fermentation is absent. Certain herds of cattle have been noted whose milk does not sour, but after a time undergoes other types of fermentation. . . . In winter-time milk is frequently found not to undergo souring spontaneously, but may be kept for a long time without curdling; and when it does show signs of fermentation, the type is entirely different from that of normal milk souring."[1]

The influence of **thundery weather** on milk has been much discussed. Milk or cream sours more quickly in such weather than any other. But this is not due to electricity, for it has been shown by experiments that electricity has the effect of retarding lactic fermentation. Neither does sterilized milk become sour during violent thunderstorms. The true explanation of the phenomenon is found in the fact that the temperature of the atmosphere before the thunderstorm is such as to favour a rapid development of the acid-producing bacteria.

The **Butyric Fermentation** is due to the presence of various bacilli, notably *Bacillus butyricum*. As regards milk itself these organisms are of little practical importance, but they are of extreme importance on account of their influence upon the keeping property of butter; for rancid butter contains much butyric acid, and it has been found that the rancidity begins and proceeds with the development of this acid.

The type of fermentation in which this acid is produced is accompanied by the development of an alkaline reaction. The changes produced in milk are similar to those following the action of rennet; a coagulum is formed which subsequently dissolves into a clear liquid having a bitter taste and containing butyric acid. About a dozen bacteria have been described which contain an enzyme capable of producing butyric acid. It has been pointed out by Freudenreich[2] that butyric acid is a residue resulting from the breaking down of casein and lactose in various ways, and is not to be regarded as a uniform process.

Ropy Milk.—This peculiarity is due to the transformation of lactose into a slimy or ropy substance, which gradually spreads throughout the milk. Such milk is useless for dairy and domestic purposes; it furnishes no cream, cannot be churned, and is unfit to drink. Stringy or ropy milk is capable of producing disease, and various epidemics of diphtheria have been associated with its consumption. It is a character of milk which disappears rapidly, and attempts have failed to trace its origin to a particular cow. Various theories of its causation have been formed, such as diseases of the mammary gland, variations in the food of the cow, and differences in the environment. But the ropy or slimy fermenta-

[1] Farmers' Bulletin 29, U.S. Department of Agriculture.
[2] "Dairy Bacteriology," p. 88.

tion of milk has been found in connection with the presence of numerous, or according to some authorities eighteen, distinct organisms, including—

Bacillus viscosus.
Bacillus lactis pituitosi.
Bacillus mesentericus.
Leuconostoc mesenteroides.
Actinobacter polymorphus.
Potato bacillus (tyrothrix).
Streptococcus Hollandicus.
Micrococcus Freudenreichii.
Bacterium Hessii.

Some of these organisms give to the milk only a slight sliminess; others render it tenacious almost beyond belief. One described by Conn renders the milk so stringy that it can be drawn into threads 10 feet long, and so fine as to be scarcely visible. Some render the milk slimy in their early growth, others only after several days; and some do not render fresh milk slimy, but first curdle it, and then dissolve the curd into a slimy solution. The nature of the slimy substance produced also varies. In some cases it is like cellulose, in others an albuminoid substance. The by-products of the fermentation are mannite, lactic acid, butyric acid, carbonic acid, peptone, etc.

When stringy milk is caused by the development of fungi—*e.g.*, leuconostoc—in the milk, its origin may be due to the food or to the animal. The spores of the fungi may be in the atmosphere of the byre, and arise from hay or straw. But the spores may also be in the system of the cow, and be excreted with the milk. In the latter case it is probable that several animals are affected, and they will probably have a temperature 2° or 3° above the normal. Like most other fungi, these spores do not develop into fungi in the body of the cow, but in five or six hours after milking the upper layers of the milk are a dense mass of filaments.

Blue Milk and Other Coloured Milk.—There are various micro-organisms which give to milk a blue, violet, yellow, green, or red colour, owing to the formation of various pigments, according to Erdmann and other bacteriologists, from proteins. **Blue milk** is believed to be harmless, but is undesirable. The blueness of skimmed or watered milk is not the same thing as is here referred to. The colour is of a deepish hue, and the milk has an acid odour, but does not possess any poisonous properties. It can be churned, but does not make good butter. The change is due to the presence of *Bacillus cyanogenus*, of which there are several varieties. The organism is sometimes present in the milk-ducts, and gains entrance to the milk when it is drawn; but the milk may become polluted with it after it is drawn. The explanation of the occurrence of blue milk is a double one: "Ordinary milk contains lactic acid organisms, and these, acting in conjunction with another species of bacteria, produce the brilliant blue colour which characterizes

this infection. When growing in ordinary milk the effect of this organism is very marked. For a few hours no change is noticed, but just about the time the milk begins to become acid some intense blue patches make their appearance."[1] It is, in fact, an example of symbiosis, or association of organisms to produce some special effect, such as is observed in other departments of the vegetable kingdom. The quicker the lactic acid is formed, and coagulation of the milk occurs, the smaller are the patches of blue ; but where the acid is slowly produced the blue patches of colour are larger and of a deeper colour.[2] There is no doubt that the infection is associated with dirt ; it may be said that it never occurs in a clean dairy or in the milk of well-tended cows. It is confined usually to individual dairies, and sometimes to a single cow. When the latter is the case, the trouble can be stopped by washing the teats with diluted acetic acid ; but it has been known to be very prevalent in a district, and almost epidemic.[3]

Red Milk or bloody milk is occasionally due to the presence of blood-cells, which cause it to be wholly or partially red or pink. Blood may escape with the milk when the udder has been injured by blows, when it is congested or inflamed, and when the circulation through it has been suddenly increased by a richer or more abundant food. Deposits of tubercle and tumours or indurations of the gland from any cause may also account for the presence of blood in the milk. But when milk turns red *after* it is drawn, the change is usually due to the development therein of micro-organisms. The organisms most commonly associated with the coloration are the *B. lactis erythrogenes*, *Micrococcus prodigiosus*, and *Sarcina rosa*. Lastly, it may be due to the addition of madder.

Violet milk is produced by the *B. violaceus*, and **yellow milk** by *B. synxantheus*. These organisms cause the milk to coagulate rapidly, somewhat after the manner of rennet ; then the coagulum dissolves into a yellow, orange, or amber-coloured liquid. In some cases the organism also leads to the decomposition of proteins and production of trimethylamine, which is recognized by the characteristic herring-like odour.

Bitter Milk.—There are quite a number of organisms which produce this unpleasant change in milk. In particular it has been associated with the presence of *Proteus vulgaris*, Conn's bitter-milk micrococcus, and Weigmann's bitter-milk bacillus. The nature of the bitter principle produced is not exactly known. Hueppe considers it is a peptone ; and Warrington[4] has shown that the following micro-organisms are capable of peptonizing milk : *B. subtilis*, *B. anthracis*, *B. floccus*, *B. toruliformis*, and Finkler's comma bacillus. Freudenreich, however, says the bitter principle is not a peptone. The bitter taste is most often developed in milk which has been boiled, and afterwards allowed to stand for some

[1] Farmers' Bulletin 29, p. 13, U.S. Department of Agriculture.
[2] *Ibid.* [3] *Ibid.* [4] *Chemical News*, 1889, i. 8.

time. Boiling destroys the bacteria, but the spores are very resistant and remain effective.[1] The Farmers' Bulletin quoted above says that one case of bitter milk was traced to feeding a herd of cows on turnips which had been washed in foul water. It appears probable that micro-organisms were the direct cause, but whether they produced some change in the turnips, or these roots were merely the instrument of their introduction into the body, is unknown.

Soapy Milk.—Milk having a soapy taste has been described. The milk did not undergo the lactic fermentation properly, it frothed badly, and the cream was difficult to churn. It has been traced to bacteria on the hay or straw used for the cows, and its occurrence ceased after discarding the use of the particular material.

Other Fermentations of Milk.—Although the curdling of milk is usually the result of lactic acid fermentation, this is not invariably the case. Milk curd has not a constant and invariable character ; the greatest variety occurs in the degree of stiffness, amount of whey, the taste and colour. Bacteria other than the lactic acid group are capable of producing the coagulation.[2] Thus, the milk may be coagulated into a soft slimy mass having a bitter instead of a sour taste, and a neutral or alkaline instead of an acid reaction. This is due to bacteria which contain alkali-producing ferments—*e.g.*, *B. fluorescens non liquescens* and the bacillus of septicæmia. After a day or two the curd breaks down into a clear substance, and ultimately liquefies and forms a semi-transparent liquid not at all like milk. As a general rule, however, the bacteria which set up the alkaline fermentation are of little importance, because they grow very slowly. The acid-producing bacteria, on the other hand, grow rapidly, and, having got a start of the others, produce sufficient acid to check their growth. But milk which has been standing some time always contains some of the bacteria which produce the alkaline ferment. Moreover, they form spores which resist a high temperature, and render the process of sterilizing milk by heat somewhat difficult. Their presence is therefore of importance in dairying, and they are sometimes sufficiently numerous to produce a noticeable result.

Other bacteria which produce no acid in milk, but which effect the coagulation of the casein or produce fermentation without coagulation, are sometimes present. Amongst this group is included the potato bacilli, a group to which Duclaux gave the name **tyrothrix,** which decompose casein and albumin, and cause the milk to have an unpleasant odour.

The Standard of Bacterial Purity.—Milk is rendered impure by adulteration with water, addition of materials to increase the specific gravity, preservatives, dirt, and bacteria. The number of bacteria in a given sample of milk is evidence to a limited extent of the quality or purity of the milk. But very much more depends upon the kind of bacteria than their number. As regards the number, the widest possible variations occur under identical conditions. As a matter of fact, there is no uniformity even in very good milk. *Immediately* after milking the number of bacteria varies from 0 to 10,000,000 in a cubic inch. They begin to multiply immediately, and continue to do so with marvellous rapidity. Miguel found that milk brought to his laboratory had—

[1] Aikman's "Milk," p. 91.

[2] Farmers' Bulletin, *loc. cit.*

Bacteria in Milk.

Immediately after milking	9,000 per c.c.
One hour after milking	31,750 ,,
Nine hours after milking	120,000 ,,
Twenty-four hours after milking	5,600,000 ,,

This is not only a common experience, but a moderate estimate of the bacteria in milk; for other observers have recorded 60,000 to 100,000 per c.c. immediately after milking, and from 2,000,000 to 6,000,000 in six hours. The temperature at which the milk is kept influences the development of these bacteria considerably. Conn found that a sample of milk kept in a cold cupboard for four days had only 10,000 bacteria per c.c.; but a sample of the same milk left in a warm room for only one hour had 1,000,000 bacteria per c.c. The rate of increase of the bacteria in milk kept at 12·5° C. (54·5° F.) and at 34° C. (93° F.) was estimated by Cnoff, and is given in the following table:

Multiplication of Bacteria in Milk.

Time since Milking.	Temperature 12·5° C.	Temperature 34° C.
1 hour	nil	7·5-fold
2 hours	4-fold	23 ,,
3 ,,	6 ,,	64 ,,
4 ,,	8 ,,	215 ,,
5 ,,	26 ,,	1,830 ,,
6 ,,	435 ,,	3,800 ,,

Miguel found that a rise of 10° C. made an enormous difference in the growth of the bacteria; *e.g.*, milk kept at 25° C. for fifteen hours had 100,000 per c.c., and kept at 35° C. for fifteen hours it had 72,000,000 per c.c. Freudenreich found that milk kept at 25° C. for twenty-four hours had 577,000,000 bacteria per c.c.

The actual number of bacteria in milk, however, is of little importance providing they are not pathogenic organisms. But, on the other hand, some species of bacteria are of great value for dairy purposes, and are by no means injurious if consumed with the milk. This applies especially to the rapidly-developing group of lactic acid bacteria, and to others which are of importance in cheese and butter making. All these bacteria continue to multiply in the milk until their development is checked by an accumulation of their own products. In town milk, which is often kept for twenty-four or thirty-six hours, their number is enormous, unless the milk is kept on ice or in a cooling-room in order to check their multiplication. Judged by the number of bacteria per c.c., milk which contains not more than 3,000,000 or 4,000,000 bacteria per c.c. may be regarded as fairly good. In American cities, where the free use of ice obtains, milk is generally superior in this respect to that of European cities. Where, however, the milk is refrigerated im-

mediately after being drawn, and is kept cool until it is wanted, the bacterial growth is kept in check. Robertson[1] gives the following as examples :

Source.	Temperature.	Bacteria per C.C.	Time after Milking.
Country milk ..	61·5° F.	111,000	5 hours.
,, ,, ..	70·5° F.	263,000	4½ ,,
Town milk	73·0° F.	223,000	4½ ,,
Railway milk ..	57·2° F.	541,000	15 ,,

But more important than number is the kind of bacteria. Many samples of milk contain bacilli of the colon group (*Bacillus coli*), of which MacConkey has described 36 varieties; the *Bacillus enteritidis sporogenes* is present in some samples ; in others, *Streptococcus pyogenes aureus*, *Staphylococcus pyogenes aureus*, and *Staphylococcus albus*, have been found. These are pathogenic organisms. The presence of the two first-named bacteria affords direct evidence of the pollution of the milk by cow-dung or human excrement. *B. enteritidis* is of particular importance, because it does not multiply in the milk, and its presence is indicative of the original pollution ; it is a fertile source of disease in infants. *Streptococci* ought not to be present in the milk ; their appearance therein only occurs when the mammary gland or teats of the cow are inflamed or otherwise diseased. Their presence in milk will cause sore throat in the consumer.

The following is the **Standard of Purity** of milk[2] set out by Dr. Houston in his report to the London County Council :

The Standard of Purity of Milk.

1. 1 c.c. should not give evidence of the presence of *Bacillus enteritidis sporogenes*.
2. 0·001 c.c. should not give evidence of the presence of *B. coli communis*.
3. 0·001 c.c. should not give evidence of the presence of streptococci.
4. The primary sediment of milk should not exceed 100 parts per 1,000,000 after standing twenty-four hours.
5. The secondary sediment, obtained after centrifugalization, should not exceed 50 parts per 1,000,000.
6. Pure milk should not contain more than 20,000 micro-organisms per c.c. if it is strained and cooled immediately after milking.

Source of the Bacteria.—The air is undoubtedly an important source of the contamination of milk. When we consider the kind

[1] *Journal of the Royal Institute of Public Health*, 1907, 610-614. [2] *Ibid.*

of air which pervades the ordinary byres, this is obvious. An ill-ventilated hovel, which has been occupied by cows for hours or days, has an atmosphere which is more or less laden with bacteria, arising from the hay and the dust. Another important source is the animal's hair. This as a rule is dirty, to say the least dusty, and when the animal is milked such dust becomes disturbed and floats in the surrounding atmosphere, and some of it falls directly into the milkpail. To show the danger from this source, it is only necessary to say that when milk is drawn by an exhauster or milking machine it contains about 500 bacteria per c.c., but when it is drawn by hand into an open pail it often contains as many as 30,000 per c.c. directly after milking. When such milk is allowed to stand twenty-four hours, a sediment may be collected which consists wholly of extraneous matters, and is simply dirt and partly manure.

The animal itself is a source of bacteria which cannot be denied. In spite of cleanly methods of procedure, clean stalls, sterilized vessels, and vacuum exhausters, the *first* milk drawn from a cow in by far the large majority of cases contains bacteria. Lehmann found that the first 10 ounces of milk contained from 50,000 to 100,000 bacteria per c.c., and that it was only the last 10 ounces of milk which was quite free from bacteria on being drawn. This is due to the fact that the milk-ducts of the animal are open to the air ; at the termination of milking a small portion of milk remains in the ducts or adherent to its walls. This is contaminated by bacteria which enter the duct with the air. Here they multiply rapidly, and by the next milking-time have become very numerous, and therefore must of necessity contaminate the milk. It has been suggested that, having gained an entrance to the ducts, such bacteria permeate the gland, and even find their way into the acini. It therefore appears to be impossible, even with the greatest precautions, to avoid contamination of the milk.

As a general rule, the bacteria which enter the milk from internal sources are not pathogenic organisms. It is only when the animal is suffering from a general infection or some disease of the udder that she is likely to contaminate her milk with pathogenic organisms. As a rule these bacteria get into the milk from external sources, and most of them multiply in this fluid with extreme rapidity. The external sources of contamination are the air, dust, dirt on the hairs of the cow ; also from the milk vessels, the hands and clothing of the milker, and the water with which his hands and the milk vessels are washed.

Cooling the Milk.—To obtain pure and wholesome milk it is necessary, therefore, to have healthy cows and keep them clean. Having received such milk from the cow, it is the dairyman's duty to preserve it from external sources of contamination and check the development of bacteria in it. This important point is obtained by thoroughly cooling the milk as soon as it is drawn. When drawn the milk has a high temperature, and most kinds of bacteria will

develop in it with great rapidity. When left to itself milk loses heat very slowly, and in the summer season a long time elapses before it is cool, and it never gets a temperature lower than that of the surrounding air. Consequently such milk swarms with bacteria. If, however, the milk is reduced to a low temperature immediately after milking, the growth of bacteria is checked at once, and will not begin again until the milk once more attains a temperature above 50° F. Pure country milk, having 500 bacteria per c.c. when drawn, will if kept at 61° F. have 110,000 per c.c. in five hours, or 250,000 per c.c. in the same time if kept at 70° F. The proper and usual treatment in good dairies is **refrigeration** to a temperature of 50° F. or lower, immediately transferring it to cool sweet "churns," and placing them in a cool and shaded room. If a pure country milk develops a high proportion of bacteria, it is to be assumed that it has not been properly cooled, or its temperature has been allowed to rise again, or it was produced under insanitary and uncleanly conditions.

For the preservation of milk in hot weather the ideal method of handling the milk is as follows, says the *Creamery Journal:* "When the milk is drawn from the cow, it should at once be cooled down by means of a circular capillary cooler in which very cold water or brine is being circulated. The best temperature to attain is 38° F. by means of the refrigerator or ice. But the latter method is expensive, and the treatment can only be done in a large dairy. When the proper temperature is reached the milk is ready for the road. . . . On arrival in town it should be pasteurized by heating it to 140° F. for twenty minutes, and then promptly placed in bottles which have been washed, and dried in a cupboard. The bottles should be closed by a stopper, and cooled down by water or by being placed in a cold room to 38° F. before being sent out to the users." Milk thus treated should be free from pathogenic organisms, and will not go sour quickly. Such milk is sold universally in Sweden and Denmark, and to an increasing extent in Great Britain.

Preservatives in Milk.—When milk is properly treated there is no necessity for the addition of preservatives. But it is often found that boric acid, salicylic acid, formalin, or other preservatives (sold to the dairyman under fancy names), have been added to prevent it from souring. As much as 1·5 to 9 grains of boric acid has been found in a pint of milk, and formalin is used in the proportion of 1 part in 50,000 to 100,000, or at most 1 fluid ounce in 310 gallons of milk. The question as to the influence of preservatives on the digestion and health of the consumer has been much debated. With respect to formalin, there is little doubt that the presence of this preservative is injurious even in small quantities. Solomone[1] considered its action upon digestion. He found that formalin enters into combination with the proteins, and that such

[1] *Giorn. Farm. Chim.*, lvi. 289-294.

protein is consequently rendered less digestible. His experiments, however, were confined chiefly to dried fruits, which were preserved by soaking them in a 3 per cent. solution of formalin for a period varying from ten to sixty minutes. The results of his experiments showed that from 50 to 70 per cent. less protein in such fruits was digested than in fruit dried without the preservative. His statement is uncompromisingly against the use of formalin as a food preservative. The proportion of 1 in 50,000 means one drop of formalin in 5 pints of milk. It would hardly be thought that so small a proportion could have any injurious effects. Nevertheless, Rideal and Fullerton found that this minute proportion—the minimum amount required to keep milk sweet for twenty-four hours—inhibits the action of the digestive ferments. In consequence of the difficulty of detecting minute quantities of this bactericide, it is considered by most authorities that its use as a preservative of foods ought to be forbidden ; and a recommendation to this effect was made by the Departmental Committee of the Local Government Board after hearing the evidence of many experts.

Respecting the action of boric acid in the human organism, and its influence upon it when used as a preservative of milk and other foods, there is a difference of opinion. Chittenden found that in proportions up to 1 per cent. boric acid increased rather than checked the action of saliva ; that it had no influence upon protein metabolism or general nutrition, nor upon putrefactive processes in the bowels ; that a dose of 3 grammes a day given to a guinea-pig was so rapidly absorbed and eliminated that none could be found in the body if the animal were killed thirty-six hours after the last dose. He therefore concluded that the continuous use of small doses of boric acid did not injuriously affect the health. Similar results were obtained by Neumann, Rosenheim, Tunnicliffe, and other investigators.

But evidence on the other side is quite as strong. Rideal and Fullerton found that 36 grains of boric acid in a gallon of milk (about 1 in 2,000), a proportion which is not at all uncommonly used, inhibits the action of both the salivary and pancreatic ferments upon carbohydrates. Mann also found that the same proportion of boric acid causes diarrhœa, and Handford that it is responsible for convulsions and delirium in the infants who consume such milk. The effects of **boron** upon the nervous system cannot be entirely ignored, and the use of boric acid as a preservative of milk ought to be discontinued. The Committee before whom this evidence was given recommended to the Local Government Board that the use of preservatives in milk should be made an offence against the laws regulating the sale of food in the United Kingdom.

CHAPTER X

MILK PREPARATIONS

Skimmed Milk.

Skimmed Milk is that which remains after the removal of the cream by hand or machine. It contains the proteins and carbohydrate of milk, and is therefore a food of no mean value. When milk is skimmed by hand, it must be "set" for the cream to rise; during this period the milk undergoes changes, owing to the development of bacteria, which more or less impair its freshness; consequently hand-skimmed milk does not find a ready sale, and is used chiefly for feeding pigs and poultry. However, since the introduction of the centrifugal separator, the cream is removed directly the milk is drawn from the cow in order to supply the cream trade. There is thus provided a great quantity of skim milk which is perfectly fresh and is not to be despised as a food; it is a *partial* substitute for milk, suitable as a beverage, for making milk puddings (in which butter or other fat is used), and of great value in the manufacture of bread, cakes, biscuits, ices, and ice-creams. It is also useful for making kephir, koumiss, and other sour-milk preparations. In large butteries and creameries the skim milk is largely used for feeding pigs and poultry, and in other establishments for making various casein preparations.

Skim milk alone is of course not a suitable food for infants, for the amount of fat in hand-skimmed milk is usually less than 1 per cent., while that in machine-skimmed milk averages only 0·1 to 0·3 per cent.

Composition of Skim Milk—Percentages.

	Hand-skimmed.	Machine-skimmed.
Water	89·73	90·25
Casein and lactalbumin	3·95	4·02
Fat	·89	·25
Lactose	4·62	4·65
Ash	·81	·83

The following recommendation to the Board of Agriculture was made by the Milk Committee in 1901: "That any skimmed or separated milk in which the total milk solids are less than 9 per

cent. should be deemed so deficient in normal milk constituents as to raise a presumption, until the contrary is proved, that it has been mixed with water." The sale of skim milk as entire or whole milk would be fraudulent, and the offender would be liable to prosecution under the provisions of the Food and Drugs Act.

Condensed Milk.

When milk is heated the water evaporates from it rapidly, and, by a prolonged application of heat, as in cooking the milk slowly in an oven, the milk becomes somewhat thick and creamy. This fact is taken advantage of in the manufacture of condensed and desiccated milk. "Extract of milk" is partially skimmed milk evaporated to the consistency of treacle. "Condensed milk" consists of whole or skim milk evaporated to one-third its bulk, and unsweetened or sweetened with cane-sugar.

The manufacture of condensed milk dates from the middle of the last century. The earliest method consisted in the slow evaporation of milk, at a comparatively low temperature, to a firm consistency, afterwards pressing the substance into cakes. These, however, did not readily dissolve in water, and were liable to deterioration through rancidity of the fat and other changes. But a few years later the vacuum condenser was introduced by Gail Borden, and was used in the manufacture of condensed milk. This method, with the addition of cane-sugar and hermetically sealed tins, has continued in use to the present day. The milk has one-eighth its weight of cane-sugar added to it and dissolved by the aid of moderate heat. The mixture is then transferred to the vacuum-pan, where it attains a temperature of 60° to 70° C., and condensed to one-third, or even one-fourth, of its original bulk. This, however, is not the only method now used, especially for unsweetened condensed milk. In Campbell's method the milk is placed in a tank and heated by a hot-water jacket ; heated air is driven through the milk, by means of which the evaporation of water is induced until the milk is brought to the required consistence and composition. In another mode of manufacture the cream is first removed by the centrifugal separator ; the skim milk is then reduced to a fine powder, and afterwards combined with a quantity of cream equivalent to that previously removed ; finally the mixture is condensed at 104° F. until it attains a proper consistence.

In the preparation of condensed unsweetened milk by the vacuum process, it is necessary first of all to coagulate the lactalbumin by boiling ; otherwise it would coagulate during condensation, and the preparation would be lumpy. The milk is then condensed in the vacuum-pan to one-third its original bulk.

All kinds of condensed milk are canned, hermetically sealed, and finally submitted to a temperature of 280° to 285° F. to insure complete sterilization. When the tins are perfectly soldered such milk will keep indefinitely.

COMPOSITION OF CONDENSED MILK—NUTRIENTS PER CENT.

	Water.	Fat.	Milk-Sugar.	Cane-Sugar.	Casein.	Soluble Albumin.	Ash.	Authority.
I. FULL CREAM.								
Unsweetened, average ..	60·10	10·30	15·80	—	11·20		2·50	Pearmain and Moor.
	63·47	10·22	13·94	—	9·81	·49	2·07	Richmond.
	62·97	10·67	14·55	—	9·24	·32	1·50	Faber.
	61·30	11·70	14·30	—	9·10	1·50	2·10	Goodfellow.
	67·20	10·13	9·55	—	10·21	·65	1·74	Lloyd.
	62·38	10·85	14·15	—	9·87	·75	2·00 to 2·10	Tibbles' mean of available reports.
Sweetened, average ..	20·00	9·89	13·60	43·90	10·50		2·10	Hehner.
	15·30	8·85	13·63	50·00	9·98		2·17	Pearmain and Moor.
	27·40	11·61	15·14	38·50	9·75		2·10	Harrison.
	25·48	11·52	12·89	38·57	9·43		1·93 to 2·00	
	25·04	9·58	13·06	39·40	10·00			
Made in England, average	18·70	9·94	58·21		10·95		2·20 to 2·84	Lloyd.
Made in Switzerland, average	16·52	8·20	62·54		9·90			
II. SKIM MILK.								
Average	26·43	·87	14·28	45·90	10·36		2·16	Tibbles' mean.
	29·00	1·30	13·30	45·40	10·70		1·80	Pearmain and Moor.
	25·97	·75	14·07	44·72	10·99		2·39	Harrison.
Made in Holland ..	26·14	1·02	62·41		8·34		2·00	Lloyd.

COMPOSITION OF NAMED VARIETIES OF CONDENSED MILK—CONSTITUENTS PER CENT.

	Total Solids.	Fat.	Protein.	Milk-Sugar.	Cane-Sugar.	Ash.	Analyst.
FULL CREAM :							
Viking	35·10	10·40	9·10	13·80	—	1·80	A. H. Allen.
First Swiss	36·70	10·50	9·70	14·20	—	2·10	Pearmain and Moor.
Hollandia	43·00	9·80	11·30	18·50	—	2·50	
Italian	44·60	9·50	14·70	16·50	—	3·50	
Gallia	77·80	9·00	8·45	12·82	44·61	1·92	Dold and Garratt.
Home and Colonial	77·20	10·00	8·63	17·61	38·96	2·00	
Nestlé's	74·80	11·00	9·07	13·40	39·43	1·90	
Lipton's	76·80	11·00	8·75	11·60	43·40	2·05	
Fourpenny	76·50	10·40	9·80	13·00	41·30	2·00	Pearmain and Moor.
Full-Weight	76·50	11·00	12·30	13·50	37·20	2·50	
Milkmaid	76·30	11·00	9·70	14·60	38·70	2·30	
Rose	76·60	12·40	8·30	17·60	36·10	2·20	
Royal Arsenal	76·60	9·00	9·46	18·15	37·99	2·00	Dold and Garratt.
Tip-Top	74·80	13·00	8·43	14·00	37·32	2·00	
SKIMMED MILK :							
Cowslip	70·90	1·40	11·40	14·60	41·90	1·60	Pearmain and Moor.
Goat	71·00	1·20	9·90	12·00	48·90	2·00	
Alderney, 60 per cent. of cream	68·10	11·05	10·95	—	—	—	A. H. Allen.
Arcadia, partly skimmed	71·20	8·08	10·25	—	—	—	
Threepenny	66·25	·30	10·49	—	—	—	
Farm	66·60	·12	10·63	—	—	—	
Devon	70·60	8·50	10·63	—	—	—	
Cup	—	·77	10·73	10·92	50·35	2·16	Dold and Garratt.
Cross	—	·76	12·08	18·85	39·45	2·86	
Cow	—	·98	10·30	11·75	49·01	2·26	
Goat	—	·60	9·52	11·20	52·66	2·02	
Minster	—	·84	10·77	14·52	46·81	2·46	
Pound	—	1·52	10·90	12·02	44·93	2·20	
Shepherd	—	·62	10·00	16·40	46·10	2·32	
Threepenny	—	1·44	10·71	10·45	36·40	2·36	
Triangle	—	·70	9·76	13·00	50·86	2·32	

It would, however, not be correct to say that they are quite sterile, although the number of bacteria is less than in ordinary milk, but from 700 to 120,000 bacteria per c.c. are found. Fortunately, the pathogenic organisms are absent, although streptococci are sometimes observed.

The findings of the majority of analysts show that in **sweetened** condensed milk the fat may vary from 9 to 18 per cent., but the maximum is rarely reached; the casein also has a wide range, a variation of 8 to 20 per cent. having been observed; the milk-sugar varies from 10 to 18 per cent., and the added sugar from 25 to 55 per cent. In the **unsweetened** kinds the variations are not so great. The fat varies from 9 to 12 per cent., the milk-sugar from 12 to 15 per cent., and the casein from 9 to 11·5 per cent. In condensed **skim milk** the fat is practically *nil*, and rarely exceeds 1 per cent.; the casein varies from 8 to 12 per cent., the milk-sugar from 14 to 16 per cent., and cane-sugar from 40 to 48 per cent.

The Standard of Condensed Milk.—These variations in the composition of condensed milk are so great that it is essential that some standard should be fixed. Now, a medium quality of cow's milk would contain before condensation 3·3 per cent. of fat, and if condensed to one-third its bulk 10 per cent. of fat. Such milk would also contain 8·5 per cent. of solids-not-fat before evaporation, and the condensed substance at least 25 per cent. of solids-not-fat. It has therefore become an established custom of the British Government, in obtaining contracts for the supply of condensed milk for the army and navy, to stipulate that it should contain not less than 10 per cent. of fat and 25 per cent of solids-not-fat. These points were also embodied in a recommendation of the Milk Committee to the Board of Agriculture to make the following a regulation under Section 4 of the Food and Drugs Act, 1899:

"That any condensed milk (other than that labelled 'Skimmed Milk' in conformity with the provisions of Section 2, Food and Drugs Act, 1899) in which the amount of milk-fat is less than 10 per cent., or the amount of non-fatty solids is less than 25 per cent., shall be deemed to be so deficient in some of the normal constitutents of milk as to raise a presumption, until the contrary is proved, that it is not genuine."

Although it is desirable that the amount of cane-sugar added to condensed milk should be limited, there is no regulation upon this point. It should not exceed 33 per cent.; for the greater the proportion of cane-sugar, the lower will be the proportion of milk-solids until they sink below the limit of the above regulation. It usually, however, varies from 40 to 50 per cent. Although no regulation has been made by the Board of Agriculture in respect to the proportion of sugar, the opinion expressed by the Milk Committee was so strong that a penalty has been imposed by the magistrates for selling condensed milk containing 40 per cent. of cane-sugar.

Condensed Milk as a Food.—Unsweetened condensed milk has not been in vogue so long as the sweetened variety, and the public,

having become accustomed to the sweet variety, do not take to it so well. It is, however, supplied largely to the army and navy, and is in great demand in the colonies, and especially for numerous expeditions. Condensed milk is usually put on the market in cans of different sizes, and its manufacture has become an industry of great importance. The addition of preservatives is unnecessary, but some manufacturers add boric acid ; Lloyd reports the presence of 0·10 to 0·17 per cent. in Swiss and English condensed milk. The low proportion of water, and especially the large proportion of sugar, do not favour bacterial growth, and so the milk will keep good for a considerable time after the can is opened without the addition of a preservative.

Under certain circumstances and conditions unsweetened condensed milk has a proper place in dietetics. It can be used in many ways like fresh milk or cream. To bring back such milk to the composition of ordinary cow's milk it requires to be dissolved in twice its bulk of water. Its bulk was reduced from 3 to 1 volume ; it should therefore be raised from 1 to 3 volumes. In such proportion it may form a part of many foods ; it can be used in cookery like ordinary milk, and it is very satisfactory for that purpose, especially in the tropics and in all expeditions beyond the bounds of ordinary civilization.

As regards the use of condensed milk as an infants' food, the writer is opposed to it ; he believes that such milk has lost many of the characteristics of **new** milk, especially by the destruction of lecithin and the bactericidal properties possessed by fresh milk. It is true that condensed milk has the advantage of being sterile, and investigations have shown that the coefficients of digestibility of its constituents are practically the same as those of fresh milk. But its use is by no means so satisfactory as that of fresh milk or pasteurized milk. A prolonged use of it leads to scurvy-rickets and other ailments of the infantile period. Children fed with it have not the stamina which characterizes naturally-fed infants of the same age.

When we consider the amount of condensed milk which should be fed to a child, it should be observed that the recommendation of 1 part of condensed milk to 12 or 14 parts of water reduces it to only 25 per cent. of the strength of average cow's milk. Children fed with such milk are insufficiently fed, and must emaciate. Condensed milk is three times as strong as cow's milk; therefore—

DILUTION OF UNSWEETENED CONDENSED MILK.

Condensed Whole Milk.		Water.		Strength.
1	to	2	=	Cow's milk.
1	,,	3	=	75·0 per cent. of cow's milk.
1	,,	4	=	60·0 ,, ,, ,,
1	,,	5	=	50·0 ,, ,, ,,
1	,,	6	=	45·0 ,, ,, ,,
1	,,	8	=	33·3 ,, ,, ,,
1	,,	9	=	30·0 ,, ,, ,,
1	,,	11	=	25·0 ,, ,, ,,

As the sweetened brand contains about 43 per cent. of cane-sugar in addition to the normal constituents of milk, this must of course be allowed for in making calculations for an infants' dietary.

Powdered Milk—Casein Preparations.

Powdered milk has come into use within recent years, various modes of evaporating the milk and reducing it to a powder which keeps well and is convenient for transport having been introduced. Powdered milk is an article of great utility, especially when fresh milk is unobtainable or when from some peculiar idiosyncrasy sick persons are unable to retain fresh milk. It is also used as a food for infants, and enters into the composition of various proprietary foods. The composition of powdered milk naturally varies according as it is made from entire milk or skim milk, and the origin of the powder ought to be distinctly stated upon the package, because of the great difference in the proportion of fat.

Composition of Powdered Milk—Percentages.

Nutrients.	Skim-Milk Powder.	Whole-Milk Powder.
Water	3·0	6·0
Protein	34·0	33·3
Fat	3·1	12·0
Milk-sugar	51·9	41·7
Ash	8·0	7·0

When a due proportion of water is added to milk-powder, a mixture is formed which closely resembles ordinary milk in appearance and composition, and can be used in cookery and in many preparations in the same way. The flavour depends to a great extent upon the mode of manufacture; in some cases it is almost the same as fresh milk, in others it has a slightly scorched taste, or some other taste distinct from that of milk, which, however, is not sufficiently pronounced to be noticeable in puddings and other cooked materials in which it is used.

The mode of manufacturing milk-powder varies in different establishments. In one method[1] the milk is placed in a tank heated by a water-jacket; heated air is driven through the liquid until it is of the consistence of condensed milk. It is then transferred to a rolling drum, and more hot air driven through it until it is a semi-solid mass. The mass is then broken into lumps and pressed through a sieve to make it granular. The granules are dried and reduced to a powder.

The Just-Hatmaker process is more simple. The machine consists of two revolving cylinders heated by steam to a tempera-

[1] *Journal of State Medicine*, May and July, 1902.

COMPOSITION OF CASEIN AND DRIED-MILK PREPARATIONS—NUTRIENTS PER CENT.

	Water.	Protein.	Fat.	Lactose.	Salts.	Other Substance.	Remarks.
CASEIN PREPARATIONS:							
Plasmon	10·50	80·00	·34	—	7·00	Soda bicarb.	Obtained from skim milk by acetic acid.
Protene	3·75	80·00	—	—	4·37	Ditto	Almost identical with Plasmon.
Biogen	10·00	78·75	1·58	—	4·73	4·04	Casein; free from starch and sugar.
Casumen	7·00	86·47	3·60	—	2·93	—	Casein in flake-like powder; free from starch and sugar.
Tilia	8·51	76·37	·17	—	9·25	5·70	Contains 1·83 P_2O_5 and 11·97 N per cent.
Sanatogen	—	—	—	—	—	5·0 sodium, glycero-phosphates	Excepting for the addition named, they are similar to Plasmon, Protene, etc.
Sanose	—	—	—	—	—	20·0 albumose	
Nutrose	—	—	—	—	—	Soda bicarb.	
Eucasein	—	—	—	—	—	Ammonia	
DRIED MILK:							
Lacvitum	5·34	28·04	29·40	31·36	5·96	—	Dried whole milk.
Galak	—	—	—	—	—	—	Similar to Lacvitum.
Trumilk	·77	26·44	28·00	38·92	5·84	—	Dried whole milk, without starch or preservatives.
Lacumen	9·00	40·00	2·00	39·00	6·25	—	Dried skim milk.
ALBULACTIN	—	95·00	—	—	—	—	The albumin of milk.

ture above 212° F. The milk is continually sprinkled, like a fine spray, over the cylinders, which, revolving in opposite directions, spread the condensing milk in a thin layer over their surface. A layer of solids is thus formed upon each cylinder ; it is removed in thin sheets, dried, and pulverized.

Casein Preparations are used to a considerable extent in the sick-room and by many sufferers from less acute ailments. In addition to commercial casein, there are several valuable preparations on the market, such as Sanatogen, Plasmon, Tilia, Eucasein, etc. One special brand is a fine powder of a pale yellow colour, obtained from skim milk by the precipitation of casein with acetic acid, which is afterwards neutralized by sodium bicarbonate. The dried residuum is said to contain 13 per cent. of nitrogen, estimated by Kjeldahl's method, or 81·25 per cent. of protein. Some casein preparations contain even more than this. They differ in composition from powdered milk, being almost purely a nitrogenous food. Casein preparations are almost entirely absorbed in the alimentary canal, and they are used with considerable success in catarrhal states of the stomach and bowels, acute and chronic, in chronic dyspepsia, in hyperacidity and hypersecretion, gastric ulcer, carcinoma of the stomach, intestinal tuberculosis, neurasthenia, and in all those conditions where hyperalimentation is deemed an essential part of the treatment. Casein preparations and milk-powder can be added to fresh milk in order to fortify it ; it can be used in milk puddings, biscuits, cocoa, and many other foods, in order to increase the actual amount of nutriment being taken by the patient.

Lactalbumin is prepared in a commercial form, and is available for use in the feeding of infants. It is a well-known fact that cow's milk contains much less albumin than human milk does. It is also a fact that the albumin is coagulated by boiling the milk, and the child may thereby be robbed of one of its important elements. If cow's milk is diluted to 1 in 3, the casein is equivalent to that in human milk, but the lactalbumin is reduced to one-ninth that in human milk. This deficiency may be remedied by the addition of commercial lactalbumin to the warm mixture. One of the most popular preparations of lactalbumin is Albulactin.

Cream.

When milk is allowed to remain undisturbed, the globules of fat rise to the surface, owing to their specific gravity being lower than that of the entire milk. The upper layer of milk which has been allowed to stand therefore contains the fat, and is called "cream," and when obtained by skimming is called "gravity cream." But the cream can be separated, as soon as the milk is drawn, by means of the centrifugal cream-separator. Commercial cream is very largely obtained in this way, and is distinguished from the former by the name of "separator" or "centrifugal" cream.

Cream is a yellowish-white opaque fluid consisting of the norma

constituents of milk, but containing a much larger proportion of fat. The colour of cream is due to lactochrome, but annatto is sometimes added by the purveyor in order to heighten the colour or give it a richer appearance. The composition of cream is usually stated to be—Water 74·0, casein and albumin 2·5, fat 18·5, milk-sugar 4·5, ash 0·5, per cent. But the amount of fat varies from 15 to 55 per cent., according to the length of time the milk has been allowed to stand and the care exercised in collecting or centrifugalizing it. Domestically skimmed cream is that which is removed from only a small quantity of milk, and contains from 15 to 25 per cent. of fat, with an average of 18 per cent. Commercial cream, however, is sold in two grades : " Single," containing 24 or 25 per cent. of fat ; and " double," containing 50 or 55 per cent. of fat. Veith found an average of 45·5 per cent. fat in " single " and 53·5 per cent. fat in " double " cream from 716 samples purchased in London ; but the former percentages are now common. *There is no legal standard for cream*, but Wynter Blyth suggests that it should be made illegal to sell anything as cream which contains less than 25 per cent. of fat ; and Pearmain and Moor suggest that the standard should be 45 per cent. of fat.

Separator cream is always sweet and fresh when produced, and therefore needs no preservative. Gravity cream, on the other hand, even when the pans are cooled by being placed in ice-water, is not quite fresh when it is collected ; the milk has been exposed to the air for a varying period, perhaps twenty-four hours, during which *B. lactis* and other micro-organisms multiply in it. Such cream, therefore, does not keep so well as separator cream, although the multiplication of bacteria may be checked by keeping the pans in cold water. Owing to the increased sale of cream in jugs or pots, the " trade " considers it necessary to add to it a preservative in sufficient proportion to keep it sweet for ten or fourteen days. To check the use of too much or too varied preservatives, the Departmental Committee on the Use of Preservatives in Food recommended to the Local Government Board " that the only preservative allowed to be used in cream be boric acid equal to 0·25 per cent." which is practically $1\frac{1}{4}$ grain of boric acid to each ounce of cream. Most dairymen use a mixture of borax and boric acid, but occasionally formalin or salicylic acid are used.

Cream which has been kept on ice or in an ice-house is much thicker than that which has been kept at the ordinary atmospheric temperature. This change gives a fictitious appearance of quality, but the procedure is more or less justified on the ground that cream kept on ice is sweeter than cream kept otherwise. Cream also becomes thicker when it is slightly heated—*e.g.*, in pasteurization—which is due to coagulation of some of the abumin or casein. But cream is sometimes artificially thickened by the addition of albumin, gelatin, gum, or starch, or a solution of lime in cane-sugar syrup (called " sucrate of lime "), which are used to give a fraudulent appearance and the consistence of " double " cream to one which

is comparatively poor in fat, and consequently to obtain for it a price above its proper value. Such thickening may be the ground of prosecution, and in 1900 the Milk Committee recommended the adoption of the following regulation by the Board of Agriculture: "The artificial thickening of cream by the addition of gelatin or other substance shall raise a presumption that the cream is not genuine."

Whipped Cream.—When cream is whipped or beaten, the bubbles which are formed do not readily break, so that it may be beaten until it forms a froth which is almost as stiff as that produced by whipping the white of eggs. If the whipping is continued too long the fat globules separate and form butter; and neither very thin nor very thick cream produces such a good stiff froth as medium cream, which is represented by "single" cream. Several explanations of the property of forming a stiff froth from cream have been offered, but none is entirely satisfactory. It is believed, however, that the property is dependent upon the proportion of calcium, for if a small proportion of saccharated solution of lime be added to a thin cream, which does not form a good firm froth, a better result will be obtained.

Composition of Clotted Cream—Percentages.

	Analyst.		
	Blyth.	Richmond (*a*).	Richmond (*b*).
Milk-fat	65·000	58·20	57·09
Casein	3·500		
Albumin	·500	8·60	6·80
Peptones	·050		
Milk-sugar	1·723		
Water	28·685	32·48	35·54
Ash	—	·71	·57

Clotted Cream, Devonshire Cream, consists of a soft paste of greater density than ordinary cream, and differing from it by containing coagulated albumin and casein. When milk is boiled, a film of coagulated albumin and casein forms upon its surface. The same occurs when cream is boiled, and it is the combination of casein, albumin, and milk-fat, which gives the consistency to clotted cream. Its preparation is as follows: The milk is set overnight in a shallow pan, 9 or 10 inches deep; the next morning the pan of milk is heated on a hot-plate until, in the course of an hour or two, the temperature rises to near the boiling-point. Or fresh milk is exposed during several hours to a more gentle heat; during this period the cream rapidly rises. The albumin, and with it some of the casein, becomes coagulated, the heat driving off carbon dioxide and liberating the lime salts which held the casein in

solution ; the latter then rises to the surface, and is dried by rapid surface evaporation, just as a skin is formed when submitting milk to heat in ordinary cooking. The pans, of which several are set at one time, are put aside to cool, after which the cream is removed by skimming, and put into tins or jars. The cream is sterilized by the mode of treatment, but most makers add some borax and boric acid in the summer-time. There is, however, no necessity for preservatives when the cream is put into tins and hermetically sealed, like condensed milk, and some of the best makers put none.

The analysis of cream is done in the same way as that of milk. It consists of fat *plus* a solution of casein, milk-sugar, and salts of the same strength as existed in the milk from which the cream was derived. The proportion of solids-not-fat in this solution is to the water as 1 : 10, just as in the non-fatty portion of milk. In deciding the question as to whether the cream has been thickened by the addition of gum, gelatin, or starch, Wanklyn [1] says a decided answer in the negative may be given if the ratio of water to solids-not-fat is the same as in the non-fatty portion of milk. If the solids-not-fat be in excess of that in the non-fatty portion of milk, the analysis should be continued, to see if the excess be due to casein. If the cream contains starch, it will give the characteristic blue colour with iodine.

Cream as a Food.—The fuel value of cream depends on its percentage of fat, and is as follows : 18 per cent.=54, 30 per cent.=66, and 58 per cent.=151, calories per ounce. Judging by available data, cream when consumed in large quantities is digested less easily than equal amounts of milk, because of the high proportion of fat ; but the fat of cream, on the other hand, is more easily and thoroughly digested than most other forms of fat. It is for this especial reason that cream is ordered in many cases of ill-health, especially in nervous ailments and wasting diseases, or when the individual is below the average weight. It is more agreeable and better borne than cod liver oil. Most people could consume $\frac{1}{4}$ pint (yielding 372 calories) per day, along with porridge, cooked fruit, puddings, tea, coffee, cocoa, etc. The only objection to cream is its price, which is so high as to make it a luxury to most people. It should, however, be borne in mind that the fat of cream is the same as butter, and that as a general rule butter is more economical, because it contains a much greater percentage of fat.

Junket—Curds and Whey.

Junket is a favourite dish prepared by adding rennet to milk and allowing it to stand undisturbed until it coagulates. It is an important article in invalid dietetics and for more general use, to be eaten like custard with stewed fruit, jam, etc. When the junket is broken up, the casein separates and contracts, and the entire substance divides into **curds and whey.**

[1] "Milk Analysis," p. 51.

One of the most remarkable characteristics of milk is that its chief protein is coagulated by the action of rennin ferment in the presence of a due proportion of calcium salts. If the milk has been deprived of its lime salts, rennin will not precipitate the casein; but the addition of lime salts to a solution of casein previously acted upon by rennin will cause a precipitation of the casein, even after boiling the solution to destroy the enzyme. It is thus shown that rennin changes the character of the casein, but lime salts are essential for its coagulation. Neither the action of rennin nor the influence of lime salts in producing coagulation is clearly understood. But it appears there is a primary action of rennin upon the casein, and a secondary action of lime salts on the casein, and that the change induced by the enzyme is of such a character as to enable the calcium ion to unite with it. The curd formed under the influence of rennin contains a large proportion of calcium phosphate; but according to Söldner calcium phosphate is without any influence in the reaction, which is entirely due to soluble salts of lime.

It was formerly supposed that rennin or chymosin was the same as pepsin. But Hammarsten separated the two ferments, and showed they were different in various respects. Pepsin requires an acid medium for its action, and has not the power of coagulating milk, except in the presence of a comparatively high degree of acidity. Rennin, on the other hand, coagulates neutral or amphoteric milk, whose alkalinity is recognizable. One part of rennin may be sufficiently powerful to coagulate 1,000,000 parts of milk, but it has no appreciable action on albumin. But although rennin is able to coagulate fresh milk or amphoteric milk, it is a fact that the increasing acidity of milk by the production of lactic acid favours the action of rennin, a fact which is taken advantage of in cheese-making.

Rennin is secreted in the stomach of all animals, and especially in large quantities in the fourth stomach of the calf, which is commonly called by dairymen the rennet or "vell." A piece of rennet the size of half a crown will coagulate enough milk to make 60 pounds of cheese, but the actual amount of enzyme in it cannot exceed a few grains. The dried rennet, or vell, is for convenience kept by shopkeepers in cheese-making districts. But many cheese-makers now use liquid rennet, which is made by cutting up the vells into small pieces and macerating them in 5 per cent. salt solution with some boric acid for a few days; it is then filtered, and constitutes liquid rennet or extract of rennet, and is kept at many stores. Such extracts, however, are not always reliable, and are sometimes impure, and are therefore best replaced by solid preparations, such as junket tablets. By using the enzyme in the latter form the milk can be curdled, and a wholesome and nutritious food prepared. Rennin acts most effectively at 100° F.; if the temperature much exceeds this degree, the coagulation will be incomplete, while a lower temperature somewhat delays the coagu-

lation. Thus, milk which would coagulate in ten minutes at 80° to 100° F. would require a few hours to coagulate at 60° F. with the same amount of enzyme, and twelve hours or more if the temperature is only 40° F.; while the temperature of freezing-point absolutely inhibits the action of rennin, whence it happens that iced milk or ice cream will not undergo proper digestion until its temperature approximates that of the body. The use of junket tablets is a great convenience, as milk is readily coagulated by the enzyme at 70° to 80° F., and a soft or gelatinous mass is produced which is highly appreciated as a dessert, and is a useful dietetic article in the sick-room. It should be observed that pasteurized or sterilized milk does not make such a good firm junket as milk which has not been raised above blood-heat, owing to some of the lime salts having been thrown out of solution.

Whey.—Whey can be prepared domestically by the addition of two teaspoonfuls of essence of rennet or a dissolved tablet to 1½ pints of milk warmed to 104° F., and setting it aside until it is firmly coagulated. The coagulum is then gently broken or cut into pieces, and transferred to a muslin or cheese-cloth and hung up to drain. It yields about a pint of whey, which is collected as it drains from the curd.

The reaction between the milk, the enzyme, and the lime salts, having taken place (as described above), the chief protein separates as paracasein, which continues to contract until the milk is completely separated into "curds and whey." Whey is the liquid which exudes from the coagulum or remains after the removal of the proteins and fat in cheese-making. It is a thin, transparent liquid of a pleasant sweetish, subacid taste. It contains most of the soluble protein of the milk (lactalbumin), lactose, very little casein and fat, traces of urea, creatin, and mineral salts. It contains 6 to 8 per cent. of solids. Richmond states that the average composition is as follows :

Composition of Whey.

Lactose	4·45 per cent.
Proteins	1·24 ,,
Fat	·04 ,,
Ash (including CaO=0·051, P_2O_5=0·103) ..	·52 ,,
Water	93·79 ,,

As the coagulum encloses and the contracting curd retains the milk-fat, fresh skim milk does quite as well as fresh whole milk for making whey. The whey can be pasteurized immediately after draining it, and thus preserved from the lactic fermentation and other modes of deterioration.

Whey is a pleasant refrigerant beverage of general utility in the summer months where it is obtainable, and at all times useful in the sick-room during febrile attacks. It is, however, to be especially recommended as a diluent of cow's milk for the feeding of infants. A more general recommendation of its use for this purpose would

lead to its better appreciation. A mixture of equal parts of milk and whey would have the following composition :

Milk-sugar	4·45 per cent.
Proteins	2·49 ,,
Fat	2·03 ,,
Salts	·63 ,,
Water	90·40 ,,

In this mixture the proportion of protein is nearly that of human milk, and the addition of a little *cream* to each feed would bring up the proportion of fat to 3·5 per cent., as in human milk. Besides being of use in the general feeding of infants, it is an admirable temporary food, and may be given alone in cholera infantum and other gastro-intestinal disorders.

The Whey Cure.—As a mode of treatment the administration of whey is recommended for enteric fever, for catarrhal conditions of the alimentary canal, abdominal plethora, auto-intoxications, renal and dropsical affections, chronic phthisis, chronic bronchitis, and laryngeal catarrh.

The value of whey in typhoid fever has long been established, but it has recently been used as a *sole* diet in some cases, being given in doses of 5 ounces every two hours. It is an undoubted fact that many cases of typhoid fever have ended fatally through over-feeding—that is, through giving more milk than the patient could digest, through the bacterial decomposition of such milk, distension of the intestines, the stretching of ulcers followed by hæmorrhage and perforation. It has been observed that when the enteric patient is on *whey diet* such distension does not occur, the passage of undigested milk is prevented, and the serious consequences following a more abundant dietary avoided.

In abdominal plethora, the gastric or intestinal catarrh, and liver troubles, consequent upon high living, the treatment by whey is very beneficial. It is usual to begin by giving a tumblerful morning and night, increasing by one tumblerful daily until 3 to 5 pints are taken in twenty-four hours. It should be taken warm, and may be aerated by the addition of seltzer or soda water. The dietary should consist chiefly of fruit and vegetables, the animal food being correspondingly diminished. Whey diet is also valuable in chronic bronchitis and laryngeal catarrh in certain cases ; but a diet of such low caloric value is not justifiable in phthisis.

Buttermilk.

When butter is made, a fluid remains behind which is similar to whey, and is almost equally useful in dietetics. Buttermilk, however, contains more protein and fat, and its reaction depends upon its source. That derived from " separator cream " has very little if any acidity ; that from " ripened cream " is more acid, but usually only feebly so, and is an agreeable beverage, very suitable as a refrigerant and slight diuretic in feverish conditions, and as an

ordinary beverage for persons who are unable to drink milk, and for the healthy. Its composition varies according to the quality of the cream and mode of making butter. The protein varies from 2·5 to 3·8, fat 0·31 to 1·28, lactose 3·00 to 5·00, and the ash from 0·75 to 0·85, per cent. Wiley[1] gives the following :

Composition of Buttermilk—Percentages.

	From Separated Cream.	From Ripened Cream.
Water	89·74	90·93
Protein	3·28	3·37
Fat	1·21	·31
Sugar	4·98	4·50
Ash	·79	·81
Acidity	nil	·80

The buttermilk from " ripened cream " develops an acid reaction and taste owing to the formation of lactic acid during ripening. The acidity will increase slightly on keeping. It is considered that such buttermilk is preferable to that from " separator cream " in cases of gastric disturbance, because the casein forms fine flocculi which are acceptable to the stomach. Buttermilk contains 8 or 9 per cent. of milk solids. It is deficient in fat, but when used as an infants' food this is sometimes an advantage, especially during temporary disability—*e.g.*, in gastro-enteritis. Buttermilk is of service in infantile atrophy from chronic indigestion or where diarrhœa alternates with constipation. Stoos says it is harmful in acute diarrhœa accompanied by vomiting ; the writer has found whey to be beneficial in such cases.

The following is recommended by Teixero de Matteo[2] as a food for infants : A level tablespoonful of fine rice or wheaten flour is mixed in a litre of buttermilk, which is placed on a stove and constantly stirred until it has thrice been on the point of boiling over—*i.e.*, about twenty-three minutes. Two or three tablespoonfuls of sugar are now added, and the food is placed in a Soxhlet's sterilizer, each " feed " being in a separate flask, and boiled for three minutes. As the buttermilk is acid, especially when derived from ripened cream, it should not be cooked in metal utensils which are liable to be affected by the acidity.

Fermented and Sour Milk.

When milk is drawn from the cow it has an exceedingly slight acid reaction, being amphoteric, but it becomes more and more acid on exposure to the air, owing to the development therein of various acid-producing bacteria. One of those most commonly found in such milk is Hueppe's lactic acid bacillus, an organism

[1] " Foods and their Adulteration."
[2] *British Medical Journal*, 1906, i., Epit. 98.

1·0 μ long by 0·004 μ broad, which multiplies rapidly in milk at temperatures between 10° and 45° C. (50° and 113° F.). This bacillus secretes enzymes, lactase and endolactase, which transform the milk-sugar first into dextrose and galactose, and then into paralactic and lævolactic acid. This transformation of sugar into lactic acid goes on continuously until the acid attains a proportion of about 1 per cent., which checks the multiplication of the bacteria and production of the enzymes. In the meantime the milk becomes sour and coagulates spontaneously, the coagulum forming a solid mass of casein which slowly contracts and squeezes out the whey in the form of a greenish-yellow fluid. Hueppe's bacillus is not the only lactic-acid-producing organism; quite a number have been described, including bacilli, micrococci, streptococci, and staphylococci, all of which produce lactic acid from, or in the presence of, sugar, and whose multiplication is checked by the rising acidity.

The most important application of lactic fermentation is in butter and cheese making; but this is not its only use. In the United States sour milk, or **clabber,** is an article of diet commonly used in some parts, which is exceedingly nutritious, wholesome, and, to those accustomed to it, very refreshing and palatable. No special method is adopted in the production of clabber; the milk is allowed to coagulate spontaneously, although it is recognized that when the fermentation goes on too slowly, and a considerable time is occupied before coagulation occurs, the clabber may have a bitter or unpleasant taste. In order to hasten the coagulation, people who use clabber regularly inoculate the fresh milk with some of that previously soured.

In some countries, such as Russia, Tartary, Bulgaria, Roumania, Turkey, Arabia, and Egypt, various other sour-milk products have been used as articles of diet from time immemorial. These foods or beverages contain lactic acid and a little alcohol, the result of the lactic fermentation. The best known are as follows—**Koumiss**: The fermented milk of mares or asses, used largely by the Tartars, Kirghis, and other nomadic races of people in the steppes of Russia, and less commonly by the inhabitants of Moscow and St. Petersburg. **Kephir**: The fermented cow's or goat's milk largely used by the inhabitants of the Caucasus. **Yaourte** and **Leben**: Yaourte (Youghourt) is the Turkish name applied to the fermented cow's milk commonly eaten all over the Levant. Leben is the Arabian name for milk, but it is also applied to fermented milk in Egypt and the surrounding countries.

The presence of sugar in milk enables it to undergo alcoholic fermentation by the action of certain saccharomycetes. Lactose, however, is not fermentable by pure yeast (*Saccharomyces cerevisiæ I.*), but it is fermentable by other varieties of yeast and by certain bacteria, which first of all split the lactose into dextrose and galactose, as previously indicated. The manufacture of koumiss, kephir, and leben, are conducted on this basis. Both lactic acid and alcohol are produced; the alcohol rises to 10 or 30 per 1,000, the

lactic acid to 10 or 20 per 1,000, and a considerable amount of CO_2 is evolved from the destruction of sugar.

Kephir is made by means of kephir grains, which contain a special ferment. The mode of its preparation is as follows: Goat's milk is put into a sheepskin bottle, and coagulated with a piece of calf's or sheep's stomach. The bottle is agitated from time to time, more milk being added as the former coagulates. In the process of time yellowish bodies of a seed-like character, and about the size of a pea, are formed in the mass. These are the kephir grains or nuts, whose formation is essential for the production of the beverage. When about to make kephir, one of these grains is soaked in a small quantity of milk until it swells or is "ripe." The ripened "grain" is then put into the milk, previously warmed, which is to be fermented. Lactic and alcoholic fermentation begins in a few hours, and is allowed to proceed from one to three days.

Commercial Kephir, according to Zuber,[1] is made as follows: A teaspoonful of the ferment is added to a bottle of milk, which is maintained at the temperature of 15° R. (65° F.) for twenty-four hours, being frequently agitated. It is then filtered, the casein being broken down, transferred to another bottle, securely corked, and agitated for another twenty-four hours. It is then filtered and transferred to another bottle, and at the end of the third day forms a strong kephir. It should be free from coagula of casein, foam abundantly on removing the cork, and have a creamy consistence.

What is the fermentation due to? Sclotorsky considers it is due to the enzymes derived from the piece of stomach originally used. But in the light of more recent knowledge it must be admitted that bacteria have great influence, and that the active enzymes are produced by bacteria. The chief micro-organism found in kephir is the *Leptothrix dispora caucasica*, with which is associated *B. lacticus* (various types), *B. butyricus*, and "wild-yeasts" (various forms of *Saccharomyces cerevisiæ*). The object of the koumiss or kephir maker is to encourage vinous and restrain lactic fermentation. Mare's milk contains more lactose, but less casein and fat, than goat's milk, whence the preference for the former in making koumiss. Cow's milk is too rich in casein and fat to make a good koumiss; it should be skimmed or diluted before fermenting it. The milk, whatever its origin, is more or less changed in the process. There is a slight loss of protein owing to peptonization, and a considerable loss of sugar by transformation into alcohol, lactic acid, and carbonic acid gas. The production of alcohol amounts to 1 or 2 per cent., and lactic acid from 0·3 to 1·0 per cent. The lactic acid causes the casein to be precipitated in very fine particles, which include lactalbumin, and a small amount of proteose, albumose, and peptone. A very little fat also becomes disorganized, resulting in the production of fatty acids and butyric acid; when the beverage is made from cow's milk, the amount of the latter may be sufficient to render it unpalatable.

[1] *Gaz. Hebdom. de Méd.*, 1885.

In Europe and America a similar beverage is made by the fermentation of cow's milk with yeast, and is indifferently called "kephir" or "koumiss." But cow's milk does not contain sufficient sugar to permit of fermentation in this manner without reducing the saccharine content below the point esteemed desirable for palatability. It has therefore become the custom to add some milk-sugar, cane-sugar, honey, extract of malt, or about 2 per cent. of wheat flour, to the milk. When these substances are added, koumiss can be prepared from cow's milk in the manner indicated above, or by fermentation with ordinary yeast. The following recipes are suitable :

I.

Milk	1 pint.
Brown sugar	10 grains.
Extract of malt	1½ ounces.
Compressed yeast	20 grains.

II.

Milk	16 ounces.
Water	4 ,,
Brown sugar	2½ drachms.
Milk-sugar	4 ,,
Compressed yeast	30 grains.

The yeast and sugar are rubbed together with a little milk until a solution is formed ; then the extract of malt is rubbed into it (when that substance is used). The milk is warmed, the foregoing mixture strained and added to it, and the whole put into a strong glass bottle, corked and wired. The bottle is inverted, and kept at a temperature of 55° to 60° F. for two or three days. It should be agitated daily to prevent the precipitate from forming a dense coagulum, and to enable the ferment to permeate the mass. The milk becomes sour after a few days, and forms a pleasantly acid, thick, creamy, foaming liquid. It should be agitated before being poured out, to insure a mixture of all the ingredients. The composition is as follows :

Composition of Kephir and Koumiss—Percentages.

	Kephir.		Koumiss.	
	Cow's Milk (Tuschnisky).	Goat's Milk (Hammarsten).	Mare's Milk (Fleischmann).	Cow's Milk (Sharp).
Water	89·970	88·915	91·53	91·970
Fat	2·000	3·088	1·27	1·943
Casein	3·800	2·904	1·91	2·340
Lactalbumin		·186	—	·540
Peptones		·067	—	·260
Sugar	·900	2·686	1·25	2·500
Mineral salts	·650	·708	·29	·210
Alcohol	·800	·720	1·85	1·060
Lactic acid	1·026	·727	1·02	·567
CO_2	—	—	·88	·610

Leben or **Yaourte** is made by coagulation of milk with a special ferment, called "maya," in the following way: Cow's milk is evaporated by boiling milk to half its volume. It is cooled to 45° C. (113° F.), and inoculated with maya ferment. The vessel is then surrounded with flannel to maintain the temperature of the liquid at about 20° C. (68° F.) for eight or ten hours. It is then cooled, and is ready for consumption. It is a thick, creamy, pleasantly acid fluid, containing masses of coagulated casein, considered very agreeable by those accustomed to it.

The maya ferment contains the following bacteria:

Streptobacillus lebenis, or the Bulgarian bacillus of Massol.
Streptococcus lebenis, a diplococcus.
Bacillus lebenis, a minute organism.
Saccharomyces lebenis } yeasts.
Mycoderma lebenis }

These bacteria are all harmless. The two first named are lactic-acid-producing organisms, and contain an enzyme which coagulates milk in a similar manner to rennin or lab-ferment of the stomach. The action of the small bacillus is not clearly understood, but it takes no active part in the production of lactic acid. The two yeasts produce a small amount of alcohol, and certain aromatic bodies which give to leben a delicious fragrance and characteristic taste.

The *Streptobacillus lebenis*, sometimes called the "Bulgarian bacillus" or "bacillus of Massol," is the most powerful lactic-acid-producing organism known to exist. It is the chief factor in the formation of leben. In combination with the other bacteria named it forms the ferment maya. This ferment acts upon each of the constituents of milk, but in different degrees of intensity. Thus, about one-tenth of the casein is peptonized, and a still larger portion rendered soluble; a small portion of the hydrolyzed casein is used for the formation of the new cells of the ferment. A very small portion of the fat is saponified, and if the fermentation be prolonged some butyric acid is produced. Most of the lactose is hydrolyzed by means of the enzyme lactase or endolactase. As in kephir, the lactose is first split into dextrose and galactose; the dextrose and galactose are then more or less split into paralactic and lævolactic acid, the former predominating.

The composition of leben is as follows: Water 89·00, fat 3·0 to 3·75, casein 3·0 to 3·25, peptones 0·25 to 0·45, lactose 1·25 to 2·5, alcohol 0·5 to 1·0, lactic acid 1·0 to 1·25, succinic acid 0·005, formic acid a trace, per cent.

Leben or yaourte is very easily prepared by means of the maya ferment; the only inconvenience is the possible introduction of undesirable bacteria or such as are of a harmful nature. Leben is not only a food, it is the best and most agreeable mode of introducing the lactic-acid-producing organisms into the human system. This consideration has led to the culture of the pure bacteria, or a mixture of those best suited to the production of leben, which are

obtainable from various institutions. It might be argued that *ordinary* sour milk would probably answer the same therapeutic purposes as a properly-prepared leben. The reply to this is, that in spontaneously curdled milk both the lactic and alcoholic fermentations are an unknown quantity. There is also no guarantee against the introduction of undesirable organisms, but, on the other hand, ordinary sour milk has been found containing bacteria of the colon group, *B. enteritidis sporogenes*, staphylococci, and other pathogenic organisms. It may therefore be concluded that ordinary sour milk is unsafe. On the other hand, the Bulgarian bacillus is greatly superior to ordinary lactic acid organisms, and is better adapted for growth in the alimentary canal. Leben carefully prepared from a pure culture of the bacteria found in leben or yaourte will be free from undesirable organisms, will have undergone the desired changes, and contain a sufficiency of lactic acid and the organisms producing it to have a therapeutic effect. With such cultures leben is prepared in the following way :

1. Fresh milk, free from preservative, is boiled for a few minutes to sterilize it ; it is allowed to cool to 104° F., the film on its surface is removed, and it is inoculated by addition of the culture in solution.

2. The milk is now placed in a Thermos flask, previously warmed, corked and wrapped in a flannel, and laid aside for eight or ten hours. It will then be found that the milk is curdled and pleasantly acid ; when quite cold it is ready for consumption. Various " warm chambers " are sold wherein the temperature of the milk can be maintained during fermentation. The vessel in which the milk is fermented must be kept scrupulously clean, filled with an alkaline solution—*e.g.*, sodium bicarbonate—when not in use, and carefully rinsed with boiling water to free it from alkali immediately before being filled with the milk.

Milk which is properly prepared will keep good for about two days. It becomes more and more acid, the lactic acid increasing from 1·05 per cent. in four hours to 1·638 per cent. in fifty-four hours. According to Frouard, a litre of milk contains 10·3 grammes lactic acid after four and 16·38 grammes after fifty-four hours' fermentation. The temperature at which the milk is kept influences the production of the acid, more being produced at 80° than at 68°, and the greatest proportion by incubation at 104° to 110° F.

Sour milk or leben can be prepared by means of various commercial tablets and liquids, which, however, contain a varying proportion of the requisite bacteria.

The period over which the fermentation should be allowed to extend varies according to the temperature at which the incubation proceeds ; it is usual to allow the fermentation to continue four or five hours when a high temperature is used, and eight or ten hours when a low temperature is used. Attempts have been made to extend the period of fermentation ; but although this results in lactic acid being increased until it checks bacterial growth, the

result is not satisfactory from a dietetic point of view. After thirty-six hours the butyric fermentation is liable to set in, by which means both lactic acid and fatty acids are decomposed, butyric acid being produced, and the milk made more or less unpalatable.

The Therapeutic Uses of Sour Milk.—1. **As a food** all forms of sour milk can be used in diabetes, being more or less free from sugar, except when sugar has been added to the milk. It may be given in gout, not only because it is free from purin bodies, but because it reduces the formation of purins and toxins from other nitrogenous foods. It is serviceable in Bright's disease by reason of the diuretic action of lactic acid and lactose, and the absence of irritating substances; in arterio-sclerosis and the presclerotic stage marked by high arterial tension; in entero-colitis, muco-membranous colitis, dysentery, sprue, and chronic diarrhœa; in furunculosis, carbuncles, eczema, chronic urticaria, acne, etc.; in malnutrition from any cause, especially tuberculosis.

2. **As a remedial agent** the lactic-acid-producing organisms in sour milk have a twofold action. Firstly, that of producing lactic acid, which has a definite therapeutic action. It exercises an antiseptic action throughout the alimentary canal, and assists in checking the growth of various pathogenic and putrefactive organisms. This action has long been known, and lactic acid in various ways has been used by Dujardin-Beaumetz, Hayem, and others, in the treatment of enteric fever, intestinal tuberculosis, diarrhœa, dysentery, cholera, and other diseases of the intestinal canal. But lactic acid in a nascent condition is endowed with more activity as an antiseptic than commercial lactic acid, which gives the sour-milk treatment an advantage over ordinary lactic acid. It has also a local effect on the mucous membrane, which is esteemed beneficial in the treatment of ulcerative surfaces, entero-colitis, etc., and a *reflex* action by which it stimulates the biliary and pancreatic secretions. Secondly, by the repeated administration of sour milk, especially that containing the Bulgarian bacillus, the lactic-acid-producing organisms gradually replace the putrefactive or pathogenic organisms, thus driving out one class of bacteria by means of another. This occurs partly because the lactic-acid-producing organisms use up some of the carbohydrates. By means of sour milk the intestinal fermentation and the bacteria which cause it can be effectually controlled, as shown by the decreasing amount of indican in the urine.

The sour-milk treatment has been effectively employed in the following cases: (1) *Diseases due to bacteria:* Infantile diarrhœa, green-stool diarrhœa, gastro-enteritis; dysentery, sprue, tropical and other forms of chronic diarrhœa; ulcerative and muco-membranous colitis; intestinal tuberculosis; typhoid fever. (2) *Diseases resulting from fermentation:* Dilatation of the stomach, flatulence, pyrosis, regurgitation; auto-intoxication, arterio-sclerosis and its prevention, Bright's disease, cirrhosis of the liver; skin diseases, eczema, erythema, chronic urticaria, boils, carbuncles.

(3) *Diseases due to constipation* and disturbances of the alimentary secretions : Constipation, fæcal stasis ; gall-stones, pancreatic diabetes. (4) *Constitutional states :* Gout, gravel, diabetes, chronic rheumatism, rheumatoid arthritis, tuberculosis. In colitis and entero-colitis the internal administration of sour milk is sometimes aided by enemata consisting of whey containing a culture of the lactic acid bacteria. In ulcerative conditions of the mucous membrane a " cure " depends largely upon the constitutional condition ; but reports of treatment are good, the ulcers being put into a favourable condition for cicatrization, and the general condition of the patient improved. The results of treatment of enteric fever by sour milk are very promising, and it has been used in many hospitals. In intestinal auto-intoxication the cause is removed and the sequelæ prevented. In most of these diseases the general diet of the patient must be duly considered, and in those of a chronic form the lacto-vegetarian diet appears to be well suited.

CHAPTER XI

CHEESE

CHEESE is a very ancient form of food. Its date and mode of origin are lost in the mists of antiquity. Its manufacture was practised by Jews, Greeks, and Romans, thousands of years ago, and probably by the people of more ancient nations. Hippocrates, Aristotle, Cæsar, Pliny, and other ancient literary men, mention it. As a storage food, it has probably been of value to nomadic tribes in all ages. Its preservation and concentration permit of its being stored or readily transported in the many circumstances calling for the storage or transportation of food materials from place to place. Its manufacture probably arose through the accidental curdling of milk and the bacterial activity which occurs in the subsequent changes. The coagulation of milk is usually due to lactic fermentation or the action of the rennin enzyme. The stomach of various animals was, and in some countries is still, commonly used as a vehicle for the storage and transport of liquids. It is possible that the discovery of cheese was an accident arising out of the storage of milk in stomachs which were too fresh, or were not properly freed from mucous membrane. Aristotle and Hippocrates, however, speak of milk being curdled by the juice of figs, which also rank as a food of great antiquity. But in whatever way the discovery and early use of cheese was brought about, it has been known for ages; and the great proportion of protein and fat contained in it entitle it to a high rank as a food material.

Cheese-making.—It is unnecessary to repeat all that has been said in the preceding chapter about the action of rennin upon milk. Cheese-making, however, depends upon the activity of rennin, chymosin, or lab-ferment, as the enzyme has been called. Added to milk this enzyme precipitates the casein in the form of a large toughish coagulum, which, when cut or broken into pieces, continues to contract until the milk is divided into "curds and whey." A piece of the vell or rennet (which is the fourth stomach of the calf) about $1\frac{1}{2}$ inches or 3·75 centimetres diameter is said to coagulate enough milk to make 60 pounds of cheese. A better conception of the coagulating power of the ferment can be formed from the use of extracts. Söldner extracted the dried stomach of a calf, and obtained a greyish-brown powder, which at a temperature of 35° C. (95° F.) was able to coagulate one million times its weight of milk. On further examination the powder was found to contain 36 per cent. of pure rennin or lab-ferment, whence it was calculated that one part of the enzyme will coagulate three million times its weight of milk. In cheese-making it is customary to use 1 part of ordinary rennet (vell) to 10,000 parts of milk, and the rennin is extracted by infusion of the vell in warm water. Rennet extracts are also

used. The latter are made and sold commercially of such strength that 1 part of extract will coagulate 1,000 parts of milk. The action of rennet is influenced by various circumstances, whence it is usual to try the extract or infusion on a small amount of milk. The proportion of enzyme is not the only important point. It must be obtained from *fresh* stomachs. An inferior solution will communicate bad properties to the cheese. The temperature of the milk is also important. A high proportion of fat necessitates the use of a large amount of rennet. An excess of rennet causes the curd to be less adhesive, but tougher and drier ; it communicates an unpleasant flavour, and the cheese does not ripen so readily.

According to Hammarsten, rennet acts quite independently of milk-sugar, but the presence of lime salts is essential, and a fluid of a slightly acid reaction favours its action. The temperature most favourable to the enzyme is 30° C. (86° F.), but cheeses are made at temperatures varying from 18° to 35° C. (65° to 95° F.) ; a temperature of 60° C. (140° F.) destroys the enzyme. The coagulation of milk only occurs in the presence of lime salts, and the process is considered by Hammarsten to resemble the clotting of blood. The casein of milk is in a colloidal form ; casein proper is an acid, lime is a base, and paracasein, which is the coagulum resulting from the action of rennin, is a salt formed by the union of casein and lime.

The Influence of Lactic Acid.—Rennin alone is not sufficient for making a good cheese. A certain proportion of lactic acid is desirable ; it favours the action of rennin, and is essential for the future ripening of the cheese. Lactic acid develops, during the "ripening" of the milk previous to cheese-making, owing to the transformation of lactose into lactic acid by various bacteria. There are more than 200 dairy bacteria, and about 100 which produce lactic acid ; but, according to Kozai, the bacteria most commonly concerned are the *Bacillus acidi paralactici* (the same as the *B. acidi lacticus* of Esten), *B. acidi lævolactici* (an aerogenic bacterium), and a micrococcus. The two former vary from 1·3 to 1·6 μ in width, and 2·0 to 2·5 μ in length. The products of their activity are lactic acid, acetic acid, traces of salicylic acid, and alcohol. The development of the acid is favoured by raising the temperature of the milk to 29° C. (84° F.), and keeping it uniform for some time. The amount of lactic acid produced naturally varies, but there is an *optimum* for cheese-making, which appears to be about 0·2 per cent. If the proportion exceeds this amount, the final result is not so satisfactory. If it is less, the milk is not "ripe," and does not coagulate with the necessary rapidity. When the normal production of lactic acid is slow, or bacterial activity appears to be insufficient, it is customary in large cheese factories to use a "starter." The latter consists either of some previously ripened milk, or sour milk, or a liquid containing a pure culture of the bacteria. Milk is said to be "ripe" when upon testing it a small quantity will coagulate with rennet in about a minute.

Differences between Rennet-Curd and Acid-Curd.—If the lactic acid fermentation is allowed to go on long enough, it will, as we have seen in the preceding chapter, ultimately convert the milk into "curds and whey." But there is a difference between curd produced by rennet (rennet-curd) and that produced by acids (acid-curd). Rennet-curd is an elastic substance, scarcely soluble in water, and not sticky or greasy in the least degree, and the calcium salts are chemically combined with it. Acid-curd is not elastic, it is sticky and greasy (contains more fat), and is less soluble in water; it only contains a small quantity of calcium phosphate, the latter being mostly dissolved out by lactic acid. Rennet-curd is only slightly acid; acid-curd is strongly acid. Acid-curd is not so suitable for cheese-making as rennet-curd, because its constitution is less favourable to the growth and activity of the necessary bacteria. Acid-curd undergoes changes which proceed from without inwards, and tend to putrefaction. Rennet-curd is essentially favourable to the growth and activity of bacteria, and it ripens throughout the whole simultaneously.

CHEESE-MAKING.

Variety of Cheese.	Temperature of Milk (Degrees F.).	Time of Coagulation.
Cheddar	84	45 to 50 minutes
Cheshire	84	60 ,,
Leicester	78 to 84	90 ,,
Stilton	80 ,, 90	50 ,,
Wensleydale	84 ,, 88	60 ,,
Gorgonzola	77 ,, 90	15 ,,
Edam	84	15 ,,
Pont d'Évêque	88	15 ,,
Parmesan	77	20 to 30 ,,
Gruyère	65	30 ,,
Port du Salut	86	30 ,,
Camembert	80	2 hours
Brie	82 to 86	2 to 4 hours
Neufchâtel	90	2 ,, 4 ,,
Gervais	65	8 ,, 12 ,,
Cantal	90	1 hour
Gouda	93	½ ,,

The process of cheese-making by the Cheddar method consists of—(1) Setting the milk, (2) cutting the curd, (3) heating the curd, (4) removing the whey, (5) cheddaring the curd, (6) milling the curd, (7) salting and pressing the curd, (8) curing the cheese, (9) ripening the cheese.

Setting the Milk.—As soon as the milk is "ripe," it is coagulated, or "set," by stirring into it a proper proportion of rennet. The amount of rennet varies with the character of the cheese. To make a quick-curing cheese enough is added to coagulate the mass of

milk in fifteen to thirty minutes, and to make a slow-curing cheese enough is added to set it in forty-five to ninety minutes. The commercial extract of rennet is used in the proportion of ½ to 5 fluid ounces for each 100 pounds, or 12 gallons, of milk. It is mixed with twenty to forty times its bulk of water at 85° to 95° F. The temperature of the milk is raised to between 80° and 90° F., according to the variety of the cheese; it is then stirred to insure a uniform mixture of the cream; the rennet and some sour whey (containing lactic acid bacilli) are added, and the agitation of the milk continued for a few minutes—in fact, until the coagulum is partly formed. It is now covered to prevent it cooling too rapidly, and is left undisturbed until the coagulum becomes solid. The time occupied in coagulation varies with the temperature of the milk and proportion of rennet. In the West of England the milk is usually set at 85° F. in the autumn, and 90° F. in the spring; in Scotland a temperature of 84° F. is usually employed. The table by Professor James Long, on the previous page, shows the temperature of the milk usually employed when the rennet is added, and the time occupied in the coagulation of milk.

The after-treatment of the coagulum is important.

Cutting the Curd.—The coagulum contracts until there is a separation of the milk into curds and whey. In cheese-making the separation is hastened by cutting or breaking the curd into small pieces. The time at which cutting is performed varies with the variety of cheese to be produced, but with cheddar it is usually about an hour after setting the milk. It is, however, governed by the condition of the curd, which an expert maker knows by the feel of it, and the cleanliness with which it leaves a finger pushed into it at an angle of 45°. If the curd is cut too soon there will be a loss of fat, and therefore a decrease in the value of the cheese. If the contraction is allowed to go on too long, the curd becomes hard, and the whey does not leave it so readily; the quality of the finished cheese is also in this case inferior. The curd is broken into pieces of ½ to 1 cubic inch in size. These are put into a tub or vat, surrounded by cheese-cloths, and as they contract the whey is pressed out and escapes.

Heating the Curd.—After cutting, the curd is slowly heated until it attains a temperature of 98° to 100° F., at which it is maintained for about forty minutes. This process favours the development of lactic acid, the action of which produces changes in the curd. It is known to be sufficiently "cooked" when a portion of curd pressed in the hand falls apart again upon relaxing the pressure, or when a small portion, squeezed dry by the hand and pressed against a hot iron, leaves behind it on separation a few silken threads about one-eighth of an inch long. It is now ready for use, and the **whey is drawn off.**

Cheddaring the Cheese.—This process takes its name from the fact that it originated in the manufacture of Cheddar cheese. It is, however, now used in making many kinds of cheese, but its

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application is not universal. After the whey is drained off, the cubes of curd are left at the bottom of the vat until they become matted together again. Sometimes, moreover, the curd is removed from the vat into a proper curd sink. When it is matted together and formed into a solid mass, it is cut into blocks about $8 \times 8 \times 12$ inches in size. These blocks are turned over repeatedly, to favour the escape of whey, and afterwards piled upon one another in columns, so that the whey may be eliminated by gravity and pressure. Two objects are obtained by cheddaring the cheese: (1) Whey is expressed ; and (2) the lactic acid continues its chemical action upon the curd until the mass is changed from a tough, spongy, rubber-like substance to a soft, smooth, velvety, and plastic material.

Salting, Milling, and Pressing the Curd.—It is again broken down, mixed with about $2\frac{1}{2}$ per cent. of dry salt, warmed to about 70° F., and ground in a mill to insure the proper mixture of the salt and uniform consistence of the curd. It is then put into cylindrical moulds, and subjected to a pressure of about one ton for several days.

Curing the Cheese.—Being removed from the moulds, salt is rubbed into the exterior of the cheese in order to form a rind. Each cheese is bound round with linen. They are kept in a cool, moist room, where they are turned over daily at first, and afterwards three times a week, to insure the even permeation of moisture, the exterior being now and then rubbed over with a little butter. The curing process would proceed more rapidly in a warmer atmosphere, but at the end the cheese would not have the excellent character which denotes a cheese ripened under proper conditions. Experience has shown that an atmosphere having a temperature of 55° F., and a moisture equivalent to 65 or 75 degrees of saturation, gives by far the best results. But when *cured* at this temperature the ripening occupies a longer period to produce a superior quality of cheese, having a firm, solid body, a smooth and velvety substance, with a proper odour and flavour. It is then kept in a cellar with suitable and even temperature, where it becomes ripened, and is ready for use in two to four months. The changes which it undergoes are described below.

The Yield of Cheese.—The quantity of cheese obtained from a gallon of milk has a direct relation to the proportion of fat in it. In the New York experiment stations the yield of cheese varied from 0·97 to 1·45 pounds, or an average of 1·23 pounds per gallon of milk. The amount of cheese obtained is proportionate to the amount of fat, and the latter always bears a definite ratio to the casein. The solid matter in the cheese is approximately 50 per cent. of the solids in the milk ; the whey retains the sugar, some fat and albumin. According to Long, 100 pounds of milk containing 3·5 per cent. of fat yields 9·1 pounds of cheese, and 9 per cent. of the fat is left in the whey ; if the milk contains 5 per cent. of fat, 100 pounds will yield 13·6 pounds of cheese, and only 6 per cent. of

fat remains in the whey. But the losses in cheese-making—that is, the quality of the whey—varies according to the season.

WHEY FROM 100 POUNDS OF MILK (PROFESSOR JAMES LONG).

Fat.		*Casein and Albumin.*	
June	·28 per cent.	April	·640 per cent.
September	·42 ,,	October	·850 ,,
Average	·35 ,,	Average	·745 ,,

The Ripening of Cheese.—Cheese contains the proteins and fat, a small proportion of sugar, and mineral substances from the milk. The coagulation of the milk, whether brought about by rennin enzyme or lactic acid enzyme, is followed by changes in the material, called *ripening*. These changes are due to the action of other enzymes upon the substances in the cheese. Milk is normally rich in *catalases*, or unorganized ferments; it also contains the enzyme called *lipase*, and a proteolytic enzyme called *galactase*. These enzymes produce chemical changes in the constituents of the cheese, which are of special importance in the later stages of ripening. Russell and Babcock claim that the ripening of cheese is entirely due to these normal enzymes of the milk. But Bockhoet and De Vries have shown that it is difficult to get a cheese to ripen without the presence of bacteria. When cheese is made of milk under perfect aseptic conditions, during the collection and cheese-making, only a few bacteria gain entrance to it. Such a cheese contains all the normal enzymes of the milk, and differs from cheese made the ordinary way only in the absence of bacteria. But it does not undergo normal ripening, whence it must be concluded that the ripening of cheese is chiefly due to the influence of bacteria, and that the changes are produced mainly by bacterial enzymes.

Bacteria flourish in milk and cheese. The number in 1 gramme of cheese varies from 500,000 to 100,000,000. They vary according to the period of ripening and the kind of cheese. Adametz found 90,000 to 140,000 in 1 gramme of fresh cheese, 850,000 in 1 gramme of Swiss cheese, and 5,600,000 in 1 gramme of House cheese. Freudenreich found 1,800,000 bacteria in 1 gramme of fresh cheese. These numbers are compatible with the number of bacteria which are found in milk within a few hours of milking. They, however, are not distributed uniformly throughout the cheese, but are more abundant in some parts than in others. Studies of normally ripened cheese, from the first day after making until it is fully ripened, show that the multiplication of bacteria in cheese is slow, as compared with their multiplication in milk or cream. In cream the bacteria increase from 600- to 1,000-fold in twenty-four hours. In cheese their development is so slow that in one case observed the bacteria were multiplied only sixty-fold in eighty-five days, and in another case 180-fold in twenty-eight days.[1] The maximum number of bacteria is present when the cheese is taken

[1] Farmers' Bulletin, 29, p. 20, U.S. Department of Agriculture.

out of the press. They do not increase with the age of the cheese, but diminish, at first rapidly, and more slowly as the cheese ripens. The number of organisms becomes less and less ; at the end of ripening it is very much smaller than in the middle of the period, and in fully ripened cheese the number is sometimes nearly the same as in the original milk. The number of bacteria in cheese is influenced by the temperature at which it is kept ; thus, if the cheese is taken from a room of low temperature (about 24° F.) to one in which it is about 60° F., the number of bacteria declines more rapidly than if it remains at the lower temperature. The decline of the bacteria is believed to be brought about by the development of enzymes, for as the proportion of the enzymes rises the number of bacteria diminishes.

Source of the Bacteria.—The milk contains an immense number of bacteria when it arrives at the cheese factory, and these continue to multiply by a rapid progression. In addition, the bacteria in a cheese factory probably impregnate most of the utensils ; and, unless they are boiled or otherwise disinfected, such articles as cheese vats must be a prolific source of infection. The rennet is also an important source of bacteria, and is considered to be the direct means of inoculating the milk. It has long been recognized that rennet from one source may produce different results during ripening from those produced by rennet from another source ; such variations are probably due to different types of bacteria.

Whether the normal ripening of cheese depends upon the presence of a single species or several species of bacteria, whose combined activity results in the production of specific changes, is unsettled. The idea is becoming prevalent that different types of cheese owe their flavour and other peculiarities to special kinds of bacteria ; and if we could inoculate milk with this or these species, we should always produce a definite result. But this idea at present rests on inference, and not on demonstration. It appears certain, however, that a particular locality is more favourable than another to a special kind or type of cheese, and that such a cheese can be invariably produced. The deduction is that the locality is favourable to the existence of certain bacteria, whose activity produces the particular changes and flavour in the cheese. Experience supports this idea in so far that, when a new cheese factory is started, the factor takes the precaution to rub the shelves, vats, and other new utensils, with old cheese, in order to infect them with the organisms desirable for ripening the cheese.[1]

It has been proved that the same bacterial flora does not always produce in cheese the same results. *Environment* plays a part in cheese-making. This is a complex condition, including locality, temperature, and various physical conditions, which together combine to make up the particular environment essential for the production of special varieties of cheese. Special cheeses are the products only of certain localities. It would be thought that, given

[1] Farmers' Bulletin, 29, p. 21, U.S. Department of Agriculture.

the same material, bacteria, enzymes, and temperature, it would be possible to produce the same cheese in any part of the world ; but apparently it cannot be done, although Neufchâtel, Gorgonzola, Parmesan, and others, are now made elsewhere than in their place of origin. There is something in the conditions which cannot be transferred from one place to another. The cheese of certain localities has properties and qualities which defy production elsewhere, which give characters to the ripened article that distinguish it from imitations of the same material made in other localities.

Changes during Ripening.—The cheese gets richer in fat owing to changes in the protein ; the protein decreases in proportion, some becomes soluble ; various aromatic bodies and extractives are developed ; there is also a slight decomposition of fat and a constant loss of water. Fresh cheese has an acid reaction, but ripened cheese is alkaline. There is a generation of a small amount of ammonia, the proportion of which, as well as that of lactic acid and free fatty acids, varies as the ripening goes on. The changes in the protein are chiefly responsible for the production of the aromatic and odoriferous substances.

The changes in the casein are brought about by various bacterial enzymes, which are not yet thoroughly understood. These enzymes have been called **casein ferments** ; one of them has been isolated by Duclaux, who called it **casease.** The source of these enzymes is not definitely settled. Duclaux, however, believes that they are derived from bacilli which grow upon hay and potatoes. They form a group of eight or nine species, to which he gave the name of **Tyrothria.** They have the power of coagulating milk by the production of an enzyme like rennin. One of the best known is the *Tyrothrix tenuis,* which was investigated by Duclaux. Another rennin-like enzyme was obtained in the form of a powder by Conn. These enzymes play an important part in the ripening of cheese ; the decomposition of casein which they initiate is of a most complicated character, and is indicated below. The bacilli which produce the enzymes are, for the most part, spore-bearing organisms ; the spores are very resistant to heat ; in fact, they are not destroyed by boiling even at 115° C. (240° F.) ; it is therefore almost impossible to sterilize milk which contains them.

The changes which occur during ripening are not wholly shown by an ordinary analysis. The composition of new and ripened cheese,[1] as given in table on p. 303, shows that there is a loss of water and protein and an increase of fat.

Loss of Weight.—There is a constant loss of weight by evaporation of water from the surface, the loss in a ripened cheese amounting to 15 or 20 per cent. of the water in a new cheese. If there were no evaporation of water, a ripe cheese would contain more than a new one. Water is formed in the cheese in consequence of the chemical changes which are progressing, whereby water, alcohol, volatile bodies, and gases such as nitrogen, hydrogen, and carbonic

[1] Wiley's " Foods and their Adulteration."

anhydride, are generated, and partly escape. The diminution in the amount of water is considered an advantage. On the other hand, the cheese should not become too dry ; otherwise the ripening will be delayed, or the changes insufficiently marked to develop the texture, taste, and aroma, which characterize a properly ripened cheese.

CHANGES IN CHEESE DURING RIPENING—PERCENTAGES.

Composition.	New Cheese.	Same Cheese One Year Old.
Water	40·42	33·00
Protein	24·80	27·35
Fat	28·00	31·70
Sugar	1·65	2·96
Ash	5·43	4·87
Water-free substances :		
Protein	41·62	40·89
Fat	46·90	47·40

Increase of Fat.—The proportion of fat is increased at the expense of the casein. This is one of the changes which enhance the value of the finished and ripened material, by giving the cheese a softer and more buttery consistence. The change is greater in some cheeses than in others ; in the foregoing example the ripe cheese has 3·7 per cent. more fat than the fresh cheese. The following shows the changes in a specimen of Roquefort cheese.

	Protein per Cent.	Fat per Cent.
New cheese	40·8	53·91
Ripe cheese	37·8	56·14

But as a portion of the protein is broken down into other nitrogenous and non-nitrogenous bodies, some writers argue that the increase of fat is relative and not actual. It has, however, been shown in other cases that fat can be produced from proteins. Again, some of the fat undergoes changes during the ripening—*i.e.*, it is decomposed into fatty acids—*e.g.*, butyric, valeric, succinic, and other volatile acids being produced. These changes, likewise due to bacterial enzymes, are of such a character as would render butter unpalatable ; but in cheese the products do not detract from its value, but add to the complex character of the flavour and aroma.

Loss of Protein.—The changes in casein are the most important which take place in the cheese. Casein is transformed from a tough and leathery substance, which is insoluble and practically impermeable to water, into something which is softer, more soluble, more easily permeated by liquids, and more readily digested. These

changes are due to the breaking down of some of the casein into amino-acids (among which leucin and tyrosin are notable), fats, ammonia, and other volatile materials. The loss of protein varies in amount from 7 or 8 per cent. of the casein present (a common proportion) to 20 or 25 per cent. in exceptional instances. The change which is going on in the proteins appears also to influence the undecomposed proteins, for ripened cheese is more soluble and more easily digested than new cheese.

"When cheese ripens, the most prominent change takes place in the nitrogen compounds. The casein of milk is changed by the action of rennet into curd, chemically known as **paracasein.**[1] In the process of cheese-making lactic acid is formed, and unites with the paracasein, forming a compound known as **paracasein monolactate.** It is this compound which imparts to cheese the property of forming fine strings on a hot iron, and it is the formation of paracasein monolactate that accounts for the changes in the appearance, plasticity, and texture, of cheese curd during **cheddaring.** There is reason to believe that the changes which take place in cheese-ripening start with, and are dependent upon, the presence of paracasein monolactate or some similar compound. From a chemical point of view, cheese-ripening consists mainly of the changes of paracasein monolactate into other forms of nitrogen compounds, chief among which, in the order of their formation, are paranuclein, caseoses, peptones, amido-compounds, fatty acids, and ammonia. These compounds, formed from paracasein monolactate, are soluble, while paracasein monolactate is insoluble. Hence in ripened cheese we have larger amounts of substances that are soluble, and a smaller amount of substances that are insoluble. Ripened cheese is for this reason believed to be more digestible than green cheese. The amount of soluble nitrogen is a measure of the extent of cheese-ripening."[2]

The amount of paracasein monolactate in cheese varies at different stages, and even in cheeses of the same character at the same period. In cheeses of one or two weeks old the proportion varies from 40 to 66 per cent. of the whole nitrogen, with an average of 57·49 per cent. It decreases with age, owing to the conversion of paracasein monolactate into soluble nitrogen compounds; and it sinks to a point varying from 30 to 36 per cent. of the total nitrogen in as many weeks. The change is influenced by the temperature at which the cheese is kept, being more rapid when kept at 60° F. than at 40° or 50° F.

The amido-compounds are of especial interest, because, whether it is due to them or not, there is little or no development of flavour until they are formed. Not only does the amount of amido-

[1] The chief protein of milk is called by Hammarsten "casein" before it is acted on by rennet, and "paracasein" afterwards. Halliburton calls it "caseinogen" before, and "casein" after, the action of rennet upon it.

[2] Twentieth Report of the Bureau of Animal Industry, U.S. Department of Agriculture, p. 220.

compounds increase with age, but they are developed more rapidly in cheese kept at a high temperature than in those kept at a low temperature [1]—*e.g.*:

Temperature.	Time.	Amido-Compounds.
Cheese kept at 60° F.	20 weeks	13·30 per cent.
,, ,, 50° F.	28 ,,	12·70 ,,
,, ,, 40° F.	35 ,,	9·00 ,,

The formation of ammonia in cheese is also closely associated with the development of flavour. There is no ammonia in fresh cheese, but it begins to appear about the fourth week, and increases with age. The proportion developed at a high temperature is greater than at a low one, and the average is as follows :

Temperature.	Time.	Ammonia.
Cheese kept at 40° F.	28 weeks	2·50 per cent.
,, ,, 50° F.	28 ,,	3·48 ,,
,, ,, 60° F.	20 ,,	3·36 ,,

It is believed that the enzymes are all-important in the later stages of ripening, and that they very much influence the flavour. This is supported by the fact that the flavour of cheese develops more rapidly, as shown by the amount of ammonia and amido-compounds, at a higher temperature. This is also shown by the following table :

Temperature.	Time.	Increase of Soluble Nitrogen Compounds.
Cheese kept at 40° F.	35 weeks	14·5 to 27·64 per cent.
,, ,, 50° F.	28 ,,	,, 33·00 ,,
,, ,, 60° F.	20 ,,	,, 36·34 ,,

The sum of the changes influenced by temperature shows that good cheese can be produced by ripening at from 40° to 60° F. Cheese develops more rapidly at 60° than at 50° or 40° F., *but it goes off sooner*. While cheese develops more slowly at 40° or 50° F., it reaches the same quality in time as that ripened at 60° F., and may even surpass it ; in fact, cheeses ripened in the lower temperature retain their condition longer ; *i.e.*, their keeping quality is more pronounced, and the value is thereby enhanced.

[1] Twentieth Report of the Bureau of Animal Industry, U.S. Department of Agriculture, p. 222.

Moulds in Cheese.—The moulds which grow in cheese during ripening are usually innocent ; they contain numerous enzymes which assist in the process of ripening and development of the flavour which characterizes the cheese in which it grows. " Blue mould," or *Penicillium glaucum*, occurs in Stilton, Wensleydale, Cotherstone, Roquefort, Gorgonzola, Camembert, Gruyère, and Brie cheeses. Other moulds occurring in or on cheeses are *Penicillium candidum*, *Mucor mucedo*, and *Sporendonema casei ;* the two former are white, and the latter red mould.

Animal Parasites in cheese are the " cheese-mite," or *Acarus siro*, which exists in great numbers in hard cheeses, especially in those which have been carelessly treated in the store-room ; they would in time convert the entire cheese into a fine dry powder. " Jumpers " or maggots are the larvæ of the fly *Piophila casei*.

Cheese-Colouring.—The natural colour of cheese is that which arises from the ripening of good milk and cheese. A custom has, however, existed from time immemorial of attempting to improve Nature by Art. In the case of cheese, many kinds are coloured by the use of annatto, carrot-juice, infusion of marigold flowers, saffron, or safflower. Annatto gives to the cheese a yellowish-red, saffron a golden-yellow colour. These substances are not deleterious. But the readiness with which colour can be given to many substances by aniline dyes has led to the use of " coal-tar yellow " by various cheese-makers. Aniline dyes are, however, far from being innocent, and, in consequence of their injurious effects upon the human organism, their use for colouring any kind of foodstuff should be discountenanced. Mineral substances have occasionally been used for the double purpose of giving colour and adding weight to the cheese. But this mode of colouring is not likely to escape detection very long, and the fraud would bring its own punishment. In all cases, when a cheese is artificially coloured, the substance is added to the milk before the rennet. The red colour of cheese is not always due to artificial colouring agents, for Otto Gratz has isolated from red cheese a pigment-producing microbe which he named the *Micrococcus rubricasei*, and which is presumably present in the milk of which cheese is made.

" **Filled Cheese.**"—The chief fraud in connection with cheese, probably, is that of selling one kind for another. But another fraud is also perpetrated—namely, that of selling *filled cheese* for the natural product. When skim milk is used in the manufacture of cheese, the ripened product is deficient in fat. This deficiency is sometimes made up by adding to the curd, at the time it is milled, some other kind of fat, such as lard, margarine, cottonseed or pea-nut oil. This substance is known as " filled cheese " or " margarine cheese." It is a poor substitute for the genuine article, being in many cases little more than casein and lard, with artificial colouring. The addition of another animal or vegetable fat does not make an unwholesome food, *but it is not milk-fat ;* the cheese does not undergo the normal process of ripening, it is deficient in aroma and flavour,

THE COMPOSITION OF CHEESE—PERCENTAGES.[1]

Name.	Water.	Nitrogen.	Casein.	Fat.	Ash.	Valenta Test.	Reichert.
English Cheddar	33·8	4·20	26·7	30·5	4·1	31·0	26·4
Canadian Cheddar	33·3	4·34	27·6	30·6	3·6	41·5	24·0
American Cheddar	29·8	4·76	20·3	33·9	2·7	47·5	26·2
Gorgonzola	40·3	4·36	27·7	26·1	5·3	26·5	22·1
	33·9	4·06	25·8	26·7	4·6	45·0	23·6
Dutch	41·8	5·11	32·5	10·6	6·3	40·0	27·0
	37·6	4·58	29·1	22·5	6·5	49·0	23·0
Gruyère	28·2	4·93	31·3	28·6	4·7	37·5	30·0
	35·7	4·49	28·7	31·8	3·7	41·0	31·1
Stilton	19·4	4·73	21·1	42·2	2·6	38·5	29·0
	21·2	4·14	36·3	45·8	2·9	45·5	32·0
Cheshire	37·8	4·03	25·7	31·3	4·2	43·0	31·6
	31·6	4·16	26·5	35·3	4·4	47·0	31·8
Double Gloucester	33·1	4·99	31·8	23·5	5·0	38·0	31·4
	37·4	4·50	28·3	28·1	4·6	41·0	32·3
Camembert	47·9	3·43	21·8	41·9	4·7	32·0	31·0
	43·4	3·83	24·4	22·6	3·8	33·0	35·0
Parmesan	32·5	6·86	43·6	17·1	6·2	28·0	28·0
Roquefort	29·6	4·45	28·3	30·3	6·7	19·0	36·8
Double cream	57·6	3·14	19·0	39·3	3·4	40·0	31·3
York cream	63·1	2·76	17·9	6·5	1·4	41·0	29·0
Bondon	39·5	1·48	9·4	24·4	·7	42·0	29·4
Cheddar, average	33·5	4·30	27·4	29·0	4·0	—	25·9
American, average	27·5	4·60	29·7	30·4	4·5	—	—

[1] Pearmain and Moor, *Analyst*, 1894, p. 146.

and the amount of soluble proteins does not increase to a like extent. The sale of such a substance, without a label which would indicate to the purchaser the nature of the material he is purchasing, would be a fraudulent misdemeanour. The legal definition of margarine cheese or filled cheese is given in the Food and Drugs Act, 1899, Section 25: "The expression *margarine cheese* means any substance, whether compound or otherwise, which is prepared in imitation of cheese, and which contains fat not derived from milk." Section 5 of the same Act extends the Margarine Act of 1887, as amended in 1899, to the sale of margarine cheese. In the United States "filled cheese" is defined as a cheese manufactured from skim-milk, the deficiency in milk-fat being made up by the addition of foreign substances, such as lard or cottonseed-oil. The most common expedient is to mix 2 or 3 per cent. of lard with skim-milk or with the curd at the time of milling. In the United States every package sold must be branded with the words "Filled Cheese," under a liability to a heavy penalty.

Skim-Milk Cheese.—Many varieties of cheese are made from milk which has been deprived of more or less fat, or a mixture of skimmed and entire milk. But there is no legal standard for such cheeses, although they contain less fat than when whole milk is used. The difference is not so great when partly skimmed milk is used, as in Edam, Gloucester, or Cheshire cheese, where the fat in a ripened cheese amounts to 25 or 30 per cent., or even more. Cheese made from machine-skimmed milk sometimes contains as little as 5 per cent. of fat, and only 1·0 per cent. was found in a sample analyzed at Somerset House.[1] Such cheeses are usually dry and tough or crumbly, instead of being soft, smooth, and velvety to the touch.

The table of analyses by Bell,[2] on p. 309, shows the proportion of contents of various substances not included in the foregoing table—*e.g.*, lactic acid, fatty acids, and common salt:

Cheese is analyzed in the following way: WATER: Take 5 grammes of cheese; dry it in a platinum dish over a water-bath until it ceases to lose weight. The loss in weight represents the water; if loss $=x$, then $\frac{x \times 100}{5}$ = water per cent. in the cheese. ASH: Incinerate the dried cheese. The weight of residue (y) now represents the ash in 5 grammes of cheese, and $\frac{y \times 100}{5}$ = ash per cent. FAT: 10 grammes of cheese is now cut into very small pieces and boiled with ether in a flask. The solution is decanted. More ether is then added to the cheese, which is boiled again, and decanted. Both etherial solutions are evaporated to dryness. The residue is the fat in 10 grammes of cheese, and the percentage proportion is ascertained as before. MILK-SUGAR: The non-fatty residue is then washed with alcohol and boiling water. These liquids are decanted, and evaporated to dryness. The residue is ignited in a platinum dish, and the difference in weight before and after ignition represents the amount of milk-sugar in 10 grammes of cheese, from which the percentage is ascertained. CASEIN: The amount can be estimated *by difference*, after allowing for water, ash, fat, and sugar, in 10 grammes; or it may be ascer-

[1] Report of Principal Chemist of Government Laboratory for 1902.
[2] Thorpe's "Dictionary of Applied Chemistry," vol. i. 503.

COMPOSITION OF CHEESE—PERCENTAGES.

Analyses by Bell.

Variety.	Water.	Fat.	Casein, etc.	Free Acid, as Lactic.	Ash.	Fat in 100 Parts of Dry Cheese.	Fat in 100 Parts of Casein and Fat.	Salt in Cheese.	Fatty Acids in the Fat.	
									Soluble.	Insoluble.
Stilton	23·57	39·13	32·55	1·24	3·51	51·19	52·50	·67	4·42	88·96
American Red	28·63	38·24	29·64	—	4·49	53·57	52·12	·72	4·26	89·65
American Pale	31·55	35·93	28·83	0·27	3·42	52·49	53·34	0·82	4·81	88·49
Roquefort	32·26	34·38	27·16	1·32	4·88	50·75	54·24	3·04	4·91	88·70
Gorgonzola	31·85	34·34	27·88	1·35	4·58	20·39	53·09	2·11	4·40	89·18
Cheddar (medium) ..	35·60	31·57	28·16	·45	4·22	49·02	50·49	1·43	4·55	88·75
Gruyère	33·66	30·69	30·67	·27	4·71	46·26	47·07	·81	4·41	88·97
Cheshire	37·11	30·68	26·93	·86	4·42	48·78	50·84	1·69	5·55	87·76
Gloucester (single) ..	35·75	28·35	31·10	·31	4·49	44·12	45·24	1·28	6·68	86·89
Dutch	41·30	22·78	28·25	·57	7·10	38·80	42·41	4·45	5·84	87·58

tained by weighing the residue left after removing fat and milk-sugar from 10 grammes of cheese, incineration and weighing the residue again. The loss on ignition now represents the amount of casein, from which the percentage is ascertained.

Cheese as a Food.—The composition of cheese shows that it is a valuable source of fat and protein. Cheese is all nutriment, one of the most concentrated foods known, and takes rank with pemmican, biltong, and various other meat preparations. It contains from 20 to 45 per cent. of casein and other nitrogenous matters, the same proportion of fat, from 1 to 2 per cent. of milk-sugar in some cheeses, and 2 to 7 per cent. of ash. The nitrogen, it should be observed again, is not all in the form of casein, but is partly in a predigested form as caseoses, albumoses, and peptones, and partly as amides. A remarkable example of this occurs in Camembert cheese, in which Stutzer[1] estimated the nitrogen to be in the following forms :

NITROGEN IN CAMEMBERT CHEESE.

Total nitrogen	2·900 per cent.
Nitrogen as ammonia	·386 ,,
,, casein and albumin	·397 ,,
,, albumoses and peptones ..	·885 ,,
,, amides	1·117 ,,
Indigestible forms	·115 ,,

The energy-value of cheese and meat respectively are as follows :

One pound of beefsteak yields 72 calories per ounce.
One pound of ripe cheese yields 120 calories per ounce.

The class of persons to whom cheese is of special value as a source of nitrogen and fat are those who work in the open air, labourers and others, whose digestion is keen. The cheese most readily digested is a well-ripened cheese in which the soluble proteins have attained a good percentage. New cheese, on the other hand, is not so easily digested. Artificial digestion experiments show that 93 per cent. of protein and 95 per cent. of fat in a ripe Cheddar cheese is digested. But these experiments also show that cheese is more readily acted upon by pancreatic than by gastric ferments ; *i.e.*, it is more easily digested in the bowels than in the stomach. It is, however, a well-known fact that everybody cannot digest cheese, even of the finest class. This is due to the presence of a large amount of fat, which forms a protective covering to the proteins, prevents the access of the digestive juices to the casein, and renders it an impossible food to many delicate stomachs. Another disagreeable effect of cheese arises from the presence of certain fatty acids—*e.g.*, butyric acid—arising from the decomposition of fats. But when cheese once gets into the intestines, it is digested as easily as meat, and the residue is about the same.

Owing to the difficulty of gastric digestion of cheese, it is not a

[1] *Zeit. f. Analyt. Chem.*, 1896, 493.

proper food to be eaten in bulk by a large class of persons, and especially by persons of a sedentary occupation, whose business confines them largely indoors. Such people find that the consumption of a large piece of cheese is very apt to derange their stomach, to cause dyspepsia, and, reflexly, headache and other cerebral symptoms, amongst which we must include the dreams and nightmare which not uncommonly follow a supper of bread and cheese. But the custom of eating a small piece of ripe cheese—say ½ to 1 cubic inch—at the end of a full meal is probably correct, as cheese undoubtedly has a condimental value, provokes the secretion of the digestive juices, and thereby assists in the digestion of other foods. It is therefore as a condiment rather than a food that cheese should be regarded by people who do not lead a very active life, or whose occupation is of a sedentary character. It is believed also that the enzymes of cheese exert some influence upon digestion, and that this is the scientific basis for the well-grounded assumption that cheese is an aid in the digestion of most foods, and for the wise saws, such as the adage :

"Cheese! thou mighty elf,
Digesting all things but thyself!"

The Varieties of Cheese.

Cheeses are classified as soft and hard varieties, according to their texture and various other characteristics, but no hard-and-fast line can be drawn between them. Soft cheeses have a large proportion of water and a relatively small proportion of protein and fat. In whole-milk cheeses of the hard class fat usually exceeds the protein in a ripe cheese ; but in skim-milk or partly skimmed milk cheeses, when ripe, the protein exceeds the fat.

I. **Soft Cheeses**—(*a*) *English.*—Cottage or Colwick cheese, Cream cheese, New Forest, Surrey, Yorkshire, and Caerphilly.

(*b*) *Foreign.*—Bondon, Brie, Camembert, Coulommiers, Gervais, Gournay, Limburger, Livarot, Neufchâtel, Pont l'Évêque, Stracchino.

II. **Hard Cheeses**—(*a*) *English.*—(1) **Stilton type** (blue-veined) : Stilton, Wensleydale, Cotherstone, Cottenham. (2) **Cheddar type** (pressed) : Cheddar, Cheshire, Gloucester, Leicester, Derby, Dorset, Dunlop, Lancashire, Somersetshire, and Wiltshire.

(*b*) *Foreign.*—American Cheddar, Gouda, Gruyère, Emmenthaler, Edam, Gorgonzola, Parmesan, Roquefort, Cacio-cavallo, Port du Salut, Schabzieger, Glarner, Bra, Gisler.

I. *Soft Cheeses.*

Cottage Cheese (*Pot Cheese, Green Cheese*).—This is the simplest form of cheese. It is called by different names in different localities. In England, it is called "Colwick cheese" in Nottinghamshire, "straw cheese" in the southern counties, and "green cheese" in many places. It consists simply of the fresh coagulum of the milk,

precipitated by rennet or the natural development of lactic acid. The coagulated milk is heated to 85° or 125° F., according to circumstances, and put into a muslin bag to drain off the whey. The curd is then kneaded by the hand, seasoned with a small proportion of salt, which checks the formation of lactic acid, and pressed into a shape, which varies with the district or fancy of the maker. This is fresh, green, or unpressed and unripened cheese (Dutch cheese, Cottage cheese, Schmierkase, etc.). Some persons consider it an improvement to season it with spices—*e.g.*, nutmeg or caraway. It is made very largely for domestic consumption; but in most towns and villages, especially during the summer months, there is a considerable demand for it, and its manufacture is a source of income to the farmers. It is usually sold and consumed in a fresh state. It has at first only the flavour of the acidulous curd; but within a few days the ripening begins, and by the end of a week it becomes more or less creamy, owing to the transformation of casein, is then extremely palatable and nutritious, and very highly esteemed by a large number of people. *Composition:* Water 40·0, protein 25·0, fat 28·0, sugar 2·5, ash 4·5, per cent.

Foreign cheeses of this class are—*Schabzieger*, made in Switzerland from milk which has become sour, and is curdled by warming it to 100° or 120° F.; *Quark*, the caraway cheese of Germany; and *Glarner*, a hard cheese made in a similar way in Switzerland.

Cream Cheese.—This is another example of a cheese made on a large or small scale, and intended to be eaten comparatively fresh. It is made from cream or from milk to which cream has been added. Its composition varies according to the mode of manufacture. An English cream cheese, made entirely of cream, contains 50 to 70 per cent. of fat, and only 3 to 10 per cent. of casein; when made of milk and cream, the proportion of casein is greater. In the United States the standard for whole-cream cheese is 50 per cent. of fat.

1. *English Cream Cheese*—(*a*) *Cream only.*—When made on a large scale, the milk is creamed by a separator, and the cream ripened for three days in a temperature of 60° F.; lactic fermentation occurs, and the cream curdles. The cream is then put into muslin bags, and allowed to drain for twenty-four hours. When removed from the bags, it is submitted to gradually increasing pressure for twenty-four hours longer, being then taken out of the press, kneaded to give it a uniform consistence, moulded, and wrapped in butter muslin. It is scarcely a cheese, because no rennet is used.

(*b*) *Equal Parts of Cream and Milk.*—The new milk is raised to a temperature of 70° F., and skimmed by centrifugal separator. The cream is then diluted with fresh whole milk, and the mixture warmed to 84° F. and coagulated by means of rennet. It is gently agitated until coagulation begins, when it is allowed to rest until the coagulum begins to separate into curds and whey. The curd is then removed, drained, mixed with 2 per cent. of common salt,

and pressed into squares, which are intended to be eaten while fresh.

2. *French Cream Cheese.*—(*a*) Fresh morning's milk is warmed to 70° F., and enough rennet added to coagulate it in two or three hours. It is allowed to rest twenty-four hours. The exuded whey is poured off, the curd cut into slices and laid on a sieve to drain. When well drained, the curd is kneaded in a vessel (by means of a wooden pestle), with a quantity of cream equal to the amount of milk originally used, until it is of a uniform consistence. It is moulded into various shapes, and intended to be eaten fresh. It may be kept in an ice-box for several days.

(*b*) *Double cream* or Swiss cream cheese is exceedingly popular in Paris and its environs. One part of cream is mixed with 6·4 parts of fresh new milk, and its temperature raised to 55° or 58° F. Enough rennet is added to coagulate it in twenty-four hours. The curd is then removed, cut into slices, placed in linen bags, drained, and pressed for about eighteen hours or until whey ceases to escape. It is afterwards kneaded by hand, enough cream being added to give it a soft, smooth, uniform consistency. It is left exposed for a few hours to become firmer, and then moulded and wrapped in paper.[1] According to Pourian, it has the following composition : Water 55, fat 30, casein, etc., 15, per cent.

3. Special cream cheeses are made by various manufacturers, having particular characteristics, such as a Cheddar flavour. York, St. Ivel, Cream-Gouda, and Royal, are cheeses of this class. Neufchâtel and Gervais are, when fresh, essentially cream cheeses.

It remains to be seen in what way other soft cheeses differ from Cottage and Cream cheese.

Camembert.—This is a type of cheese made from the whole milk of the cow. The evening and morning milk are mixed together, the temperature raised to 85° F. ; rennet is added, and the mixture agitated for two or three minutes, after which it is covered for five or six hours while the coagulum forms. The curd, having attained such a consistency that it will not adhere to the finger, is put into perforated cylindrical moulds, and allowed to drain for two days. The surface of the cheese is now sprinkled with salt, turned upside down, and allowed to remain another day ; it is then removed from the mould and placed in the *drying-room*. In this room the cheeses are arranged upon racks and covered with straw. Fungi grow upon them ; first the "white mould," or *Penicillium candidum*, appears, and then the "blue mould" (*Penicillium glaucum*). The cheeses remain in this room two or three weeks, plenty of air being admitted ; but sunlight, dust, and insects, are carefully excluded. At the end of this period they are transferred to cellars having a uniform temperature of about 50° F. Here they are left about a month to ripen, being carefully watched and frequently turned over. A Camembert cheese requires about eight weeks

[1] "The ABC of Cheese-Making," J. H. Monrad.

for its manufacture, from drawing the milk to ripening of the cheese. It is known to be ripe by its appearance and *feeling* on pressure, which are understood by an expert. These cheeses are largely made in the province of Calvados, France ; but they are not all made from entire milk, some being produced from a mixture of whole milk and partly skimmed milk. Camembert is a small flat circular cheese, about 6 or 7 inches in diameter and 1½ or 2 inches thick.

Coulommiers Cheese is made in a similar manner, but it is thicker, and is sold either when a week old or after being ripened.

Brie is also a French cheese, made near Paris. It is made in a manner similar to the former. Rennet is added to milk warmed to 82° or 86° F. The curd is drained and put into moulds which rest on a straw mat, by which the surface becomes marked. When well drained and firm, it is removed from the mould, sprinkled with salt, turned over a time or two, and then removed to the drying-room, where it is kept at a temperature of 62° F. In a few days the white mould appears on its surface. It is then transferred to another room, where the temperature is 65° F., for three or four weeks, to ripen, during which it becomes covered with blue mould exteriorly, and the interior becomes yellowish throughout. It is now ripe. Brie has the general characteristics of Camembert cheese. It is made in two sizes—*Petit Brie*, a round flat cheese, 8 to 12 inches diameter, and ¾ to 1 inch thick ; *Grande Brie* has a diameter of 16 inches, and is somewhat thicker.

Pont l'Évêque is another French cheese, made in the village of that name, near Havre. There are some little differences in the mode of manufacturing it, but it is usually made as follows : The milk is heated to 88° F., enough rennet added to precipitate the curd in ten or fifteen minutes. It is then covered and allowed to rest until the curd is firm enough to be cut. It is afterwards removed from the whey, and put upon straw mats to drain. As the whey escapes the curd toughens, and when it is sufficiently drained it is put into moulds of a square or oblong shape and pressed. It is transferred to the drying-room, and in due time is ripened in moist cellars, where the temperature is 58° F. As the cheese ripens, the exterior becomes tough, while the texture of the interior is in general firmer than that of Camembert. It will keep for some time after being ripened.

Gervais Cheese is manufactured in great quantities in France, and is especially popular in Paris. Its name is derived from the original maker. Its general characteristics are very like those of a cottage or cream cheese. It is made from a mixture of new milk and cream, warmed to 65° F. and coagulated by rennet. The rennet, however, is added gradually in small quantities, so that the entire separation of the curd occupies seven or eight hours. At the end of this time the coagulum is broken up, drained in linen bags, and then moulded into shape by kneading and gentle pressure. Gervais cheeses are eaten fresh or *partially* ripened, and therefore combine the flavour of cheese and cream.

Bondon Cheeses are made in a similar way in Normandy. They are not so rich as Gervais cheeses. There are two classes—(1) made of whole milk ; (2) made of partly skimmed milk. The curd is obtained in a manner similar to the former, and is set to drain in baskets for twelve hours, after which it is transferred to a perforated mould and lightly pressed. The curd is afterwards put into small moulds of about the size of a teacup until it becomes firm. It is then removed from the mould, salted, and allowed to drain again for twelve to eighteen hours, and finally transferred to cellars to ripen on straw. The cheeses become mouldy in two or three weeks, during which time they are frequently turned. They are then dressed and pressed, but moulds again appear on the surface, and they are ready for consumption. The ripening process continues, and they are at their best about a fortnight after removal from the cellars.

Neufchâtel is also made in a similar manner. Fresh morning's milk is used at a temperature of 90° F., enough rennet being added to form a coagulum in two to four hours ; it is then covered and left for twenty-four hours in a room having a uniform temperature of 60° F. The whole mass is then poured into a cheese cloth or basket, and hung up to drain for twelve hours, after which it is placed in a box with perforated sides and submitted to gentle pressure for twelve hours. The curd is then kneaded until it has a uniform consistency, some cream or new curd being added if it is too dry. It is put into tin cylinders 2½ inches in diameter and 3 inches high. When removed from the cylinders, they are sprinkled all over with salt and allowed to drain for twenty-four hours. They are then put upon shelves, covered with straw, in the drying-room, and frequently turned to prevent loss of shape and adhesion to the straw. White mould appears after five or six days, and blue mould in ten or fifteen days, when the cheeses are said to have their *first skin*. After this they are placed on straw upon shelves in a moist, cool cellar, and turned every three or four days. After three weeks red spots begin to appear, and the cheese is said to be at its best when six or eight weeks old.[1]

Limburger cheese, although originating in Belgium, is made largely in Germany. Properly it is made from whole milk, but it is frequently made from a mixture of whole and skim milk, which is coagulated at 92° to 100° F. by rennet. After a sufficient interval for the coagulum to become firm, it is broken into pieces of the size of an egg, and allowed to collect at the bottom of the vat, where it continues to contract until a complete separation into curds and whey has taken place. The whey is then drained off, and the curd transferred to perforated rectangular moulds to drain again, the moulds being frequently turned to promote drainage. When sufficiently dry, the cheeses are removed from the moulds, sprinkled with salt, and removed to cellars having a temperature of 60° F. and a saturation of 90° of moisture. They are sprinkled with more salt every two or three days, and submitted to light pressure between boards. The salt sprinkled on the surface diffuses through the mass. As the cheese ripens, it becomes softer from the outside towards the centre, and the whole mass is transformed to a yellow or reddish-yellow colour. The process of ripening verges upon putrefaction, and the odour of a ripe cheese has that characteristic. This is due to a special kind of fermentation which occurs in a very damp atmosphere. The special enzymes convert the casein into a substance having a characteristic greasy appearance, texture, and colour. The cheese is soft throughout in six or seven weeks, but it is considered ripe enough to eat in five or six weeks. It has the following composition : Water 35·7, protein 24·3, fat 34·2, sugar, amides, etc., 3·0, ash 2·0, per cent.

[1] Monrad's "ABC of Cheese-Making."

II. *Hard Cheeses.*

1. **The Cheddar Type** of cheeses are those in which the curd is heated and the cheese is pressed. Those belonging to it are Cheddar, Cheshire, Derby, Leicester, Gloucester, Dorset, Dunlop, Lancashire, and Wiltshire cheeses. The manufacture of Cheddar cheese was the example used for describing the process of cheese-making (pp. 395-305). But there are differences in the mode of making cheeses of this type, as well as in the characteristics of the products, which deserve a brief notice.

Cheddar Cheese has a wax-like texture and solidity. It is chiefly made in Somersetshire. The milk is coagulated solely by rennet, at a temperature of 80° F., in which particular it differs from others of this type. It is made with the evening's and morning's milk mixed together. It is coloured with annatto, carrot, or marigold, and is seasoned with 2 per cent. of salt. The season is from May to November. The cheeses are made in three sizes: Small cheeses (18 to 22 pounds), which are ripe in three or four months; large ones (60 or 70 pounds), ripe in six to ten months; and larger ones (100 to 160 pounds), ripe in eighteen to twenty months.

American and Canadian Cheddar is made in large cheeses, from whole or partly skimmed milk, the mode of manufacture differing little from the English method. They are large hard cheeses, of reddish colour and piquant flavour.

Cheshire Cheese differs from Cheddar in character, the interior being loose and flaky, having a tendency to crumble, a more pungent odour and flavour, and a sweetish taste. These characteristics are due to the degree of fermentation. The chief points of difference from the typical Cheddar method are as follows: The evening milk, which has been kept cool until it is used, is mingled with fresh morning milk. It is then coloured with annatto, warmed to 90° F., and enough rennet added to form a coagulum in one hour. Sour whey, containing about 1 per cent. of lactic acid, is added to the milk *before the rennet* to promote the formation of acid in the curd. The whey is then drained off; the curd is cut or broken, laid upon drainers, and sprinkled with 2 per cent. of salt, which sets the curd and facilitates the drainage of the whey. Great care is exercised in the next part of the treatment, as upon this depends the rapidity of curing and final quality of the cheese. The curd is milled twice, and is therefore much finer than in Cheddar. It is then pressed into perforated moulds, and allowed to remain in a warm room for a day or two, or occasionally put into a "cheese oven" during that period, to encourage fermentation and development of lactic acid. It is afterwards removed to the "press-house," where it is subjected to pressure for five or six days, and thence to the cellars to ripen, where it is turned over frequently to insure the equalization of moisture. It ripens in about four months. Cheshire cheese, however, is made in *three qualities*, and their weight may be anything up to 100 or

200 pounds: (1) Early-ripening cheese, which possesses a strong flavour and a large percentage of moisture; (2) medium; (3) long-keeping cheese. In the early-ripening variety the curd is formed in forty-five minutes, is cut in large pieces, and left longer in contact with the whey in the vat; it is not ground in a mill, and less pressure is afterwards applied to it. In the medium quality the curd is cut into smaller pieces, which are ground in a mill, and subsequently placed in a hoop in an oven with temperature of 80° F. for twenty-four hours, pressed for four or five days, and salted with 2½ per cent. of salt. The long-keeping cheese has enough rennet added to coagulate the milk in sixty minutes instead of forty-five; the curd is cut very small, ground twice, placed in a hoop in an oven, and submitted to longer pressure than the former. Quick-ripening cheeses have low keeping qualities, but medium and slow-ripening cheeses keep in good condition for several months after ripening. In some factories an endeavour is made to combine Cheddar and Stilton methods, and thereby produce a Cheshire-Stilton cheese, wherein a flavour is produced by *Penicilium glaucum*.

Gloucester Cheeses are more solid than Cheshire and Derby cheeses, being less flaky and more or less waxy in consistence, after the manner of Cheddar. The interior has a clear yellow tint, with veins of blue mould, and a mild flavour. It is made in two sizes: (1) Single Gloucester, or Berkeley, which is 2 or 3 inches thick, and weighs about 14 pounds; (2) double Gloucester, which is 4 or 5 inches thick, and weighs 25 to 30 pounds or more. There is an erroneous notion that *single* and *double* have reference to the quality of the cheese, whereas it only refers to their weight.

The cheese is made from whole milk, or whole and skim milk, or entirely of skim milk. Usually the evening's milk is skimmed and added to the morning's milk. Cheddar methods are employed. The curd is pressed to remove whey, ground in a mill, put into cheese moulds, and again pressed. When they have been in the ripening cellars for about a month, the exterior is brushed over with beer containing Spanish brown or Indian red, in order to give a distinguishing colour to the cheese, which is a pale vermilion.

Dorset Cheese is also made by Cheddar methods. The final product contains rather more water than the Gloucester variety. It is a mellow cheese, having blue veins (*Penicilium glaucum*), but is less flaky than Cheshire, and approaches more nearly to the typical Cheddar in character.

Wiltshire Cheeses are of two kinds: (1) Small cylindrical cheeses about 9 inches in diameter, called "Wiltshire loaves." They are made by the Gloucester method—that is, the curd is only heated once. (2) Larger cheeses, also made on the Gloucester method; but the curd is heated twice, as in typical Cheddar, whereby the flavour and texture of the cheese differs from that of Gloucester.

Derbyshire Cheeses.—(1) *Cheddar Type:* Most of the British factories where Cheddar cheese is made by the American method are in Derbyshire. When well made, this kind of cheese is equal to Cheshire. It is, however, more solid than Cheshire and more flaky than Cheddar; but it does not always attain the same degree of excellence, and may be inferior. (2) *The true Derbyshire Cheese* is quite different. It has a pale creamy colour, and is generally rich

and buttery in consistence. It is made in cylinders or thin flat discs. The curd is not scalded or heated in an oven ; salt is not mixed with the curd, but is rubbed into the exterior. They mature slowly. (3) *Sage Cheese :* Cheeses of various kinds are made containing a mixture of vegetables. Cabbage, potato, and other cooked vegetables, are mixed in the curd, and render the cheese a more typical and well-balanced food. Sometimes, however, one vegetable alone or an infusion of one vegetable is mixed with the curd, to give it a characteristic flavour. The sage cheese of Derbyshire is made by adding sage-tea to the curd before salting it.

Leicester Cheese is made in the same way as true Derbyshire. The milk is warmed to 76° or 84° F., enough rennet added to form a coagulum in half an hour. The whey is drained off, the curd cut, etc., as in other cheeses of the Cheddar type. The cheeses, however, are smaller than Cheddar ; they are rather more flaky in consistence, but less so than Cheshire cheese.

Lancashire Cheeses are also made in the same way as Derbyshire. When properly ripened, they have a mellower flavour and softer consistence than typical Cheddar.

Dunlop Cheeses, or Scotch Cheddars, are made over a large area of Scotland, but chiefly in Ayrshire, Dunlop being the centre of the industry. They are made after the Cheddar method, of round or disc shape, and from 30 to 60 pounds in weight. They have a flavour and richness of quality which has established their reputation.

2. **The Stilton Type of Cheeses.**—The curd is neither heated nor ground in a mill after the Cheddar method of preparation. On the other hand, it is unpressed and uncoloured, and it is ripened by the aid of *Penicillium glaucum,* which forms blue veins in the interior. The chief varieties are Stilton, Cotherstone, and Wensleydale. Stilton is given as the type ; any variations from the method used in the preparation of other cheeses will be noted.

Stilton Cheese originated at Wymondham, near Melton Mowbray, Leicestershire, and was for a long period sold only at Stilton in Huntingdonshire, on the road from London to Edinburgh, by the proprietor of an inn. This gentleman for a long time managed to keep its origin a secret. By-and-by, however, the mode of its manufacture became known to others, and the cheese is now made over a large portion of Leicestershire and the adjoining counties.

The ripened cheese has a cylindrical form, about 9 inches in diameter and 12 or 14 inches high. It has a grey, wrinkled exterior ; a whitish-yellow interior, of mellow, creamy consistence, marbled with blue mould, and of a characteristic piquant flavour. It is made from April or May to the end of September or October. It is presumably made from the milk of cows fed on pasture-land only, and it is said that connoisseurs are able to distinguish differences in the flavour of the cheese when the animals are fed with cake or other dry foods, which do not give such a fine flavour and quality to it as the milk of grass-fed cattle.

Originally the cheese was made of fresh morning's milk, to which was added the cream from the previous evening's milk. Now, however, it is usually made from a mixture of the evening and morning milk, extra cream being added only when it is desired to produce a superior quality of cheese. The best milk is that containing 4 per cent. of fat. The temperature is raised to 80° or 82° F., enough rennet added to " set " it in fifty or sixty minutes.

When the coagulum is firm—in about one and a half hours from addition of the enzyme—it is cut into slices and put upon cloth or linen drainers for about an hour. It is then squeezed dry with light pressure, and again put into a vat to drain for twelve hours, or until it is acid. In some factories it is only allowed four hours to drain. It is now cut up and mingled with 1½ or 2 per cent. of common salt. The curd is now ready for use.

In some cheese factories what is known as " the two-curd method " is adopted. Two separate lots of curd prepared, soon after milking, at an interval of twelve hours, are mixed together, with the due proportion of salt. The first curd is more acid than the second, which is believed to be an advantage by forming a larger proportion of paracasein monolactate. In the one-curd method, one lot of milk has usually been standing for twelve hours before being coagulated, and lactic fermentation has already taken place to some extent. But when the milk is curdled at once, and allowed to stand for twelve hours, a chemical union takes place between the paracasein and lactic acid, which does not occur in the uncongealed milk.

When the curd is ready for use, it is put into cylindrical tin moulds, 10 inches wide and 15 inches deep, and perforated all round with quarter-inch holes. It is then transferred to a cheese-room, where the temperature is maintained at 58° or 60° F. to drain, being turned over twice a day to insure equalization of the moisture. After ten days the cheeses are taken out of the moulds and surrounded with a linen band, which at first is changed every day, until the exterior becomes dry and a crust begins to form. They get a coating of *white mould* in four or five days in this room, which is kept moist and cool. It is then transferred to the drying-rooms, where the crust begins to dry and become tough, the temperature being 62° F. It is afterwards moved into the ripening room, where it remains in a temperature of 65° F., or thereabouts, for several months.

The chief differences between the Cheddar and Stilton methods are these :

Cheddar Cheese.	*Stilton Cheese.*
Large quantity of rennet.	Small quantity of rennet.
Slightly acid or ripened milk.	Fresh milk is used.
The curd is heated.	The curd is not heated.
The cheese is pressed.	The cheese is not pressed.

During the process of making Stilton, especially in the two-curd method, ample time is given for spores of *Penicillium glaucum* to fall upon the curd. These spores become intimately mixed with it during cutting, salting, draining, etc. The cheese forms a suitable nidus for the development of these spores, which grow and develop a mycelium therein, and the efflorescence which characterizes the blue venation of good Stilton. In turn, the enzymes of the fungus materially assist in ripening the cheese.

Wensleydale Cheeses are made in Yorkshire. The curd is heated and ground in a mill, after the Cheddar method. Formerly the cheese was salted by being dipped in brine for two or three days ; but this has been discontinued, and the salt is mingled with the curd when it is ground. There are two sorts : one resembles Stilton in shape, colour, and consistence ; but the blue mould is more or less distributed throughout the cheese, and therefore does not produce venation or marbling. It ripens slowly. The other kind is a flat cheese, having less of the Stilton characteristics, and ripens rapidly.

Cotherstone Cheese, made in Yorkshire, also resembles Stilton, and, although less known, is preferred by some connoisseurs.

Cottenham Cheese, made in Cambridgeshire, also resembles Stilton in taste, colour, and consistence ; but the cheeses are flatter.

3. **Foreign Hard Cheeses.**—Some of these are made by Cheddar, others by Stilton methods ; but various others have characteristics which are due to a special mode of manufacture or fermentation.

Gouda is a cheese made in Friesland by methods similar to those of Cheddar, which it resembles more or less in colour, flavour, and texture. It is a small flat cheese of a pale or red colour. The best quality is made of whole milk, the second quality of partly skimmed milk, and it is said that only the latter is exported. There is a variety of cheese made in Derbyshire to resemble this kind, and is called Derby-Gouda.

Gruyère and Emmenthaler.—These cheeses are made in France and Switzerland. They are coloured by saffron. The best qualities have a mild piquant or "nutty" flavour ; second qualities, a strong peculiar taste. They are characterized by the large cavities, or "eyes," which are distributed throughout the cheese at a distance of $1\frac{1}{2}$ to 2 inches apart. The origin of these cavities is due to gas-producing bacteria, one of which is said to be the *Bacillus diatry-pepticus casei*. These cheeses are made after Cheddar methods, with differences. The morning's milk is heated to 106° F., the cream from the previous evening's milk being added and stirred in, and then the cold skimmed evening's milk is added, so that the temperature is again reduced to about 65° or 75° F. Enough rennet is added to form a coagulum in thirty minutes. In making Gruyère, the curd is broken into pieces about the size of a pea, and heated (scalded) to a temperature of 106° to 130° F. The cheeses are pressed. Salt is rubbed into the cheese after it is formed. During ripening they are kept first in a temperature of 60° F., then at 57° F., and finally at 52° F. In making Emmenthaler the cream of the previous evening's milk is not added. The curd is cut, heated, and milled, as in the Cheddar method. Salt is rubbed into the exterior in the drying-room. The manufacture and curing of the cheeses is arranged so that the gas-producing bacteria do not develop too soon. Cavities usually begin to appear two or three weeks after removal of the cheeses from the press. When the cheese is ripe, these cavities should have a dull glitter, but ought to be devoid of moisture. The cheese should be free from cracks. The largest cheeses are 3 or 4 feet in diameter, and require from eight to twelve months to ripen.

Parmesan Cheese is made in Parma and Emilia, in Italy. It is a hard cheese made of partly skimmed milk, and coloured with saffron. The milk is curdled at 120° F. After being in the drying-room for two or three weeks, the exterior is pared away, the surface brushed with oil, and one side coloured red to distinguish it. It is transferred to cellars or caves to ripen, which occupies a long time, the finest samples requiring one and a half to two years. The cheeses are usually bought by merchants soon after they are made, and stored until they are ripe. Some of the cheeses become hard, dry, and almost uneatable in their natural condition. They are then powdered and sold in bottles as "grated Parmesan."

Edam Cheese.—These are small globular cheeses of 4½ to 9 inches in diameter, and weighing as many pounds. They are made in great numbers in Holland, especially at Edam, near Amsterdam, at Hoorn, and in the district of Beemster-Alkmar. Cheddar or similar methods are used, but more salt is put in. The finest quality are made from whole milk, but as a general rule skimmed or partly skimmed milk is used. The milk is set by rennet at a temperature of 84° F., enough rennet being added to form a coagulum in fifteen minutes. It is then left in a vat until it is very acid and considerable paracasein monolactate is formed—in fact, until the curd pressed to a hot iron will form strings of ½ to 1 inch in length. Edam cheese owes its characteristics to a special fermentation—viz., *slimy fermentation*—which is induced by adding to the milk some whey from previous curd, which has in it the ferment capable of inducing slimy fermentation. There are various theories as to the cause of this change, and it has been found to be associated with the presence of various bacteria, notably the *Bacillus viscosus*, of which there are several types. Some of these organisms produce in milk only a slight sliminess ; others render it so slimy that Conn was able to draw it into threads 10 feet long without breaking. Some of them produce the slimy degeneration quickly, others require days to make the milk slimy, and still others curdle the milk before they convert it to a slimy liquid. When the whey from a previous cheese-making of this character is added, the milk is inoculated with a nearly pure culture of the organism, which multiplies rapidly, and produces the slimy degeneration during ripening of the cheeses. During ripening they are kept in an atmosphere at 60° F., and with moisture amounting to 80 degrees of saturation. The best quality, called "präsent," require nine or twelve months to get into good condition. They are small—4½ to 6 inches in diameter—and weigh as many pounds. They keep for years, and have the following composition : Water 36·34, protein 22·25, fat 31·17, ash 4·25, per cent.

Gorgonzola is an Italian cheese, made chiefly in Lombardy. It has a soft or even buttery consistence, creamy-white colour, with blue veins consisting of *Penicillium glaucum*, and a pungent taste and odour, which become stronger when the interior of the cheese is exposed to the air.

There is a prevalent idea that Gorgonzola is made from goat's milk. It is, however, usually made from cow's milk containing 4 per cent. of fat. It is made by the "two-curd" method; one curd is used quite fresh; the other is made twenty-four or forty-eight hours before it is used, and therefore becomes very acid, and has ample opportunity to become the seat of the spores of *Penicillium glaucum*. These curds are put into the moulds in alternate layers, and the fungus grows at the junction between the two. Some makers inoculate the cheese with crumbs of mouldy bread; and most makers push into the hardening curd a metal skewer or bodkin at intervals, so as to admit air, which carries with it more spores and assists in their development. The cheeses are ripened in caves or cellars where the temperature is 55° F. The ripening occupies several months, and merchants buy them as soon as they are hard enough to be transported, and keep them in suitable cellars. During the ripening various moulds appear upon the exterior, a reddish fungus growing on the best quality of cheeses. The appearance of this mould probably suggested to the mind of the merchants the formation of the coloured paste which is seen on the exterior of many Gorgonzola cheeses, which is formed by first rubbing into the cheese flour, and then a mixture of flour and brickdust or other colouring matter.

Cacio-Cavallo is also made to some extent in Lombardy, but is the typical cheese of Southern Italy, and is made chiefly in Calabria, but also in Asso Romano, Puglie, and Abruzzi. *It is made from the milk of sheep*, and, when well prepared, is considered a delicacy; but if it is not carefully prepared it may have a slight odour of the animal from which it is derived, which is obnoxious to many people.

Roquefort is made from the milk of sheep and goats in several departments of France. Its manufacture was formerly confined to Roquefort, but it is now made in Aveyron, Gard, Hérault, Lozère, and Tarne. The cheeses are 3 inches thick, 6 inches in diameter, and weight 4 to 6 pounds. When ripe it has a friable consistency, not soft or buttery, and is marbled with greenish-grey mould, due to *Penicillium glaucum*, which is an important factor in the process of ripening. In its manufacture the curd is placed in layers, in perforated cylindrical tin moulds, and is pressed, at first lightly, but with the pressure increased day by day. Many makers sprinkle crumbs of mouldy bread between the layers of curd. When removed from the cylinders, the cheeses are bound with linen, and transferred to a drying-room for ten or twelve days. They are then removed to caves or cellars to ripen. The caves or cellars are cut in the Jurassic limestone forming the valleys or mountain passes in the districts where the cheese is made. They are cooled by currents of air which circulate through them. The cheeses ripen in seven or eight weeks. During this period salt is rubbed into the exterior several times, and the surface is scraped from time to time. Ripening is hastened by piercing the cheeses by pins in a special machine, so that air carrying spores of moulds

may gain access to the interior. Roquefort cheese is a notable example of the transformation of protein into fatty substances. The fresh curd contains 85 per cent. of casein, and only 2 or 3 per cent. of fat. According to König, the ripened cheese has the following composition: Water 36·85, protein 25·25, fat 30·61, lactic acid 1·90, and ash 5·39, per cent. The chief adulteration of Roquefort cheese is replacing the genuine article by cheeses made in the same fashion from cow's milk.

Port du Salut is a cheese made in Normandy by a process originating with, and guarded from discovery by, the Trappist Monks of Bricquebec, who derived no small portion of their revenue from its manufacture. Connoisseurs, however, assert that the farmers of Normandy seldom turn out cheeses having the perfection which characterized those made by the monks. The cheese is a circular disc about 1 inch thick; but thicker ones, weighing 4 or 5 pounds, are also sold in England. The interior of the cheese is soft and buttery, of a mellow, nutty flavour, and dotted throughout with holes. When made, the milk is heated to 86° F., and enough rennet added to coagulate it in half an hour. It is then drained and pressed by hand into moulds, and again left to drain. It ripens slowly in cellars at 54° F., during which process innumerable small holes are formed by gas-producing bacteria. If abnormally ripened, the accumulation of gas, CO_2, nitrogen, and ammonia, is so large as to transform the small holes into large cavities. Cheese infected by these bacteria is known as "Nissler cheese." The infection is similar to that which produces the cavities in Gruyère. In Great Britain, *Caerphilly cheese* answers fairly well to the description of Port du Salut, but it is not so firm in texture. It is an unpressed cheese made in Wales, where it is a favourite.

CHAPTER XII

BUTTER

BUTTER is one of the most ancient articles of food. Its date of origin is unknown, but it is mentioned in some of the most ancient writings. According to the Vedas, written from 2000 to 1400 B.C., it was used by the Hindus not only as a food, but in the sacred rites of religious ceremony. At this period cattle bred and raised by the Hindus were valued in proportion to the amount of butter yielded by their milk. The ancient Greeks and Romans used butter, not as a food, but for anointing the body and dressing the hair, and as an unguent for superficial injuries and bruises. It also appears to have been used in England and Scotland as a medicament before it was used for food. According to Beckmann's " History of Inventions," the Greeks derived their knowledge of butter from the Scythians, Thracians, and Phrygians, about 450 B.C. At a later date the Romans obtained similar knowledge from the inhabitants of Germany, but it is not mentioned as being used for food by Galen (A.D. 130 to 200). It seems probable, as butter remains solid only below a certain temperature, and cattle abound chiefly in the temperate regions, where pasturage is good, that butter had its origin in some temperate region of the earth. This idea is supported by the fact that, in Europe at least, the butter, beer, and animal food, which are customary articles of the repast in the North, give place in the South to oil, wine, and bread, olive-groves being abundant in the South, and olive-oil more or less replacing butter. The butter referred to in the English translation of the Bible was probably not the solid substance known to us, but was more likely to be some liquid preparation of cream ; and the ghee, or clarified butter, of the Hindus is also different.

In ancient times, moreover, butter was seldom eaten fresh in England, Ireland, and some other parts of Europe. It was customary to melt it into firkins and bury it in the earth, where it frequently remained a number of years, to ripen it and develop flavour. Butter stored in the earth for a long time became of a deep red colour, and was highly esteemed. This may have been due in part to some difference in the composition of ancient butter. It is certain that the ancient butter contained more casein than butter made by modern methods, and from the Greek derivation of the word it is inferred that it contained nearly as much casein as fat, and therefore resembled cheese in its composition more nearly than it resembled modern butter. The practice of burying butter in the earth to ripen it was common in Ireland up to the early part of the nineteenth century. The practice is continued in some countries even in the present day, and the wealth of a person is there computed by the quantity of butter he possesses, just as it is elsewhere by the number of sheep and oxen.

Butter as a Food.—In Great Britain the term " butter " is restricted to the product of milk or cream, or both, according to the Margarine Act of 1887. It is now a common article of food. It has been estimated that its consumption in England is equivalent to 30 pounds of butter per head, and in America 20 pounds per

head, per annum ; and in the United States it forms 2 per cent. of the total food, and 19·7 per cent. of the total fat, consumed by Americans in their diet. As a foodstuff it consists five-sixths of fat, and yields about 215 calories per ounce. It is therefore a considerable source of energy to the consumer, and a valuable addition to the diet. It may be regarded as a special food for invalids, inasmuch as it consists of fat which is easily digested and quickly absorbed, less than 0·5 per cent. being lost. It may be taken in large quantities with perfect safety. As much as 4 ounces a day can be taken by some people, when it is thickly spread upon thin bread or in other foods. Enough fat is thus provided for the body in a concentrated form. It is especially useful as a source of easily digested fat in cases of convalescence from exhausting fevers and other illnesses. Its palatability makes it a valuable source of fat in phthisis, diabetes, hyperchlorhydria, and whenever the body is emaciated from any cause, or when rapid growth causes a demand for an extra supply of nourishment. Butter is an admirable substitute for cod-liver-oil, is preferred by most people, and is more easily digested. Above all, it is healthful. Few bacteria can develop in it ; it is therefore not a very likely source of disease—far less so than milk. *Cooked butter* sometimes disagrees with the consumer, owing to the liberation of fatty acids, some of which are rendered empyreumatic, and the formation of acrolein.

The Butter-Supply of the United Kingdom.—It is estimated that the amount of butter made in Great Britain and Ireland is 88,000 tons per annum, and this is supplemented by over 200,000 tons imported from other countries. About half the imported butter comes from Holland, Denmark, Sweden, and France, the remainder from our colonies. It is by far the most important foodstuff imported.

Important as the Irish butter industry has become, the approximate value of which is £5,250,000, a large proportion of the produce is exported. The manufacture of butter in Ireland has been vastly improved in recent years by the adoption of scientific methods of manufacture, increased care in storage, package, and transport. There are now in that country 342 factories working on a co-operative system, and many others working singly. But in no country has the manufacture of butter been carried to such perfection as in Holland, where the system is under official inspection, and every pound of butter can be traced from the salesman's counter back to its source by the system of control stamps. The farms, the cattle, the milk, are all inspected ; the factories frequently visited, the " control stations " and analytical laboratories being under proper organization by the Netherlands Butter Control. The butter bears the firm's stamp and a Government label, and any infraction of the rules of the Butter Control brings a heavy punishment upon the offender. All the Netherland dairies are not under this control, but practically all the firms of good repute belong to it, and they are debarred from purchasing

milk or butter from farms which are not inspected and under official control.

In Denmark butter-making is carried out under a system of co-operative dairying, each member of a society being paid for the milk delivered to the factory, less a deduction for working expenses. It is asserted that under this co-operative system better results are obtained than in private dairying, the butter being more abundant, more uniform in character, and of better quality. The milk is heated, the cream separated by centrifugalization, and pasteurized. The system of control is not national, as it is in Holland; but nothing is left undone to secure the best results, and certain marks, such as the "Lur" (*lyre*) in Denmark and "Reine" in Sweden, which are national insignia, are allowed to be used only by dairy companies complying with certain tests and regulations.

Canadian butter is also made to some extent on the co-operative principle. If, as a large importer informs the writer, Canadian butter always arrived perfectly fresh, like the Danish and Dutch, the latter would have a formidable rival. In New Zealand the dairies exporting butter are registered, classified, and must use an official number for each package. A considerable quantity of butter is also exported from Siberia by dairies using up-to-date methods and machinery. In the spring and summer the greatest importation of butter into England is from Ireland, Denmark, Holland, and Canada; in the winter Argentina and Australian butters meet with great appreciation.

Butter-making.—Standard butter is the fat of milk obtained by churning the cream. It should contain not less than 82·5 per cent. of milk-fat, and not more than 16 per cent. of water. It always contains a small quantity of casein and milk-sugar, and common salt may or may not be added.

Milk-fat normally exists in the form of separate globules, which are prevented from forming a conglomerate mass by a membranous pellicle, a thin layer of casein, or a film of milk plasma, according to different authorities. These points have been discussed over and over again, but still remain unsettled. It suffices to know that the globules are normally separated from one another, and the process of making butter consists in causing them to coalesce. This is done by churning the whole milk or the cream which has been separated from the milk. The first method is called "whole-milk churning," and involves a considerable amount of labour; it is therefore not generally adopted. When this method is used, the milk is kept for a few days or a week until it coagulates, and is then churned. The process depends on the lactic fermentation, for new or sweet milk yields butter even more slowly than sour milk. Where this method is most in use—*e.g.*, parts of Scotland and Ireland—the process has been improved. Lactic fermentation is hastened by adding to the fresh milk some previously "soured" milk, and keeping it at a temperature of 70° F. for twenty-four or thirty-six hours; it is then churned.

The second method is called "cream-churning," and is adopted almost everywhere. The cream is usually set aside for about thirty-six hours, during which it becomes sour, or "ripens." Sweet cream gives less butter and requires longer churning than ripened cream. It is also asserted that butter made from *sweet* cream lacks the characteristic *nutty* flavour of butter made from ripened cream; but it keeps better.

The cream is obtained either by the old-fashioned method of "setting" the milk and skimming it by hand, or by the modern method of using a cream-separator or centrifugalizing machine. In the skimming method the product is called "gravity cream," and the rising of the cream is hastened by various devices, such as placing the milk in shallow pans. The milk can be perfectly creamed at a proper time, which varies with the temperature at which the milk is kept. The cream rises most rapidly in an atmosphere of 60° F., when most of it can be skimmed off in twenty-four hours; at a temperature of 50° F. the milk would require thirty-six hours to give up the same quantity of cream; and at 35° F. it would yield little cream in three weeks.

There are various forms of the centrifugalizing separator—*e.g.*, the Laval and the Alexander—by means of which the cream can be obtained immediately the milk is drawn from the cow. The principle is that of centrifugal action. The separator consists of a central closed drum, which is made to revolve 6,000 to 8,000 times per minute, in consequence of which the heavier portion of the fluid is thrown to the outside, and escapes through a slit in the outer wall of the drum. The cream meanwhile, being of lighter specific gravity, accumulates in the centre, where it forms a column, which rises and escapes through a small opening at the top, and is received on a tray and conducted by a spout to the churn. Cream obtained in this manner is called "separator cream," is perfectly sweet and fresh, and yields more butter and of greater uniformity than that obtained by skimming. There are other differences between butters made from gravity and separator cream, but these are chiefly due to the methods of dealing with it. In old-fashioned dairies the cream is allowed to accumulate for a week, during which it is liable to undergo undesirable changes; and the butter is *worked* by hand. In modern dairies the separator is in almost universal use, the butter is made quickly, and therefore undesirable changes in the cream are less likely to occur. There is practically no handling; cleanliness and carefulness in the manufacture predominate.

But the same system is not in vogue in all the large butter manufactories, and consequently there are different qualities of butter. They are as follows:

1. **Creamery Butter.**—This consists of butter made in a "creamery" from cream obtained by a separator. The creamery deals only with the cream, which is delivered to it fresh every morning by the dairyman or farmers of the surrounding district. This is

the chief system in Ireland; but it is also practised in Holland, Denmark, other European countries, and in the United States, as a part of the co-operative system of working. Besides "creameries" where cream alone is received and dealt with, there are in England and elsewhere many factories where the whole milk is received, the cream being separated at the factory and dealt with in the same manner, and the product is still called "creamery butter." In such establishments the separated milk is used for feeding pigs and calves, or for making skim-milk cheeses, milk-powder, milk-albumin, and milk-sugar.

2. **Imitation Creamery Butter** is that which is made on a small scale, in the same manner, by farmers or dairymen. Such butter is collected by dealers from numerous farms before it is washed, salted, or worked; the dealer undertakes these duties. By mingling together the butters from various sources—washing, salting, and kneading them before they are put on the market—they obtain a better quality and more uniform character than butters made by the older methods.

3. **Dairy Butter** is butter made, salted, and packed, by the dairymen, and is sold in the original packages. It is mostly made by old-fashioned methods.

4. **Factory Butter** is butter bought in rolls, lumps, or packages, and reworked by the dealer. Butter factories exist in Great Britain and many parts of the world. The system is well known in Ireland and Normandy, where the butter is churned by farmers, bought by factors, sorted by them, and sent to factories in rolls, baskets, or boxes, containing 28 to 56 pounds each. In the factory it is washed, from 3 to 7 per cent. of salt being added, and it is worked by a powerful butter-machine and packed in firkins for the market.

The butter, on delivery at the factory, is separated into salted and saltless, and is worked two or three times, salt being added at the second working. The necessity of working it two or three times is to remove as much as possible of the buttermilk, to reduce the moisture to 10 or 12 per cent. (not more than 16 per cent. being allowed), and to blend the butter received from various sources. Such butters are then weighed and wrapped in cartridge-paper. Butter can arrive in England from Denmark, be worked and blended in a factory, weighed, and sold to the consumer, within four or six days after it leaves the churn. That from other countries depends upon the distance and means of transport.

5. **Renovated Butter.**—This usually consists of factory butter which has become stale, rancid, or otherwise unsaleable. It is derived from many sources. It is purified by being melted down, clarified, refined, and deprived of deleterious odours, and especially rancidity.

6. **Milk-blended Butter.**

The Yield of Butter.—The proportion of butter obtained from milk of cows of different breeds varies with the relative richness o

fat. But the milk-fat of some animals yields more butter than that of others. Aikman gives the following particulars :

Breed of Cattle.	Butter from One Pound of Milk-Fat.
Guernsey cows	1·07 pounds.
Jersey cows	1·04 ,,
Holderness (American) cows	·98 ,,
Devon cows	·97 ,,
Ayrshire cows	·93 ,,
Holstein (German) cows	·88 ,,

The difference probably arises from differences in the size of fat-globules, Guernsey and Jersey animals yielding cream containing a greater proportion of large globules, and the Holstein a greater proportion of small globules. Milk containing large fat-globules yields richer cream, and therefore more butter.

The Changes which take place in Butter-making.—These changes are due to—(*a*) ripening of the cream ; (*b*) churning the butter ; (*c*) development of the flavour. The common mode of manufacturing the butter is to set aside the cream until lactic fermentation occurs and it becomes sour. Why this should influence the butter-making process is not quite clear. But, according to Babcock, the globules of milk-fat are kept from coalescing by a thin film of fibrin which surrounds them. It is therefore possible that lactic fermentation or ripening of the cream causes the solution of the fibrin, thus permitting the fat-globules to come together more easily. When the cream is ripe, it is transferred to the churn and agitated until the fat is separated from the buttermilk, and collects in masses. This is aided by raising the temperature of the cream to 60° F., or even 70° F., by means of warm water. The butter is formed in ripened cream by agitation for fifteen to thirty minutes, but the time is prolonged by unfavourable conditions, such as too high or too low temperature. Sweet or unripened cream requires to be churned a longer time to produce butter, and it is better to begin with a temperature of about 54° F. (12·5° C.), and raise it gradually. The crude butter is then removed, washed, salted, and worked.

The old-fashioned method of allowing the cream to ripen spontaneously left it open to the action of deleterious organisms. By the modern method, which is adopted in all large "creameries," the cream is *pasteurized* by raising the temperature to 194° F., thereby eliminating numerous undesirable bacteria. It is then cooled to about 50° F. It is ripened by the addition of a "starter," consisting of a pure culture of the desired organism, and it is churned on the following day. The crude butter is then washed and kneaded in water, to remove casein and other non-fatty constituents. It is then again "worked" (*kneaded*) by hand or machinery, to remove excess of buttermilk and give to the finished product a proper texture and grain, which is recognized as a desirable quality of the butter.

The characteristic flavour and aroma of butter are among its

highest attributes. These characteristics are developed by the action of micro-organisms, and are connected with the decomposition of certain substances. Butter which is devoid of this flavour and aroma is not so palatable, and is not valued so highly. Micro-organisms therefore are essential for the production of good butter. The chief object in butter-making is to produce those conditions which favour the development of the proper kind of bacteria.

The flavour and aroma of butter are signs of its genuineness, and are those which arise in the product of properly ripened cream, under suitable conditions. These qualities vary even in properly ripened cream. Thus, the butter made from separated cream differs in flavour from the product of skimmed or gravity cream. Even the individuality of the cow plays an important part. The period of lactation influences the flavour and other qualities of the butter, for various changes in the composition of the milk occur as this period lengthens. The milk from fresh cows—*i.e.*, soon after parturition—does not contain quite so much fat, but the globules are larger and the butter of better quality. The milk of cows well advanced in lactation contains smaller fat-globules, the butter is firmer, of lighter colour, and not so well flavoured. But the quality also depends upon the manner of feeding and housing the cattle. Butter is a sensitive product, and the taste or smell shows when it has been kept in unwholesome surroundings.

The principal factors in developing aroma, therefore, are the feeding and housing of the animals, the period of lactation, and various bacteria of the lactic-acid-producing group. So widely recognized are these bacteria as the agents in producing the changes to which the aroma and flavour are due that many makers depend entirely upon cultivations of these organisms for producing the desired flavour. "Among the bacteria found in cream, there are a few species whose growth in the cream produces therein a pleasant and desirable aroma and flavour. These are seemingly fewer in numbers than the others, but it is to their presence that a good butter is due, and it is, with little doubt, largely the presence of these species in June cream, and their absence in January cream, that gives June butter a better flavour than winter butter. The butter-maker, in ripening his cream, will always produce in it a certain amount of acid from the lactic acid organisms, and, even if no proper flavour-producing species are present, the butter he obtains will be a moderately good product, providing that he does not happen to have any of the mischievous species present [such as would cause abnormal ripening of the cream—*Author*]. He knows well enough that during certain seasons of the year he can obtain a butter that has no very bad taste, and yet that does not have the desirable flavour. No method at his disposal will enable him to give his butter the flavour he desires. . . . Conn has, however, found that winter cream and June cream contain a distinct bacterial flora in the same creamery; that the species differ in different

creameries at identical dates ; that, in short, the bacterial flora of the creamery is undergoing constant change, and that it is largely a matter of luck whether the cream at a given creamery chances at a certain time to have the high flavour-producing species present. To eliminate this factor of luck from the ripening of cream, pure cultures have been prepared of the bacteria, which sour and give the desired flavour and aroma to cream, and these cultures are now used in practical experiments. When inoculated into cream, they sour it rapidly, and produce at the same time a desirable aroma. The use of these organisms has extended from the laboratories where they started in Denmark and Germany, and at the present time are somewhat widely used in European countries."[1]

The bacteria which produce the flavour and aroma do not materially aid in ripening the cream, and therefore lactic-acid-producing organisms are essential to that process, as well as those which produce the flavour. Conn isolated an organism, called by him " Bacillus 41," which, when added to cream ripened by lactic acid bacilli, gives to it the flavour of first-class butter. He used it in good cream, poor cream, fresh cream, stale cream, separator and gravity cream, and in every instance it produced a uniform flavour. In fact, Bacillus No. 41 gives to the butter a flavour which butter-makers describe as a " quick-grass " flavour, and such as is usual in June butter. The regular use of cultures of this bacillus will produce butter having that flavour all the year round. The use of such cultures is on the increase, and is now quite common in the best creameries.

The method adopted in Denmark is to sterilize the cream by heating it to 180° F., cooling it, and then adding the bacteria for ripening it. The cultures of lactic-acid-producing bacteria are made in skim milk, from 5 to 15 per cent. of which is added to the cream, and the bacteria allowed to flourish therein until it contains from 0·5 to 0·75 per cent. of lactic acid. " If this amount of acid is not present when the cream is churned, the butter will not develop the aroma and character so much desired. If, on the other hand, too much acid is developed, the butter will be sour and have an unpleasant flavour. This ripening of cream is so important that investigators have sought other means of producing it. But the mere addition of lactic acid to the cream is useless. The bacteria must do the work in a natural and progressive way, and no other way of developing the acid in cream will produce the result desired."[2]

The desirability of sterilizing the cream is shown by the fact that the bacteria differ at different times of the year ; that butter made in the early summer is better than that made at other seasons, the proportion of undesirable ferments to the lactic-acid-producing ferments being smaller at that time than in autumn and winter

[1] Farmers' Bulletin 29, U.S. Department of Agriculture, p. 18.
[2] Report of Bureau of Animal Industry, 1903, U.S. Department of Agriculture.

seasons. Again, the butter made from sterilized cream is cleaner and keeps better than when no care has been taken to destroy the undesirable organisms so often present in unsterilized cream.

The number of **bacteria in butter** is naturally great, owing to the mode of its preparation. Investigations made by Lafar showed that a gramme of butter, taken from the centre of a pound of Munich butter, contained 2,500,000 bacteria, a gramme from other portions contained as many as 45,000,000, and average butter contained 10,000,000 to 20,000,000 bacteria per gramme. The presence of pathogenic bacteria in butter is, of course, very dangerous, but, fortunately, these are few, and do not find a suitable breeding-ground in it. Lafar gave it as his opinion that any typhoid or cholera bacteria which chanced to gain an entrance to the butter would not develop therein to any extent, that the species would die out in five to seven days ; and that the tubercle bacillus would also lose its power of doing any harm in twelve days.

Abnormal Flavours in Butter.—Various undesirable flavours get into butter in one way or another. These may be due to contamination by various gases and volatile odoriferous matters. But they are chiefly due to bacterial action and rancidity. Such bacteria do not live very long in fat, but they may live long enough to produce *enzymes* which continue to act upon the fat after their death ; *e.g.*, the peculiar fishy taste which butter occasionally gets is believed to be due to a fat-splitting enzyme. Bad flavours in butter may, however, arise from the animal which gives the milk breathing tainted air, from its consuming food containing volatile oils—*e.g.*, wild-garlic, onions, turnips, cabbages, various weeds, and the residues of breweries or distilleries, or other aromatic and odoriferous substances—or even from drinking foul water. The use of salt which has become tainted may be the means of imparting an unpleasant flavour to butter. Certain foods are also said to increase or diminish the amount of butyric acid. The period of lactation also influences the flavour and other qualities of the butter.

Rancidity.—The rancidity of butter and other fats is an unpleasant change which renders the substance more or less uneatable. During the change the butter becomes altered in colour, taste, odour, and general appearance. The colour first becomes lighter on those parts which are exposed to the air, and the decoloration gradually extends throughout the whole mass. At the same time it develops the flavour and aroma of lard, but the odour becomes gradually more and more pungent, and the taste of a burning and unpleasant character. The consistence of the butter likewise changes ; it loses the firmness which characterizes good and well-worked butter ; it becomes more or less granular in appearance, and after some months assumes a semi-solid or pasty appearance.

The cause or causes of this transformation are not thoroughly understood. But the conditions which favour the change are a combination of air, warmth, and light. The presence of nitrogenous

matter or curd is also partly responsible for the change in butter, for when the butter is well washed and freed from casein it keeps much better. The amount of moisture in butter also influences the keeping properties. There are two theories of the origin of rancidity—viz., bacterial action and oxidation. But whether the phenomenon is due to an enzyme from the growth of bacteria, or purely chemical, has never been satisfactorily settled. But the chief cause is the oxidation of fat, however that may be brought about. Olein soon becomes rancid on exposure to the air. It is probably a fermentative change due to bacteria, because there are developed, besides free oleic and butyric acids, acetic, formic, and œnanthic acids and their aldehydes ; and these are the materials that render the substance unfit for food. Chemically the action is usually represented as a splitting of the fatty molecule by means of oxygen. The fatty acid is thereby set free, and by the continued action of oxygen the normal free acids are converted into hydroxy-acids—*e.g.*, butyric becomes hydroxy-butyric acid. According to Hyerdahl, the action is due to the introduction of hydroxyls into the molecule ; and he found that by heating the fat or oil to 300° F., while conducting a current of air through it, the rancidity increased enormously, but the acidity increased but little. It matters not, however, whether the action be due to the introduction of oxygen or hydroxyl into the molecule, for there are bacterial enzymes which are capable of introducing either of them ; and it is almost certain that the changes are initiated by bacteria. Many bacteriologists have studied the problem of rancidity, and there seems little doubt that bacterial action is partly the cause when the butter contains an excess of casein and sugar. Jensen undertook a series of exceptionally careful experiments, and arrived at the following conclusions ("Studien über das Ranzigwerden der Butter," *Jahr. d. Sch.*, 1901) :

1. The air plays a part in the process of rancidity, but is not the cause of the change in question. It acts as a stimulant for the growth of bacteria.

2. The rancidity of butter is due to the action of micro-organisms.

3. The chief causes of rancidity are *Oïdium lactis*, *B. fluorescens liquefaciens*, and *Cladosporium butyri*.

4. These organisms grown in the presence, but not in the absence, of oxygen.

5. The presence of salt checks the growth of bacteria, and thus delays the rancidity. To protect butter from rancidity it is desirable to keep it in large masses, under which conditions the inner parts of the butter will remain without change, though the surface may become rancid.

The Composition of Butter.—Butter consists of small globules of fat, and moisture which contains small quantities of casein, albumin, sugar, and mineral matters in solution, adhering to them. The proportion of these substances varies in samples derived from the same dairy, or even the same animal (see Table A).

A.—COMPOSITION OF BUTTER—PERCENTAGES.

Nutrients.	Butter Average (König).	Butter Average (U.S.A.).[1]	Fresh Butter.	Salt Butter.	Fresh Butter.[2]	Butter from Normandy.	Butter from Isle of Wight.	Butter from Guildford.	Butter from Winchester.	Foreign Butter: Mean of 89 Analyses.
Water	11·7	12·0	14·50	12·80	13·0	9·3	9·7	8·6	8·6	14·1
Fat	87·0	84·0	83·38	84·06	83·9	82·7	84·7	85·5	87·2	83·1
Casein and albumin ..	·5	1·0	·80	·67	2·7	5·1	3·5	2·8	2·1	1·6
Lactose	·3		1·12	·69						
Salt	—	3·0	—	—	·4	2·9	2·1	3·1	2·1	1·2
Mineral ash	·3		·20	1·78						

[1] Bureau of Animal Industry, U.S. Agricultural Department Report, 1903.
[2] Wynter Blyth's "Foods" for this and following analyses.

B.—COMPOSITION OF BUTTER—PERCENTAGES.

Samples from Various Sources.	Water.	Salt.	Curd.	Butter-Fat.	Specific Gravity at 100° F.	Fixed Acid.	Soluble Acid.	Melting-Point.
No. 1	7·55	1·03	1·15	90·27	913·89	85·56	7·41	85·0° F.
No. 2	11·71	3·60	·95	83·74	911·45	88·24	5·41	90·0° F.
No. 3	16·89	8·56	1·23	73·32	911·48	88·22	4·64	89·5° F.
No. 4	16·28	3·32	1·56	78·84	912·79	86·00	7·00	88·5° F.
No. 5	11·42	1·29	1·12	86·15	910·47	88·53	8·44	90·0° F.
No. 6	12·55	·80	·74	85·82	910·20	89·00	4·57	90·0° F.
No. 7	12·96	2·43	1·25	83·36	912·51	88·25	5·45	89·0° F.
No. 8	13·40	1·39	2·03	83·18	911·67	88·72	5·07	90·0° F.
No. 9	12·05	·96	1·95	85·04	911·04	87·51	5·28	88·0° F.
No. 10	14·62	1·48	1·88	82·04	910·70	89·00	4·50	91·0° F.

A more extended analysis of ten samples of butter is given in Table B.

The **fat** is by far the most important constituent of butter, and stands first in necessity of consideration. Butter-fat consists of 91 per cent. of olein, palmitin and stearin (or triglycerides of the corresponding fatty acids), and 9 per cent. of *volatile* fatty acids. The fat can be separated from the water, curds, and salts, by submitting it for some time to a gentle heat, when the fat or " butter-oil " will rise to the surface, and can be removed and filtered for analysis. The oil so obtained is found to consist of 12·5 per cent. of glycerine combined with fatty acids, so that olein and palmitin together form 70 per cent. or more of the butter, but in such proportion that $\frac{3}{10}$ or $\frac{4}{10}$ is olein, and the rest is *chiefly* palmitin ; it also contains a small proportion of the triglycerides of stearic and myristic acids, and much smaller amounts of lauric, arachidic, butyric, dioxystearic, capric, caproic, and caprylic acids, and traces of *mixed* glycerides of fatty acids. The volatile fatty acids give to butter some of its best characteristics ; but it should be observed that they may also give unpleasant ones. *Butyric acid* has an odour resembling rancid butter ; *caproic* and *capric acids* have an odour resembling goats or sheep ; *caprylic acid* has a feeble but rather unpleasant odour. According to Duclaux, the volatile fatty acids amount to 70 per 1,000, of which 37 to 41 is butyric acid, and 20 to 33 per cent. is caproic acid. The following analyses are typical examples of the proportions of fatty acids obtained :

THE FATTY ACIDS IN ONE HUNDRED GRAMMES OF BUTTER-FAT.

Analysis by Hehner and Mitchell.[1]

	Per Cent.
Stearic acid	1·83
Distearic acid	1·00
Oleic ,, ...	32·50
Palmitic ,, ...	38·50
Myristic ,, ...	8·89
Lauric ,, ...	2·57
Capric ,, ...	·32
Caprylic ,, ...	·49
Caproic ,, ...	2·09
Butyric ,, ...	5·45
Total acids per cent.	94·50

Analysis by Bell.[2]

	Per Cent.	
Volatile or soluble :		
Butyric acid	6·13	
Caproic ,, ...	} 2·09	
Caprylic ,, ...		
Capric ,, ...		
		8·22
Non-volatile or insoluble :		
Oleic acid	36·10	
Palmitic, stearic, lauric, and myristic acids	49·46	
		85·56
Total acids per cent.		93·78

The chief characteristics of pure butter-fat are the high proportion, *at least* 7 per cent., of soluble or volatile fatty acids, and the melting-point—viz., 31° to 34° C. (88° to 93° F.). Pure *dry* milk-fat has a melting-point of 35·8° C., at which the specific gravity = 0·914. The high melting-point is due to the proportion of the different fats in it. Olein, which comprises 35 to 40 per cent., is a nearly colourless oil at ordinary temperatures, and solidifies in

[1] *Journal of the Chemical Society*, abstract, 1899, 55.
[2] Bell's " Chemistry of Foods," ii. 64-66.

needles at −6° C. It is without colour, taste, or smell; but it soon becomes rancid on exposure to the air. It acts as a solvent for palmitin and stearin, which form 40 to 50 per cent. of the butter, and are solid at ordinary temperatures. Stearin is the hardest and most insoluble of these fats; its melting-point is 63° C., or, when quite pure, 71° C. Palmitin, which forms the greatest proportion of butter-fat, usually melts at 62° C., but this point is variable. The combination of the fluid olein with the solid palmitin, etc., makes a mixture of which the melting-point is much lower—viz., 31° to 34° or 35° C.—which serves to distinguish it from other fats and oils.

The **casein** and **lactose** vary from 0·75 to 5·0 per cent. First-class butters usually contain 0·5 to 1·0 per cent. of **curd,** and second quality about 2 per cent. When the butter is worked, the expressed moisture is milky owing to the presence of curd. It might at first glance be thought that the presence of curd in butter would be an advantage; but the reverse is the case, because it is liable to speedy decomposition by the action of bacteria, and predisposes the butter to changes of flavour and rancidity.

The natural **mineral matters** vary from 0·1 to 0·3 per cent., and consist of the normal inorganic substances of the milk, dissolved in the moisture of the butter.

Salt.—Natural butter is without added salt, and is the product of greatest commercial value, owing to its absolute freshness, palatability, and agreeable aroma, its fine grain and even texture. It is, however, seldom sold free from salt, the custom being to add a small proportion to give flavour. There is no well-marked line between **fresh** and **salt** butters, although the two classes are recognized. The addition of salt deepens the colour, brings out the flavour, renders the substance drier, and acts as a preservative. Salt butter usually contains 1 per cent. less moisture than fresh butter. The chloride of sodium acts as a preservative by preventing the growth of bacteria. The chlorine-ion arising from the dissociation of salt in solution is the actual preservative. But it is considered that the condimental value of the salt is more important than the bactericidal. It has been shown that pathogenic bacteria do not readily develop, and do not live long in butter or other fats.

The amount of salt which may be added to butter is not defined by law, but is left to the individual taste of the maker and consumer. Formerly many salt butters contained 6 or 8 per cent., but it is now rarely found to contain more than 5 per cent. As a matter of fact, although individual tastes differ, a proportion of 2 per cent. is quite enough to give flavour, and this is considered to be the limit which should be added for *palatability*. On the other hand, a much larger amount would be necessary to act as a preservative, and would render it unpalatable or unpleasant to most people. The salt which is used in butter-making should be of the finest quality—*i.e.*, as pure as possible, and fine enough to

dissolve in the residual moisture of the butter. It should be uniformly distributed throughout the material, for the existence of recognizable or undissolved crystals would be detrimental to the value of the finished article.

Water.—The amount of moisture in butter varies from 6 to 16 per cent. When made under favourable conditions, butter seldom contains more than 15 per cent. If it contains more than this amount, it will not keep its good qualities ; if it contains much less—say 6 to 9 per cent.—the flavour will not develop, and it soon assumes a *tallowy* flavour and characters ; it is considered that from 10 to 14 per cent. of moisture is the proportion best suited for the production of good body and the development of agreeable flavour.[1]

Butter may contain an excess of moisture because it has not been sufficiently worked. On the other hand, the butter may contain an excess of moisture by *design*, for it can be made to take up milk, brine, or even plain water. "Milk-blended" butter usually consists of butter originally containing a *low* percentage of moisture, like some foreign or colonial samples, which is re-churned with milk in such a way that the moisture is increased up to 25 or 30 per cent. This procedure is now illegal, for in 1902 the British Board of Agriculture made a regulation that "where the proportion of water in a sample of butter exceeds 16 per cent., it shall be presumed for the purposes of the Sale of Food and Drugs Acts, 1875 to 1899, until the contrary is proved, that the butter is not genuine by reason of the excessive amount of moisture therein." Also, according to the Butter and Margarine Act, 1907, *milk-blended butter* should contain not more than 24 per cent. of moisture, and the proportion must be stated upon the wrapper. This point of law, however, is frequently evaded by the salesman giving to the butter a fanciful name, which is permitted by the Board of Agriculture.

Colour.—The natural colour of butter varies from white to orange-yellow, according to the breed of the cow and kind of food. The colour of butter is usually darker in summer and paler in winter. It is determined by a variety of other circumstances; *e.g.*, salt deepens the colour. But on account of the butter being paler in the winter months, it has been the custom from time immemorial to colour it artificially. This practice has been extended in most dairies to all butter, no matter what the season. The object of the artificial coloration is to make the butter more agreeable to the eye, or to give it the appearance of having a better quality than its other properties would warrant. When the animals are properly fed, even in winter months, the butter should have a naturally agreeable and characteristic appearance. If the food contains carrots, turnips, and mangolds, the product should be a butter of light amber tint.

[1] Report of Bureau of Animal Industry, 1903, U.S. Department of Agriculture.

The vegetable colouring matters—annatto or anotto, saffron and turmeric—are not unwholesome ; but the use of aniline dyes, which is practised in some dairies, is reprehensible and not without danger. In no case is the addition of colouring matter *necessary ;* the use of deleterious colouring agents should be forbidden ; and vegetable colours are liable to become paler on exposure to light.

The Solidity of Butter.—This quality, like the former, is influenced by various circumstances. Butter should be firm at 50° or 60° F. ; not soft like lard nor hard like tallow, but something between. It should, in fact, have such a consistence that it can readily be spread upon bread. When broken, it should present a **grain** similar to that of steel. This property is also influenced by different circumstances—*e.g.*, breed, food, and period of lactation. Jersey cows give butter which will resist the effect of a warm atmosphere. In advanced lactation the fat-globules are smaller and harder, the butter firmer in texture. Green fodder and mangolds cause the production of butter having a low melting-point and a high percentage of volatile fatty acids. Linseed meal or cake and wheat-bran cause the butter to be comparatively soft and oily, because these foods contain more olein. On the other hand, hay and silage produce a butter having a high melting-point, while cottonseed cake or meal produces butter which is hard and crumbly, because the food contains more stearin.

The Analysis of Butter.—The use of the term "butter" is restricted by the Margarine Act of 1887 to the product of milk or cream ; while "butterine" and other butter substitutes must be called "margarine," or some other name which distinguishes it from butter, after January 1, 1888. It is an undoubted fact, however, that butter is sometimes sophisticated ; and the object of analysis is to discover adulteration, blending with milk, excess of water, etc. It is not intended here to give a detailed account of such analysis, but merely to indicate the chief points of importance and some of the methods adopted by the analyst.

Estimation of Water.—A known weight of butter is dried in a *tared* metal dish, over a water-bath at steam heat, until it ceases to lose weight, the time occupied being probably three or four hours. Supposing 100 grains or grammes of butter are used, and the remainder weighs 89 grains or grammes, the loss of weight will be 11 grains or grammes, and it represents the percentage of water. Or take 15 grammes of butter, place it in a silver or platinum dish, together with a glass rod, both of known weight ; heat it at a temperature of 105° C. (221° F.), occasionally stirring it, *until all foaming and crackling ceases*, or steam ceases to be given off ; cool and weigh it. The loss is due to water driven off. Let x be the loss and y the percentage of water ; then $\frac{x \times 100}{\text{weight of butter}} = y$, or percentage of water.

The Proportion of Salt is estimated in a similar manner to water. A known quantity of butter is burnt in a suitable chamber ; the residue represents salt plus normal mineral ash. Let x represent the residue and y the percentage of salt, plus ash ; then $\frac{x \times 100}{\text{weight of butter}} = y$, and y minus the normal percentage of mineral ash (0·1 to 0·3 per cent.) is the proportion of common salt.

Determination of Fat.—When the moisture has been ascertained, the residue is used for determining the proportion of fat and curd. The fat is extracted by treating it with ether and allowing the residue to settle. The ether solution

is then decanted, filtered through dry blotting-paper into a beaker of known weight, and evaporated by gentle warmth. The residual fat is then weighed, and the percentage ascertained by the above formula ; x = the residual fat, and y its percentage.

The *Curd* is now ascertained. After the dried residue was washed with ether, there remained behind a residue consisting of salt and curd. This deposit is evaporated, dried, and weighed. The weight of common salt already ascertained is deducted, and the remainder is the amount of curd in the original butter. The percentage is found as before : Let x = the curd in a given weight of butter and y its percentage ; then $\frac{x \times 100}{\text{amount of butter}} = y$, or percentage of curd.

The Detection of the Adulteration of Butter.—This is a matter of much importance, and requires great care in carrying it out. The chief adulteration is the mixture of various fats from animal or vegetable sources, and various points of importance are investigated by the following tests :

Heat.—The application of heat may indicate several points. (*a*) The *melting-point* is of importance ; *pure* butter melts at a temperature varying from 86° to 94° F., but usually from 88° to 91° F. ; the melting-point of margarine and beef-fat is rarely above 82° F. (*b*) When pure butter is burnt, it does not give off a disagreeable odour ; margarine or butter adulterated with margarine gives off an odour more or less like that of tallow—that is, of a candle which has just been extinguished. (*c*) When a small piece of butter is heated in a metal spoon over a flame, a distinction may be observable between pure butter and that adulterated with margarine : pure butter boils without much noise and shows a foamy or frothy head ; margarine, or highly margarinized butter, boils noisily—it bumps and spits. (*d*) When butter is heated in a test-tube, in a water-bath, for about forty-five to sixty minutes, the butter-fat, water, salt, and curd, separate ; the fat coming to the top, the water, etc., sinking to the bottom. If it consists of pure butter, the fat is clear and transparent ; the presence of margarine gives it a turbid or milky appearance.

Specific Gravity.—This is determined by means of a S.G. bottle. The bottle is such that it will hold 1,000 grains of water at a definite temperature—*e.g.*, 100° F., or at 15° C., or some other well-known standard. Butter is sufficiently liquid at 100° F. to be poured from one vessel to another, hence the frequent adoption of that temperature. If the bottle holds 1,000 grains of water at 100° F., but will only hold 913 grains of butter at the same temperature, then S.G. of butter $= \frac{913}{1000} = 0{\cdot}913$. As a matter of fact, the S.G. of pure butter-fat varies from 0·910 to 0·914 ; it very rarely sinks below 0·910, and never below 0·908, the average being about 0·912. But margarine and other animal fats have a lower S.G.—viz., from 0·901 to 0·904. The S.G. of beef-fat is never above 0·904. If, therefore, any sample of butter has S.G. between 0·901 and 0·904, it probably consists of oleo-

margarine alone; and if the S.G. is between 0·904 and 0·910, the butter is not genuine, but is probably adulterated with margarine. If therefore we take 0·910 as the *lowest* S.G. of butter-fat, and 0·904 as the *highest* S.G. of foreign fat, the difference of six degrees would show 100 per cent. of adulteration. Now, supposing the sample of butter has S.G. 0·907, the difference will be three degrees, and therefore $\frac{3 \times 100}{6} = 50$ per cent. of adulteration. As a matter of fact, the process of taking the S.G. is done more particularly than is indicated above, for it is necessary to heat the butter over a water-bath at 150° F. until the fat separates, the water, curd, and salt, settle to the bottom, and the clear butter-fat can be poured into the S.G. bottle, the latter being provided with a thermometer, so that the weight can be taken when the temperature of the fat is exactly 100° F.

Valenta's Test is also applied for the detection of margarine in butter. It depends upon the temperature at which a mixture of melted fat and acetic acid becomes clear and transparent. It is customary to use a graduated test-tube, which must be perfectly dry. An equal volume of the clear melted fat and glacial acetic acid (S.G. 1·056) are agitated together and warmed over a lamp until the fat is dissolved. A thermometer is then put in to stir the mixture and take the temperature. The point of clearness or turbidity is then read off. Pure butter-fat is *clear* at 40° C. (104° F.); if it is boiled, the liquid becomes *turbid* when the temperature falls to 56° or 62° C. (133° to 144° F.). Margarine is *not clear below* 75° C. (167° F.); boiled margarine becomes *turbid* when the temperature falls to 98° or 100° C. (208° to 212° F.). Any sample of boiled fat and acetic acid which becomes turbid on cooling between 62° and 98° C. (144° to 208° F.) is probably a butter adulterated with margarine. But the usual method of ascertaining whether any sample consists of pure butter or is adulterated with margarine is by determining the proportion of volatile acids in it.

The **Reichert Number** is the number of cubic centimetres of a standard alkali solution which are required to neutralize the volatile fatty acids contained in 5 grammes of the fat under examination. As a general rule, English butter made in the customary manner, from a mixture of cream derived from the milk of a herd of cows, has a Reichert number = 29. The number naturally varies considerably in the butter of individual cows, and is found to range from 20 to 33. The analysts of the United Kingdom, however, have adopted a *minimum* Reichert number of 24 for genuine butter, below which, in the consensus of opinion, it should not fall. Margarine containing no butter has a Reichert number which does not exceed 1 or 2, and in a *mixture* of butter and margarine it varies from 2 to 24.

The Reichert number is obtained by the "Reichert" method, the "Reichert-Meissl" method, or the "Reichert-Meissl-Wollny" method. The presence of volatile or soluble fatty acids gives to

butter and all other fats and oils special characteristics. The most important volatile fatty acid is **butyric,** which is characteristic of butter and cheese. The proportion of volatile fatty acids varies in different fats and oils ; thus, it forms 8 or 9 per cent. of butter, and is never lower than 4·5 per cent. ; but it forms only 1 per cent. of margarine and other animal fats, and in cottonseed-oil is as low as 0·5 per cent. The object of the Reichert number is to ascertain the proportion of volatile acids present, and thereby to judge of the genuineness of butter or the presence of foreign fat. The method is as follows :

Five grammes of the clear butter-fat (rendered free from water, curd, and salt, by heating in a test-tube in a water-bath until the fat rises to the top) are put into a flask. It is treated by agitation with an alcoholic solution of potash, and heated. It is next treated by diluted sulphuric acid. In this manner the fatty acids are set free. The flask, previously connected with a condenser, is now heated, and the " volatile " fatty acids pass over into the receiver, the non-volatile acids remaining behind. The acids in the receiver are now neutralized by the careful addition of a decinormal alkaline solution, the exact point of neutralization being indicated by the use of phenolphthaleïn, which changes colour immediately the neutral point is reached, or, rather, as soon as the reaction becomes alkaline. The number of c.c. of the decinormal solution which have been used is the Reichert number. To take an example suspected to be a mixture of butter and foreign fat : If the volatile acidity of 5 grammes of the fat is found to correspond with 20 c.c. of the decinormal alkali solution, the Reichert number of that sample is 20. But the *minimum* Reichert number of pure butter-fat is 24. Therefore the sample contains $\frac{20 \times 100}{24} =$ 83·3 per cent. of pure butter-fat, and $100 - 83{\cdot}3 = 16{\cdot}7$ per cent. of margarine or other foreign fat.

Variations in the Volatile Fatty Acids.—The work done by van Rijn in the analysis of Dutch butter shows that the proportion of volatile fatty acids falls in the autumn months, especially when the cattle are kept out of doors very late in the year, because the grass becomes poorer and the nights are colder. In such cases, carefully housing the cattle frequently results in a rise of the volatile fatty acids ; indeed, van Rijn has shown that the average Reichert number in all analyses, for the last four months of the year, is as follows : September 24·8, October 23·7, November 25·2, and December 26·6. As a general rule cows are stabled in November, which accounts for the rise. Nevertheless he finds that the average Reichert number of a large number of butters made in October is 23·7, or practically 24 ; and this being the lowest average for herds, it is established as the minimum Reichert number.[1]

[1] " The Composition of Dutch Butter," by J. J. L. van Rijn, 1902. Baillière, Tindall and Cox.

It has also been shown that the food of the cattle also influences the proportion of "volatile" fatty acids. Sir Edward Thorpe has shown that green fodder and mangold-wurzels produce butter containing a large proportion of volatile acids; but when no cereals are given the proportion of volatile fatty acids sinks, and when cottonseed cake is consumed the proportion becomes very low. Adolf Mayer found that when the food is rich in carbohydrates an increase in the volatile fatty acids is produced. There is, however, no connection whatever between the amount of fat in the food and the fat in the butter. But the proportion of volatile fatty acids is influenced by the period of lactation, being at a *maximum* at the beginning of lactation and new pasturage, and decreasing with the period of lactation and the season.[1] Other points connected with the food have to be considered in deciding whether the butter has been adulterated or not. In the first place, although the adulteration of butter with fat other than margarine does occur, it is not common. Secondly, the presence of foreign fat in butter gives special characteristics to it which reveal the presence of such fat on analysis. But it is not an easy matter to say whether such characteristics are due to adulteration of the butter or to that special fat in the food. Thorpe examined various butters received from Wye Agricultural College, and found that—

1. Cows fed on cottonseed cake give a butter which shows a reaction for cottonseed-oil.

2. The butter gives this reaction even when the food contains only a small amount of cottonseed-oil, and the reaction increases, with continuous feeding, up to a certain limit which cannot be passed.

3. The reacting substance passes into the milk within twenty-four hours, and continues several days after the food is stopped.

4. The intensity of the reaction varies with different cows, but does not in any case indicate a greater proportion than 1 per cent. of cottonseed-oil in the butter.

5. Feeding on cottonseed cake produces a butter which, on analysis, shows results tending to diverge still more widely than usual from those yielded by margarine, thus making it easier to distinguish between this and a mixture of margarine and cotton-seed-oil.

6. Feeding with sesamé cake gives no reaction for sesamé-oil in the butter, even after feeding with it for two months.

Cottonseed cake causes the butter to be harder, linseed cake causes it to be sticky and softer than normal butter; maize meal also causes it to be soft and rather oily.

The adulteration of butter with cocoanut-oil is one of the most common, owing to the fact that its presence is not revealed by Valenta's test or the Zeiss butyro-refractometer. One sample

[1] Aikman, "Milk," p. 129.

of butter was found on analysis to contain 8·6 per cent. of cocoanut-oil, and only 76 per cent. of butter-fat ; another sample contained 15 per cent. of cocoanut-oil.[1] Owing to the more difficult detection of this oil, it is necessary to separate and examine the soluble and insoluble fatty acids. In butter the soluble or volatile fatty acids are determined by the Reichert number, which varies from 20 to 30. Cocoanut-oil also contains a fair amount of soluble or volatile acids, but there is a difference in their character. Cocoanut-oil contains *no* butyric and very little caproic acid, the volatile acids consisting principally of capric and caprylic acids. Butter, on the other hand, contains an average of 3·92 per cent. of butyric and 1·88 per cent. of caproic acids ; but these figures are subject to considerable variation.[2]

Preservatives in Butter.—When butter is pure and cleanly made, the use of preservatives other than common salt is unnecessary. But imported butter frequently contains salicylic or boric acid, or formalin. The Departmental Committee of inquiry into the use of preservatives in food recommended to the Local Government Board " that the only preservative it shall be lawful to use in butter or margarine be boracic acid, or borax and boracic acid up to 0·5 per cent."

Boric Acid.—The presence of this preservative is detected by the following method : A little carbonate of soda is added to some melted butter, which is then reduced to ash. The ash is neutralized by sulphuric acid, a few c.c. of alcohol added to it and burnt ; the appearance of a *green* flame is indicative of the presence of boron. The quantitative estimation is more difficult. A known quantity of butter—*e.g.*, 100 grains or grammes—is washed in hot water to dissolve out soluble mineral substances. The solution is filtered through moistened filter-paper. The butter phosphates are precipitated by calcium chloride, the liquid again filtered and treated by a standard alkali solution, a known quantity of which neutralizes a definite amount of boric acid.

Salicylic Acid.—The presence of this acid is detected by ferric chloride. A small quantity of butter is dried, the residue washed with ether to remove the fat, allowing it to stand a sufficient time to deposit any sediment ; the latter is collected, washed in ether several times, and evaporated to dryness ; finally the sediment is dissolved in a few drops of water, and the addition of a drop of ferric chloride will produce a violet colour if salicylic acid be present.

Formalin may be detected by Otto Hehner's method. Add a little clear butter-fat to a little milk ; carefully pour down the side of the test-tube an equal quantity of sulphuric acid ; if formalin is present, a violet colour will appear at the junction of the liquids.

The following table gives particulars of the examination of the

[1] *British Medical Journal*, 1906, i. 529.
[2] *Journal of Preventive Medicine*, 1906, 57.

samples of imported butter in the Government Laboratory for the year ended March 31, 1911:

Country from which Imported.	Total Samples.	Containing added Boron Preservative.		Containing added Colouring Matter.	
		Number.	Percentage.	Number.	Percentage.
Denmark	366	—	—	30	8·20
Holland	219	83	37·90	34	15·50
Australia	199	162	81·40	10	5·00
Russia	157	2	1·30	5	3·20
France	112	96	85·70	5	4·50
Sweden	106	—	—	1	·90
New Zealand	96	69	71·90	3	3·10
Belgium	49	39	79·60	5	10·00
South America	31	27	87·10	—	—
Norway	30	—	—	—	—
United States	13	1	7·70	—	—
Canada	12	3	25·00	—	—
Germany	7	—	—	—	—
Channel Islands	1	—	—	—	—
Totals	1,398	482	34·48	93	6·65
Totals 1909-10 ..	1,084	455	42·00	174	16·10

Renovated or Process Butter.—When butter has become rancid or otherwise unsaleable, it is "renovated" in the following manner: The butter is melted over a water-bath, the water and curd allowed to settle, and the butter-fat decanted. The fat is then "blown" with air to remove the objectionable flavour and odour, and rapidly cooled to prevent the separation of the component fats which liquefy at different temperatures. The purified fat is then churned with new milk containing cultures of various bacteria to develop flavour and aroma. By this means, also, the butter derives curd and water from the milk. Such butter, however, is different from genuine butter. When melted over a water-bath, the fatty layer never becomes clear even after long standing, whereas the fat of pure butter becomes clear very rapidly. It must, according to the Butter and Margarine Act, contain not less than 82·5 per cent. of butter-fat, and not more than 16 per cent. of water. According to Crampton,[1] it usually has the following composition:

Fat	82·05 per cent.
Curd	1·47 ,,
Ash	2·85 ,,
Water	14·43 ,,

Milk-blended Butter.—This may be butter which has been treated in the foregoing manner, the water being artificially raised to 20 or 30 per cent. Legally, however, it must not contain more than 24 per cent. of moisture, according to the provisions of the

[1] *Cf.* "The Modern Baker," vol. ii., p. 252.

Butter and Margarine Act, 1907. Milk-blended butter is not always a "renovated butter"; it is sometimes combined with other fats in such a manner that the substance will pass for butter. *The Practical Grocer* says: "Renovated butter is mixed in a definite proportion, in a kneading machine, with solidified milk; or a mixture of suet, leaf-lard, and cocoanut butter, is added, after which the milk is put in. The concoction is allowed to stand for twenty-four hours, and is then blended with more of the butter, being worked upon a table in such a manner as to produce a mass which, on analysis, will pass as a genuine butter."

Ghee.—The clarified butter of India is known as "ghee." The butter is heated until all the water is driven off, which is known by the cessation of crackling and giving off steam. It is then strained through muslin to remove curd, etc., treated with common salt, and sometimes betel-leaf, bottled, and corked down. So preserved, it will keep indefinitely. It is made from the butter of cows alone, or combined with that of buffaloes. It is a liquid butter. In the process of preparation it is sterilized, and, when immediately corked down and cooled, the admission of bacteria and air is prevented, and rancidity does not occur. The term "clarified butter" is also used by confectioners to denote ordinary butter which has been prepared for their purpose by heating it, and removing the curd and water as they arise on its surface in the form of scum.

Lard.

Lard is the fat of the hog separated by rendering. The term was formerly applied only to the white fat obtained by melting the fat from the omentum, or "flare," and that surrounding the kidneys. It is now, however, applied to any fat obtained from pig's flesh, and it is frequently mingled with cottonseed stearin or oil, maize-oil, cocoanut-oil, and beef or mutton fat. Lard is a *substitute for butter*, used as such domestically and by confectioners. Before the introduction of vegetable fats it was the chief substance used by confectioners in place of butter. The great demand for it has led to the creation of an enormous industry, especially in the United States. Although the whole of the fat in the hog is used in the preparation of lard, the fat of all parts is not used indiscriminately, for that of various parts of the body has different melting-points and different chemical characteristics. These facts, again, have led to the manufacture of various types of lard, which the "trade" recognizes as the following grades. They are described in "Food and its Adulteration" by Wiley, and in Bulletin 13, Bureau of Chemistry, United States Department of Agriculture.

Neutral Lard No. 1 : Leaf-Lard.—This is the fat from carefully selected "leaf," or omentum, and fat of the kidneys. It is taken in a perfectly fresh state, chilled, reduced to a pulp by machinery, and at once transferred to a rendering kettle. The latter is heated by steam under high pressure, so that the temperature of the fat reaches 45° to 50° C. (113° to 122° F.). The fat so obtained is washed in water containing salt and a trace of sodium bicarbonate or mineral acid, as required. The result is a perfectly white lard, of agreeable taste and odour, and practically neutral, as it contains no more

than 0·25 per cent. of free acid. Almost the entire production of the United States is devoted to the manufacture of margarine.

Neutral Lard No. 2.—This is made from the fat of the *back*. It is rendered and prepared in the same way as the former, and is chiefly used by bakers and confectioners.

Kettle Lard: Choice Kettle-rendered Lard.—After neutral lard has been obtained from the *leaf* and *back* in the manner indicated above, the residue still contains a considerable amount of fat. This, together with any trimmings from the leaf and back fat, are transferred to a steam-heated or open kettle, where the fat is subjected to greater heat. The result is *choice lard*, having a higher melting-point (45° C. or 113° F.) than either of the former.

Prime Steam Lard.—An inferior quality of lard obtained from the fat of the head and any fatty tissue obtained from the intestines, heart, or other parts not used to make the superior qualities, and sometimes the residues from leaf or neutral lard. It has a melting-point of 38° C. (100° F.).

Refined or Compound Lard.—A low class of lard obtained from the fat of any part of the hog not used for superior lard, combined with beef or mutton fat, cottonseed stearin, peanut-oil, etc. When pigs are fed with cottonseed cake or maize food, the lard derived from such animals is softer than normal lard. The addition of cottonseed-oil alone to ordinary lard makes it too soft. But many refined lards contain a large proportion of this oil, with 5 per cent. of beef stearin to stiffen it. Such compounds are made by churning the molten fats together, and subsequently cooling them rapidly to prevent separation.

Home-rendered Lard is that prepared in the household for family use. It is usually rendered in an open pan over a fire. The temperature is apt to get higher than is absolutely necessary; consequently some of the tissue becomes brown and the fat slightly discoloured. It is at any rate pure, exceedingly wholesome, and deserves commendation.

The Characters of Lard.—Pure commercial lard consists of a white fat of agreeable taste and odour, of neutral or nearly neutral reaction, having a melting-point of 42° to 48° C. (107° to 118° F.), and S.G. 0·931 to 0·932. The following table[1] shows the chief physical characteristics:

Physical Characters of Lard.	Specific Gravity.	Saponification Equivalent.	Melting-Point.	Melting-Point of Fatty Acids.	Crystallization-Point of Fatty Acids.	Rise of Temperature on adding H_2SO_4.	Iodine absorbed per Cent.	Water per Cent.
			° C.	° C.	° C.	° C.		
Leaf lard	·9057	272·64	41·6	43·0	40·40	39·7	59·60	·164
Pure leaf lard ..	·9028	281·01	44·9	42·8	40·40	37·1	53·04	·035
Prime steam lard	·9052	279·06	38·4	41·8	39·53	33·7	63·84	·040

[1] Wiley's "Foods and their Adulteration."

The Composition of Lard.—Lard consists of a mixture of oleic, stearic, palmitic, lauric, and myristic fatty acids, the total acids amounting to 92 or 95 per cent. combined with 5 to 8 per cent. of glycerine. The proportion of the individual fats varies according to the consistence of the lard and the part of the body from which it is derived. Lard should contain not less than 93 per cent. of fixed fatty acid, nor more than 0·5 per cent. of *free* fatty acid, and the volatile acids should be very small indeed ; the water, 0·04 to 0·165 per cent.

The reaction of *fresh* lard is practically neutral, but it attains a slight acidity on exposure to the air. The melting-point of English lard varies from 30° to 45° C., that of American lard from 38° to 48° C. Lard, like all common fats and oils, has the property of absorbing iodine, the average absorption being 62·48 per cent. of its weight of iodine. The highest quality of American lard should absorb not more than 53 per cent. of its weight of iodine, nor steam-rendered lard more than 62 or 64 per cent. English lard varies more than American, for leaf-lard absorbs 53 per cent., lard from shoulder fat 64 per cent., and that from back fat 70 per cent., of its weight of iodine. The melting-point varies with the amount of fats or fatty acids ; soft lard from back fat contains 20 per cent. more olein than hard leaf lard. Again, hard leaf-lard contains 10 to 12 per cent. more stearin than the soft lard from back fat.

Composition and Characters of English Lard.

Quality.	Leaf-Lard (Hard).	Shoulder Fat (Medium).	Back Fat (Soft).
Fats per cent. :			
Olein	62·0	74·5	82·0
Palmitin	20·0	13·5	11·0
Stearin	18·0	12·0	7·0
Ether deposit per cent.	7·6	2·0	nil
Melting-point	45·0° C.	34° C.	30° C.
Solidifying-point	32·3° C.	27° C.	24° C.
Iodine absorbed per cent. ..	53·5	64·0	70·5
S.G. at 38° C.	·9036	·9053	·9068

Adulteration of Lard.—Lard, which is derived from the fat of the hog, is adulterated by being mixed with various other animal or vegetable fats and oils. The fats commonly used are perfectly wholesome, and no hygienic objection can be raised against them ; but it is a fraudulent practice to sell as "lard" a mixture containing a large proportion of foreign substances. Beef and mutton fat, or *stearin*, have a higher melting-point than that of lard derived from the back fat, and the object of adding it is to render stiffer a somewhat greasy or oily lard, such as that of the back fat—in other words, to raise the melting-point. There is no objection to this procedure, and it raises the commercial value of the lard.

Beef-fat is detected in such lard by means of the microscope, which reveals the crystalline character of the fats. The lard is dissolved in ether, a drop is put on a glass and allowed to crystallize slowly; beef-fat is then recognized by the radiating or fan-shaped arrangement of the crystals of stearin, whereas pure lard-fat sets in long needle-shaped crystals. However, a relatively small addition of beef-fat, 10 or 12 per cent., could not be detected readily, because the stearin from a *hard* leaf-lard approximates more or less in character to that derived from a mixture of lard and beef-fat.

Cottonseed stearin, peanut butter, sesamé-oil, and maize-oil, are common adulterants of steam-rendered lard, refined lard, and compound lard. Cottonseed-oil has a lower melting-point than lard, but when combined with lard and beef-fat the mixture may have the same melting-point as genuine lards, and thus escape detection. This is a matter of importance to the manufacturers, because some vegetable fats and oils are cheaper than pork-fat. Such frauds, however, are easily detected by the analyst; *e.g.*, cottonseed-oil is revealed by the Bechi or Halphen test, and sesamé-oil by Baudouin's test (*q.v.*). Maize-oil is not so easily detected, and has to some extent replaced cottonseed-oil, whose presence can be so easily discovered.

Lard-Oil is obtained by subjecting lard to heavy pressure without the application of heat. It is a pale yellow, nearly colourless oily fluid, of peculiar odour and bland taste. It consists almost entirely of **olein,** but contains a varying quantity of stearin, and is sometimes adulterated with liquid paraffin. It is almost insoluble in alcohol, but soluble in ether, chloroform, benzene, and carbon bisulphide. It has S.G. of 0·905 to 0·915 at 25° C.; saponification value, 195 to 197; iodine value, 56 to 74.

Lard as a Food.—Being practically all fat, lard is oxidized in the system, and may be considered as giving the full value of 9·3 calories per gramme. It is digested in the intestines, and readily assimilated when taken in moderate amounts. It is largely used as a substitute for butter in making cakes, pastry, and frying various articles of food. When used as "shortening," it diminishes the adhesiveness of the flour, and makes the cakes richer and lighter. When used for frying, some of the fat becomes decomposed, and the glycerine of such portion is converted to acrolein and other empyreumatic substances. Its use in this manner is therefore open to the same hygienic objections as other cooked fats.

Margarine and Other Butter Substitutes.

Margarine is the generic name applied to a number of butter substitutes. Butter substitutes are called by various names, but **margarine** is that which has received the sanction of law; while deceptive names, which might lead to the supposition that genuine butter was being purchased, are suppressed by law. Thus, the term **butterine** is applied to a mixture of oleomargarine and butter, to impress the idea that it is a sort of butter, but legally it is mar-

garine. While genuine butter has a Reichert number varying from 20 to 33, a *minimum* of 24 is always considered a mark of genuineness. But this permits of a considerable adulteration of butter by margarine, for the detection of which other tests than the Reichert number have to be applied.

Margarine—that is, butter substitutes—consist of a mixture of animal and vegetable fats prepared so as to have a resemblance to butter. The fats used in this combination consist of beef-fat, mutton-fat, horse-fat, lard, lard-oil, cottonseed-oil and stearin, cocoanut-oil, peanut-oil, maize-oil, sesamé-oil, and other oils and fats. The fats and oils are churned up with milk to give the compound a butter flavour, and coloured with annatto, saffron, aniline and other dyes, the coal-tar colours being most frequently used.

The fats used more than any others, however, are oleo-oil (from beef), neutral lard, cottonseed-oil, and maize-oil.

Oleo-Oil is obtained from the caul fat of beef. The fatty tissue is removed as quickly as possible after the animal is slaughtered, washed, and cooled in ice-water or ice-cold water. The fat, now cold and hard, is cut into fine shreds and ground into a pulpy mass by machinery. It is then put into a tin-lined vessel over a fire, and the temperature raised to not more than 45° C. (113° F.). The fat, thus liquefied and dissolved out of the tissues, is drawn off into vats, sprinkled with salt to assist in its clarification, and allowed to stand for twenty-four hours. Most of the **stearin** separates in a solid mass. This is taken out, cut up, and submitted to hydraulic pressure. The liquid so obtained is mixed with that previously drawn off, and the mixture constitutes oleo-oil, and is chiefly used in the manufacture of margarine.

Neutral or **Leaf Lard** has already been described. Practically the entire production of the finest quality of lard finds its way to margarine factories. It is colourless, tasteless, almost odourless, and makes an admirable food material.

Cottonseed-oil is also practically odourless and tasteless. *Cottonseed stearin* is a yellowish-coloured fat which alone forms an admirable substitute for butter. Peanut-oil, especially that of the second grade, is a pale yellow or greenish oil, and is much used for making margarine. Arachis-oil is also used. In Germany it is *compulsory* that margarine shall contain 10 per cent. of sesamé-oil to facilitate the detection of the adulteration of butter by margarine. Particulars of these oils are given in the following chapter.

The Manufacture of Margarine.—The proportion and kind of fats used in margarine varies according to the current market price of these substances, and the country where it is intended to be used. When it is to be consumed in warm countries, a high proportion of cottonseed-oil and its stearin are used ; when it is to be used in a cooler climate, those fats and oils having a lower melting-point are used. The high melting-point of beef-fat, owing to its great proportion of stearin, enables it to be used with advantage

in margarine intended for warm climates, and for other countries when blended with lard or oils having a low melting-point. The following is said to represent the composition of the three grades of margarine made in America:

FATS IN MARGARINE.

Components.	High Grade.	Medium Grade.	Low Grade.
Oleo-oil	50·0	80·0	115·00
Neutral lard	65·0	125·0	60·00
Butter	46·0	—	—
Cream	—	70·0	—
Cottonseed-oil . ..	—	—	80·00
Milk	—	40·0	65·00
Salt	16·0	30·0	30·00
Colouring matter	·5	·5	·75

The oleo-oil, together with the other fats and oils, are liquefied at a low temperature (83° to 86° F.), and churned with a quantity of pasteurized milk, so as to break the fat into fine globules—that is, to produce a fine emulsion of fat and obviate the tendency of margarine to crystallize. Immediately after churning the liquefied and emulsified fat is run into cooling tanks, where it comes into contact with ice-cold water, which solidifies it and gives it a grain similar to that of butter. The mass is then transferred to a marble or slate table, where it is kneaded to express excess of moisture, the salt, preservative, and colouring matter, being blended with it at the same time. The product is margarine, oleomargarine, or butterine.

One of the principal objects of this treatment of the fat is to remove, destroy, or cover, the tallowy flavour of beef or mutton fat. This is done by the combination of genuine butter, ripened milk, or cream. Beef-fat, which has not so strong or perceptible a flavour, is much used in the United Kingdom; but on the Continent mutton-fat, which has a much more pronounced or tallowy taste and smell, is very largely used. In Great Britain it is not legal, according to the Butter and Margarine Act, 1907, for margarine to contain more than 10 per cent. of butter or 16 per cent. of water; but in the United States high-grade margarine contains 40 per cent. of butter. In consequence of the small percentage of butter allowed in margarine in the United Kingdom, the manufacturers of margarine have to seek other modes of covering the tallowy flavour. This is done by the use of ripened milk or cream, or by a judicious mixture of volatile fatty acids, aldehydes, or ethers, especially butyric, propionic, and caproic ethers. It is by such compounds that they attempt to give to the butter substitute the flavour and aroma of genuine butter, at the same time disguising the origin of the fat.

In some countries a limit is put upon the amount of milk which may be used in making margarine. When genuine butter is cooked,

it becomes frothy and brown, owing to the presence of casein and lactose. The presence of milk in margarine gives to it similar characteristics ; indeed, the more milk there is in margarine, the more does it resemble pure butter in these respects. Where manufacturers are prohibited from using enough milk to produce these characteristics in margarine, attempts are made to imitate them by combining with the substance a proportion of casein, albumin, cholesterol, or even beeswax or some other kind of wax.

THE COMPOSITION OF MARGARINE.

	Per Cent.
Water	9·35
Fat	82·70
Casein	·95
Albuminoids	·35
Common salt	3·65
Mineral ash	3·00
	100·00

The fat contains—	Per Cent.
Insoluble fatty acids ..	93·59
Soluble or volatile acids	·12
Glycerine	6·29
Fatty acids :	
Stearic acid	19·14
Palmitic acid	6·08
Myristic acid	14·33
Lauric acid	7·04
Oleic and other unsaturated acids	47·06

The composition of margarine differs from that of butter chiefly in respect to the stearic and volatile fatty acids. Butter contains only about 1·75 per cent. of stearic acid, 1 per cent. of distearic acid, and 8 or 9 per cent. of volatile fatty acids. The amount of volatile fatty acids in margarine is very small ; according to Wynter Blyth the average is 0·25 per cent., whereas Wiley finds only 0·12 per cent. ; they are butyric, caprylic, and caproic acids. The comparative absence of volatile or soluble fatty acids from margarine is considered to be an advantage by many authorities, because they are so liable to oxidation and other changes leading to rancidity, and therefore to unpalatability of the margarine. The proportion of volatile fatty acids can be raised 25 per cent. by mingling cocoanut-oil or palmnut-oil in the compound. Margarine is sometimes adulterated with substances other than fat ; *e.g.*, a conviction was obtained against a London grocer for selling margarine containing 13 per cent. of mashed potatoes.

According to the Butter and Margarine Act, 1907, it is not lawful to sell in Great Britain margarine containing more than 10 per cent. of butter-fat or more than 16 per cent. of water, and it must be *labelled* "Margarine." The chief tests for margarine are as follows : The S.G. = 0·859 to 0·863 ; the melting-point varies from 34° to 40° C. (93° to 104° F.) ; the Reichert-Wollny number varies according to the amount of volatile acids or butter-fat in the compound. Thus, margarine containing 10 per cent. of butter-fat has a Reichert-Wollny number = 4·0 ; 11 per cent. = 4·3, 12 per cent. = 4·6, 13 per cent. = 4·9, the number increasing in the ratio of 1·3 for each 1 per cent. of butter-fat above 10 per cent., so that margarine containing 20 per cent. of butter-fat will have

a Reichert number of 7·1, against a *minimum* Reichert number of 24 for genuine butter.

The Nutritive Value of Margarine.—When made under proper conditions, margarine is a wholesome article of food. A comparison with butter shows that margarine contains nearly the same proportion of fat, and that the latter is well absorbed. According to Atwater, 1 pound of margarine yields 3,525 calories, 1 pound of butter 3,605 calories, and 1 pound of lard 4,220 calories. As regards absorption, Röttger[1] showed that there is only a difference of 2 per cent. between the percentage of butter and margarine absorbed; that is, 102 grammes of margarine are equivalent to 100 grammes of butter in nutritive value. Beef-dripping is considered by many people far pleasanter than margarine. Its nutritive value is about the same, but it is not so easily obtained, as it is not prepared commercially, and that which arises in domestic cooking is usually consumed in the household.

Although margarine is by far the most important commercial substitute for butter, some of the fats of vegetable origin, which are more or less used in making margarine and compound lard, are excellent butter substitutes, being equally wholesome and nutritious. The chief of these are as follows:

Cacao Butter, or **Oil of Theobroma,** is consumed largely in the East, especially by the Hindus, as a substitute for animal fat. It is a light yellow substance, of agreeable flavour and aroma, and suitable for human food. Its high price alone is against its more general use.

Cocoanut-Oil, cokernut or coconut butter, is a white fatty substance of the consistence of butter, extensively used by bakers and confectioners as a substitute for butter. As a butter substitute it is sold to the public under various names, such as "Copra Butter," "Albene," "Cocoline," "Cocose," "Lactene," "Vegetaline," etc.

Cottonseed Stearin is a yellowish-white fat which makes an excellent substitute for butter, and is much used alone or in combination with other fats and oils by bakers and confectioners. Such butter substitutes are sold under the names of "Cottoline," "Electol," "Vegaline," etc.

Palmnut Butter or **Oil,** obtained from the kernels of palmnuts, is generally of white colour, firm consistence, and without odour. It is prepared and sold to the public as a substitute for butter under various names, such as "Palmine," "Nucoline," "Kunerol," "Laureol," etc.

Peanut Butter, or butterine-oil, obtained from the seeds of *Arachis hypogæa*, is used to make margarine, but is also frequently sold in combination as "Peanut Butter." It is very useful and wholesome.

Less known are "Shea Butter," a vegetable fat of tallow-like consistence, obtained from the seeds of *Bassia parkii*, or butter-tree of West Africa; "Dika Butter," an oily substance of cocoa-like flavour, obtained from the seeds of the ibo-tree in West Africa; "Makwa Butter," from the makwa plant of India, a fat chiefly used for making candles and soap; "Kokum Butter," a firm fatty substance obtained from the seeds of *Garcinia indica*, and frequently mingled with genuine butter in the preparation of ghee. Some of the aforementioned substitutes are much used in Europe and America, but they are in far greater demand in Asiatic countries, especially where the people are forbidden by their religion to use the fat of cattle and pigs for food. But the greatest use to which all vegetable fats is put is in the manufacture of margarine and confectionery. This is therefore regarded as a suitable place in which to treat of oils and fats more fully.

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1 "Lehrbuch der Nahrungsmittel Chemie," p. 182.

LEEDS & WEST RIDING
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CHAPTER XIII

FOOD OILS

The distinction between fat and oil is merely that of solidity. A fat is solid or semisolid at the ordinary temperature of the atmosphere. An oil is liquid, but it becomes solid or semisolid when its temperature falls below a point which varies with the composition of the oil. The composition of all fats and oils is similar—that is to say, they are compounds of fatty acids and glycerine. Although oleic, stearic, and palmitic acids are the chief acids present in any fat, each fat has special characteristics owing to its containing the acids in different proportions besides special fatty acids in smaller proportion. The proportion of glycerine in all fats varies from 10 to 12 per cent. Animal fats consist chiefly of stearin and olein, and are consequently more or less solid ; vegetable fats consist chiefly of olein, which, being liquid at ordinary temperatures, acts as a solvent of the other fats. There are exceptions, however, to the latter rule, for palm-oil consists largely of palmitin and stearin, and becomes solid at a much higher temperature than olive and other oils. Most oils contain a small amount of *free* fatty acids, and this varies with the condition of the substance from which the oil is derived ; thus, there is more free acid in *vegetable* oils derived from fully-ripe or overripe substances, and least free acid in those derived from fresh or unripe substances. Most oils contain other substances, classed as "impurities," such as a small amount of protein, carbohydrate, gum, resin, alkaloids, and other extractives, which are almost wholly removed by refining.

Many animal and practically all vegetable oils are used for foods in various parts of the world. Some of the animal oils are not agreeable to the palate of civilized people, even when they are purified and refined as much as possible. Such are seal-oil, whale-oil, sperm-oil, bone-oil, and most of the fish-oils. But almost all the vegetable oils are palatable, and make good food if properly refined.

Animal oils are derived from marine and terrestrial animals ; those of a marine origin have a high *iodine number* (*q.v.*) ; those of a terrestrial origin have a low iodine number. They are obtained by pressure combined with heat, or dissolved out by means of superheated steam, or by decomposition of the fatty tissue. They

are liquid at ordinary temperatures, and are used for cooking and medicinal purposes.

Vegetable oils are usually extracted by hydraulic pressure, the finest quality being " cold-drawn," second or third qualities being obtained after treatment of the marc, or residue. The crude oils are refined by treatment with steam or boiling water, and filtration to remove suspended substances. They are decolorized by means of charcoal or fuller's-earth, and again filtered, under pressure, to remove albuminoid, resinous, and mucilaginous substances ; at the same time any excess of free acids is neutralized by alkalies. Oils which contain much **stearin** are " demargarined," because they readily become solid or semisolid, by reducing them to the temperature at which they become solid, removing the stearin, cutting up and submitting the same to hydraulic pressure. Olive-oil does not require such treatment ; but cottonseed-oil deposits stearin at a temperature of 40° C., when it is removed by filtration and expressed.

The food value of oils depends upon their digestibility and the amount of heat evolved during oxidation, the latter being 9·3 calories per gramme. They are therefore concentrated foods of high value. Their chief use is for consumption as " bread and butter," for " shortening " in making cakes and pastry, for cooking fish, meat, eggs, and for salad-oils. They are used in baking for a variety of reasons. They increase the nutritive value of the food, give richness and flavour, while improving the texture of the material. They *shorten* pastry or make it *laminous*, according to the mode of usage. If, however, an excessive quantity of sodium bicarbonate is used at the same time, some of the fat becomes converted into *sodium oleate* (a soap), not only reducing the nutritive material, but introducing an undesired aperient substance into the food.

Substances cooked in oil are less digestible than those cooked in water or steam, for two reasons : the material becomes more or less saturated with fat, which thereby prevents the digestive juices from getting to the protein or carbohydrate elements requiring digestion ; secondly, some of the oil becomes empyreumatic—that is, it develops substances during exposure to the heat which are unpleasant and apt to upset the digestive organs ; the chief of these is acrolein. Fats have practically no boiling-point, but they are decomposed at a temperature of 480° to 570° F., becoming dark in colour, emitting carbonic acid gas and an odour of acrolein. Small portions only of fat attain such a temperature during frying, but the products of decomposition are quite sufficient to upset many delicate digestive organs.

The vegetable oils are used very extensively in Asia, and to a less extent in Europe and Africa. They are very liable to adulteration ; indeed, most edible oils are now mixtures of several kinds. Owing to such adulteration, the analysis of oils has become a matter of importance. In fact, each oil has characteristic physical and chemical properties whereby it can be distinguished from

others by an adept or analyst. The chief tests applied by them are as follows :

The Reaction.—Pure fats and refined oils have a practically neutral reaction, but owing to their exposure to air and light may become more or less acid.

The Solidifying-Point.—The melting and solidifying points of all fats and oils vary with the composition ; *e.g.*, stearin and palmitin melt and solidify at a higher temperature than olein.

The Refractive Index.—When a rod is placed in water and a ray of light thrown upon it, it has the appearance of being bent at an angle of 1·33°. That number, therefore, is said to be the *refractive index* of water. But oils refract the light more than water. Their refractive index is greater, and averages 1·44. Different oils possess a different refractive index, and its determination is a point of value in ascertaining the purity or adulteration of any particular oil.

The Specific Gravity of oils varies. The S.G. of water is reckoned either as 1,000 or 1 at 4° C. (39° F.). The S.G. of fats and oils is less than that of water, although it is estimated at the same or at some other temperature with which it is comparable—*e.g.*, 15° C. (60° F.). The S.G. of oil is therefore either an integral number or a fraction—*e.g.*, 914 or 0·914. Estimated at 15° C. (60° F.), various oils have the following S.G. : Almond oil 0·914 to 0·920, cocoanut-oil 0·915, cottonseed-oil 0·916 to 0·930, maize-oil 0·916 to 0·924, palm-oil 0·920 to 0·945, palmnut-oil 0·952, rape-oil 0·911 to 0·917, ravison 0·918 to 0·922, sesamé-oil 0·921 to 0·924.

The Saponification Value.—When an oil or fat is treated with an alkali, caustic soda or potash, the fatty acid joins with the metal and forms a soap. The amount of alkali which is necessary to saponify all the fat and set free the glycerine is called the " saponification value." In actual analysis 1 gramme of the oil or fat is treated with caustic potash until it is saponified, the number of milligrammes of KHO necessary for this purpose being the saponification number. This number varies in different fats and oils, and helps to distinguish them from each other.

The Reichert-Meissl Number has already been referred to (see Butter) as the number of cubic centimetres of a standard alkali solution which is necessary to neutralize the volatile fatty acids in 5 grammes of fat or oil. It varies like other reactions in different fats, being as high as 30 for butter, and as low as 1·5 for cottonseed-oil.

The Iodine Number, or Hubl Figure. — All fats and oils under certain conditions will absorb a definite proportion of iodine. They do not all absorb an equal proportion ; but as the amount absorbed by the same kind of fat is constant, and differs from that in other fats, the proportion of absorption, or the " iodine number," is regarded as being of importance in testing the purity or detecting the adulteration of fats and oils. If the proportion of iodine absorbed equals the weight of the fat, the Hübl figure, or iodine number, is 100—*e.g.*, rapeseed-oil ; that is to say, if 1 gramme of

fat or oil absorbs 1 gramme of iodine, the iodine number is 100 ; or if 1 gramme of fat only absorbs 0·67 gramme of iodine, the number is 67. One gramme of cottonseed-oil absorbs 1·06 to 1·10 grammes of iodine, therefore the iodine number is 106 to 110 ; 1 gramme of hazelnut-oil absorbs 0·86 gramme of iodine, and the number is 86 ; of palmnut-oil 0·55 gramme, and the iodine number is 55 ; while cocoanut-oil only absorbs 0·08 gramme of iodine, and the iodine number is only 8.

Rise of Temperature on Addition of H_2SO_4.—When fat or oil is mixed with strong sulphuric acid, a degree of heat is developed which varies in different fats and according to their constitution. The amount of heat developed with particular oils and fats is constant, and is therefore a test of purity. A proper apparatus is necessary for the test. Fifty c.c. of the oil or fat is taken, and its temperature raised or lowered to 35° C. ; 10 c.c. of strong sulphuric acid is then added, the mixture stirred with a glass rod, a thermometer put in, and the fluctuation of the mercury observed for a few minutes. As a general rule the mercury rises for two or three minutes, and then begins to fall. The maximum temperature is recorded, from it is subtracted the original temperature (35° C.), and the balance is the rise of temperature due to the action of the acid. This figure is low for nearly all edible oils, except cottonseed-oil and one or two others.

The Halphen Reaction is a colour test for the presence or absence of cottonseed-oil. The reagent consists of a mixture of equal parts of carbon bisulphide (containing about 1 per cent. of sulphur) and amyl alcohol. The fat or oil under inspection is mixed in a test-tube with an equal quantity of the reagent, and placed in a water or brine bath at boiling temperature for fifteen minutes. If a red or orange colour is produced during this period, it is indicative of the presence of cottonseed-oil ; the non-development of this colour is proof of the absence of that oil. A proportion of 1 per cent. of cottonseed-oil in any oil or fat will give this reaction. It has been observed in lard when pigs are fed with cottonseed cake, and in butter when cows are fed with it.

The Bechi Reaction is a colour test dependent upon the reduction of nitrate of silver. Cottonseed-oil is the only common oil which gives the reaction, hence the value of the test to indicate its presence or absence. The reagent consists of—Nitrate of silver 2 grammes, alcohol (95 per cent.) 200 c.c., ether 40 c.c., nitric acid 1 drop. The oil or fat to be examined is melted, 10 c.c. put into a test-tube with 5 c.c. of the reagent and 10 c.c. of amyl alcohol. The mixture is agitated and divided into two parts, one being kept for comparison of the colour. The other part is heated in a water-bath at a boiling temperature for ten minutes, and the colour is then compared with that of the unboiled specimen. If cottonseed-oil is present, the boiled sample will be black. Pure oils, except cottonseed-oil, do not give this reaction, and its production is a proof of the presence of that oil.

Baudouin's Test is another colour test of value in showing the presence of sesamé-oil in any mixture of oil or fat. It is applied in the following manner: Dissolve 1 gramme of cane-sugar in 10 c.c. of hydrochloric acid (S.G. 1·2), add 10 c.c. of the oil to be tested, shake thoroughly, and allow it to stand. If sesamé-oil is present in the proportion of 2 or more per cent., the watery layer which separates from the mixture on standing will become crimson.

The Manufacture of Oils.—All vegetable oils and fats are obtained by practically the same method. The seeds are cleaned, and thereby separated from husks, stems, leaves, and other foreign matters. Many seeds are "hulled"—that is, decorticated—and cocoanuts or palm kernels are broken up. The seeds are then reduced to a soft pulpy mass and packed in strong cloths or bags consisting of cotton or horse hair. They are then submitted to pressure in a hydraulic press. Some oils are "cold-drawn"—that is, the *cold* pulp is submitted to pressure. In other instances "hot pressure" is applied—that is, the bags of pulp or meal are heated and kept warm by steam during pressure. By the former method the pressure simply forces out the free oil; hence "cold-drawn" oils are of the finest quality, being of pleasant flavour and light colour. In the latter method of "hot pressure" other substances besides oil are liberated and removed; consequently the oil is not of such a good quality, being darker in colour, and sometimes unpleasant to the taste, and therefore not always suitable for an edible oil. Cold pressure is therefore used when the oil is intended for human food, the refuse, or marc, being afterwards treated by solvents, such as benzol, carbon bisulphide, or petroleum ether, by which all the remaining oil is removed. The solvent is then distilled from the liquid, leaving the oil free. A combination of the solvent and the pressure methods is practised in France and Russia.

Bleaching and Refining.—The oils obtained by any of these methods require clarification and refinement. In most cases the crude oil is agitated with sulphuric acid, and afterwards with dilute caustic soda or a mixture of soda and brine. By the latter the acidity is neutralized and mucilage precipitated; the purified oil is then run off, and clarified by settling and filtration. Some manufacturers use other chemicals than the foregoing. The purified oil is in some cases *bleached* by mixing it with decolorizing agents, such as hydrogen peroxide, chlorine, sulphurous acid, permanganate or bichromate of potash solution, being afterwards allowed to settle, drawn off, and filtered through fuller's earth or charcoal.

Almond-Oil.—This oil is obtained from the seeds of sweet and bitter almonds (*Prunus amygdalus dulcis et amara*). The kernels contain 40 per cent. of oil, which is free from stearin, and consists chiefly of olein, with traces of linolein and other glycerides. Sweet almonds contain less oil than the bitter variety. The oil is of a clear pale yellow colour and bland taste; it does not readily become rancid. It has S.G. 0·918 at 15° C., or variation of 0·917 to 0·919, iodine number 97 to 100, solidifying-point −14° C. (+8° F.), and refractive index 1·315. The S.G. is the same as that of rapeseed-oil, but the iodine number is rather lower. It is frequently adulterated with the oil from peach or apricot kernels, walnuts, rapeseed, cottonseed, poppyseed, sesamé-oil, or lard-oil. Apricot and peach kernel oils long enjoyed immunity from detection, because they contain the same bitter principles as almond-oil. But their iodine number is higher, and, therefore, when the iodine number of almond-oil is unusually high their presence

is suspected. Peach kernel oil also gives a characteristic colour reaction, shown thus: Put into a test-tube 3 parts of the oil and 1 part of nitric acid (S.G. 1·4), and mix them by agitation. If peach kernel oil is present, a bright red colour will be produced; pure almond-oil gives a bright yellow turning to brown colour.

Cacao Butter (Oil of Theobroma).—This oil is obtained from cocoa-nibs (*Theobroma cacao*), and must not be confounded with coconut butter obtained from *Cocos nucifera*. Cacao butter is the fat removed by pressure from the cocoa-beans when they are roasted to manufacture cocoa and chocolate, the beans yielding 30 to 50 per cent. It consists of 40 per cent. of stearin, besides palmitin, olein, and free fatty acids. The latter are removed by mixing the ground beans with alkalies before the extraction of the fat. The free fatty acids, however, are not so abundant as in coconut-oil. The fat has a high melting-point (30° to 35° C.); S.G. at 15° C. is 0·925; iodine number 33 to 38; refractive index at 40° C. is 1·46. It is of a light amber or yellow colour, but becomes bleached on exposure to light. The flavour is agreeable, and somewhat like the aroma which is characteristic of cocoa. It is quite suitable for human food, and makes a good substitute for butter, but the high price is against its use to any large extent. When pure it does not readily become rancid; but it is often adulterated with coconut-oil or palm-oil, which may become rancid. It is also occasionally adulterated with paraffin or beeswax.

Coconut Oil or Butter.—This is the fat obtained from the kernels of the coco, coker, or cocoa nut (*Cocos nucifera et butyracea*), and is therefore often called "coconut butter" and "copra-oil." It is largely imported from the islands of the Pacific—*e.g.*, Ceylon and Java—and from Malabar and Mauritius. It is a fat of moderate consistence, nearly as solid as lard, of agreeable flavour and pleasant aroma. It is extracted by pressure, and refined by heating it in water. It melts at 20° to 25° C., and solidifies at 13° to 17° C.; the S.G. = 0·915 at 15° C. and 0·903 at 100° C.; the saponification value averages 257; the iodine number is only 8 or 9; and titre 22° to 25° C. It consists of palmitic, stearic, oleic, myristic, and lauric acids, with a fairly large amount of volatile fatty acids, but varying from 5 to 17 per cent., and consisting of capric, caproic, and caprylic acids, which give flavour to it and render it a suitable substitute for butter. In fact, the proportion of volatile acids amounts to one-fourth of the proportion in genuine butter, whereas other vegetable oils or fats seldom contain more than one-sixteenth as much. The low iodine number prevents its adulteration to any extent, but does not prevent its use for adulterating other fatty substances.

It is much used by the natives of Oriental countries, owing to religious restrictions on the use of animal fats. It is also extensively used in Europe and America in the manufacture of margarine, and it is sold almost pure as a butter substitute under such names as

" Albene," " Cocoline," " Lactene," " Vegetaline," and " Vegetable Butter." When fresh, the pure fat and its preparations are by no means unpleasant to taste or smell, but they are *very liable to become rancid*. The free acids can be removed by alcohol and magnesia or charcoal, whereby the fat is made neutral, and the tendency to rancidity considerably reduced, but not entirely removed. In this form coconut-oil is much used by bakers, confectioners, biscuit-makers, the margarine-makers, and as an adulterant of other fats. The adulteration of butter with it is by no means uncommon. This arises from the fact that the presence of coconut-oil is not revealed by Valenta's test or the butyro-refractometer. The proportion of volatile fatty acids in genuine butter gives a Reichert or Reichert-Wollny number of 20 to 33. The amount of volatile acid in coconut-oil is also fairly large, so that a butter having a high Reichert number can be adulterated with a considerable proportion of this fat without reducing it below the number (viz., 24) which is the minimum experts consider should be given by pure and genuine butter. But the volatile acids of coconut-oil are chiefly capric and caprylic acid, there being *no butyric* and very little caproic acid. Butter, on the other hand, contains 3·92 per cent. of butyric and 1·88 per cent. of caproic acids. To accurately detect the adulteration of butter by coconut-oil, it is necessary to estimate the amount of each fatty acid.

Three qualities of coconut-oil are sold : (*a*) *Cochin oil*, prepared from the finest nuts grown along the Malabar coast by pressure and refinement of the product. It is a solid white substance of buttery consistence. (*b*) *Ceylon and Mauritius oils*, obtained in the same way, are also of good quality, and are obtained by pressure or by boiling the sliced kernels and skimming off the fat. (*c*) *Copra oil*, prepared in Europe and America.

Copra consists of the kernels of coconut cut into strips and dried in the sun or in kilns. It is largely imported into Europe and America, where it is boiled in water and the fat removed by skimming. **Copra butter,** made at Marseilles from copra-oil, is refined and bleached so that it can be mixed or sold as butter, or used in making margarine and lard. **Mannheim coconut butter** is also made by boiling imported copra, skimming and refining the fat, neutralizing free acids, and centrifugalizing it to remove water. It is of firm consistence, has a melting-point of 80° F., contains about 99 per cent. of vegetable fat, is practically neutral, and keeps free from rancidity for several months.

Cottonseed-Oil.—The oil expressed from the seeds of cotton plants (*Gossypium herbaceum*, *G. hirsutum*, and *G. barbadense*) grown in Egypt, India, America, and other countries. The edible oil is that which has been refined. There are several grades : Summer White, Summer Yellow, Winter Yellow, and Salad-oil. It is of sweet flavour, pale yellow colour, consisting of palmitic, stearic, oleic, and linoleic acids. It contains only about 1 per cent. of free acids, and is not liable to become rancid. The S.G. = 0·922 to 0·930 at 15° C. ;

the solidifying-point is 0° to 10° C., with an average of 3° or 4°; the refraction index is 1·470 to 1·4725; iodine number 104 to 110; saponification value 190 to 195; titre 33° to 35° C.

Cottonseed-oil gives the reaction known as the "Bechi test," which is usually applied to substances suspected of containing it. The test is not conclusive as regards butter or lard, for cows or pigs fed on cottonseed cake may yield butter or lard which gives the reaction. The Bechi test, therefore, can only be considered as being confirmatory of such adulteration. The presence of cotton-seed-oil is also revealed by the Halphen reaction, which will reveal as little as 5 or even 1 per cent. of the oil.

The seeds are grown in America, Egypt, Algeria, and Italy. They are largely imported for the manufacture of oil and cake. They contain from 20 to 42 per cent. of oil, some protein, and the alkaloids betaïn and cholin. A ton of seeds yields an average of 40 to 43 gallons of oil, and leaves about 5 or 7 per cent. in the cake. The seeds are screened to remove lint and foreign bodies, being afterwards "hulled," the kernels separated from the bran, crushed by rollers, and expressed by "cold pressure." The residue is then heated by steam to loosen the oil, and pressed while hot. A cake remains. The crude oil varies in colour from ruby to black, and requires to be refined. It solidifies at 3° or 4° C. (37° to 39° F.). To prevent this, however, the oil is *demargarined* by reducing it to a low temperature, and removing the stearin by filtration and pressure, or by merely storing it in a tank for some time, when part of the stearin separates out. The demargarined oil no longer sets in cold weather, and it has an iodine number of 110 to 116.

Summer White and Salad-oil are the purest and finest qualities, being practically tasteless and odourless. Summer Yellow oil has a pleasant nutty flavour, and is pale or of a golden yellow colour. Winter Yellow oil is that which is more or less demargarined. The best qualities are a wholesome source of fat. They are sold as "salad-oil," and are much used in the manufacture of margarine and lard; also by confectioners, bakers, purveyors of fried fish, and for adulterating olive and other oils.

Cottonseed stearin is the solid substance removed from the oil by pressure or reduction of the temperature. It is a yellowish fat, having a high melting-point—40° C. (104° F.)—makes an excellent substitute for butter, and is used by confectioners, bakers, and the manufacturers of lard and margarine.

Hazelnut-Oil. — Hazelnuts (*Coryllus avellana*) contain 50 or 60 per cent. of fat, consisting of stearin 1, palmitin 12, and olein 87, per cent. It has S.G. 0·916 at 15° C., and iodine number 86. It is an edible oil, but too expensive for general consumption.

Linseed-Oil, obtained from the seeds of *Linum usitatissimum*, is not an edible oil, but is chiefly used for paints and varnishes. The presence of linseed-oil in any other fat would be shown by the test for linoleic acid, but it is not reliable, because walnut, hempseed, poppyseed, and other "drying" oils also contain that acid.

Maize or Corn Oil.—The seeds of *Zea maïs* contain a golden-yellow oil consisting of palmitic, stearic, and arachidic acids, and having an odour like that of the fresh grain. It has S.G. 0·916 to 0·924 at 15° C., it solidifies at 16° to 20° C., has a saponification value of 185 to 193, iodine number 114 to 125, and titre 18° to 20° C. It is more viscous than olive or cottonseed oil, and contains besides fatty acids a considerable amount of unsaponifiable substance, chiefly **lecithin,** of which it is one of the commercial sources.

Maize-oil is obtained from the grain which is about to be used for some other purpose—*e.g.*, when about to make starch or glucose. It is also obtained in the manufacture of maize flour, when the **germ** is removed. The latter contains 20 per cent. of oil, about three-fourths of which can be obtained by hydraulic pressure, and is of the ordinary pale yellow or golden-yellow colour. When maize has been fermented in the manufacture of alcohol, the oil is retained by the "grains," and afterwards removed by pressure. This oil, however, is of a reddish-brown colour, and contains more free acid than the other variety. Both kinds are used as adulterants of oils, and in the manufacture of lard and margarine, and they are less easily detected than cottonseed and other oils used for that purpose.

Nut-Oil or Walnut-Oil.—This should not be confounded with peanut-oil, which is also called "nut-oil" by some persons. There are two varieties, obtained by pressure of the fresh walnuts: (*a*) *Cold-drawn oil,* which varies from colourless to a pale green colour, and is of a pleasant odour and agreeable taste; (*b*) *hot-pressed oil,* of a greenish colour, acrid taste and smell. They are "drying oils" used chiefly by artists. The cold-drawn variety is agreeable, but too costly for an edible oil.

Olive-Oil is derived from the mature and sound fruit of *Olea europæa,* of which there are more than 300 varieties grown in Italy, France, Spain, Greece, The Morea, Southern California, Mexico, Peru, and Australia. The largest quantity of oil is obtained from the Spanish fruit, but it is not of the finest quality. The ripe fruit is a dark purple or nearly black colour, and 1·25 inches long. The best oil is obtained from fruit gathered in December—that is, when they are fully ripe. Unripe fruit, sometimes used, yields an oil which is more or less bitter, and therefore less palatable. There are three qualities or grades of olive-oil: (*a*) The finest, or **virgin oil,** obtained by cold pressure of fruit which has been deprived of the skins and stones. (*b*) The second quality is obtained from the entire fruit. (*c*) The third quality from the residues—skin and stones—of the virgin oil by means of solvents and pressure.

Virgin oil is obtained by reducing the peeled and stoned fruit to a pulp (*pomace*), which is subjected to moderate pressure at the ordinary atmospheric temperature. The pomace is then heated in a steam-jacketed pan, and subjected while hot to greater pressure than before, when it yields a first quality of oil which is frequently mingled with the former, but is inferior to it. The *second quality* of oil is also an edible oil, and is obtained from the *entire* fruit by

the same processes. The *third quality* of oil is the fat removed from the residues of the former qualities by extraction with petroleum ether, carbon bisulphide, or benzol, the spirit being afterwards recovered by distillation. The oil so obtained is not edible, but is much used in the manufacture of soap and other substances.

Olive Kernel Oil.—The kernels yield an oil which very much resembles oil of almonds, and is therefore not edible; hence the custom of excluding the stones when preparing the best salad-oil.

Refining the Oil.—The oil from separate pressings is run into tanks containing water, where it deposits pulp, chlorophyll, resinous and other matters. After settling for some time, the supernatant oil is carefully decanted, filtered, and stored in a cool dark place until it is bottled.

Characteristics.—The oil as it leaves the press is green or dark from the presence of chlorophyll, etc., but most of this is deposited in the tank. The virgin oil is then nearly colourless, and first-quality oils are yellow, with a greenish tint, the second quality being decidedly greenish. The odour is faint and peculiar. The taste of the finest samples is pleasant and bland, but this characteristic varies with the region where the fruit grows, its maturity and variety. Oil obtained from Tuscan fruit has a more agreeable taste than that of Liguria. It may be stated generally that oil from the southern regions of Spain and Italy, from Algeria and Morocco, have a strongly marked flavour, more or less nutty in character, which is nevertheless highly esteemed by those who regularly consume it; while the oil from Northern regions is sweeter, but has a less pronounced taste. A slightly acrid after-taste is perceptible with some oils.

The Physical Characters are as follows: S.G. at 15° C. = 0·912 to 0·919, average 0·917; solidifying-point 3° or 4° C. (37° to 39° F.); refractive index 1·4460 to 1·4680; saponification value 185 to 196; iodine number 79 to 90, average 87; titre 17° to 25° C.

The Composition.—Olive-oil consists of 93 per cent. of olein, the remainder being linolein, palmitin, and arachin. It contains *no stearin*. The total amount of fat solid at ordinary temperature is only 5 to 18 per cent. of the oil, and may be regarded as almost entirely arachin and palmitin. The proportion of free fatty acids varies according to the mode of preparation. A high quality of oil may contain only 3 per cent., but the amount increases when the *pomace* is allowed to ferment, or when the oil is not quickly expressed from the fruit. A good olive-oil is free from rancidity, but oil which has been left too long in contact with the pomace, or when the pomace has been allowed to ferment, easily becomes rancid. The oil only appears to be free from the risk of such degenerative changes when it is derived from ripe, mature, and sound fruit, and is expressed from the pomace quickly, and afterwards protected from the light and air (see *Rancidity*).

Classification.—Most of the oil imported into Great Britain is shipped at Marseilles, Genoa, Leghorn, Mogador, and the Spanish

ports. It is usually classified as "Cream," "Extra Sublime," "Sublime," "Superfine," "Fine," "Good," and "Ordinary." The best virgin oils are those of Provence, Bouches du Rhone, and Aix, Florence and Lucca oils being the best Italian. In the United States, Californian oil ranks with the best French or Italian oil. Although not so highly esteemed as the former, Tuscan, Calabrian, Sicilian, Spanish, and Moroccan oils are of good quality.

The Adulteration of Olive-Oil.—Olive-oil substitutes include the oils of cottonseed, peanut, sesamé, sunflower, maize, poppy, mustard, rape, colza, and lard. Cottonseed-oil is the chief substitute for olive-oil in America. It is largely used under the name of "salad-oil," but is also sold as olive-oil, and used as an adulterant of the latter to a very great extent. Well-refined cotton-oil has a pleasant characteristic taste and odour, and is much less liable to become rancid than olive-oil, the mode of treatment removing all free fatty acids. Sesamé-oil also has a pleasant flavour, which renders it adaptable for use as a substitute or adulterant of olive-oil. Peanut-oil is probably more often used for the adulteration of olive-oil in Europe than America. It has a pleasant nutty flavour, and makes a good salad-oil, for which purpose it is largely used under its own name. The difficulty of distinguishing peanut-oil from olive-oil by ordinary chemical tests permits of the mixture of a very large proportion of peanut with olive oil without the presence of the former being detectable. Maize-oil has so far been little used as a salad-oil. It might be used as a frequent adulterant of olive-oil, only that the characteristic odour and flavour would probably lead to its detection. Mustardseed-oil is seldom directly used for the adulteration of olive-oil, but it is frequently added to rapeseed-oil, which is used as an adulterant of olive-oil. Rape and colza seed oils are less frequently used as adulterants than cotton or peanut oils, owing to their acrid taste even when well refined. The means of detecting the oils of cruciferous seeds—mustard, rape, and colza—other than by their acrid taste, is by no means satisfactory, although the presence of sulphur compounds affords a means of recognizing them. Sunflower-oil, although having a mild taste and pleasant odour, could be more easily detected. The oil of poppy-seed, although used as a culinary oil, is rarely used as an adulterant of olive-oil.

These adulterations are detected by means of the reactions already indicated, as well as by the variations from the normal taste, flavour, and odour, of olive-oil. Thus, if the S.G. of the oil exceeds 0·917 at 15° C., there is reason to suspect that it is adulterated. When the iodine number of the olive-oil under examination exceeds 89 or 90 per cent., there is another reason for suspecting sophistication. Cottonseed-oil, which is most commonly used for the purpose of adulteration, is recognizable by the Bechi test and Halphen reaction; sesamé-oil by Baudouin's test; peanut-oil by the bean-like odour and flavour, by the saponification, and more especially by the separation of arachic acid, which may be obtained

in a crystalline form, recognizable under the microscope. Lard-oil is detected by the odour of lard when it is heated ; sunflower-oil, by the high iodine number. The S.G. and refractive index are useful to show the nature of the adulterant, but very frequently a complete chemical analysis is necessary to show the real nature and extent of the adulteration.

Palm Oil or Palm Butter.—This oil or fat is obtained from the fleshy part of the capsules or fruit of various species of palm. The most important varieties from which it is obtained are the Guinea palm (*Eleis guineenis*) and the black-fruited palm (*E. melanococca*), which form vast forests on the west coasts of Africa from Loango to Sierra Leone. The oil is exported from all the towns along that coast, the various brands being named " Benin," " Congo," " Calabar," " Lagos," " Loando," " Niger " oil, etc. It is also exported from the West Indies, Canaries, North and South America, and wherever the trees luxuriate.

The natural oil is of a deep yellow colour, but turns to dirty red or greyish-white on exposure to the air and light. It has an agreeably pleasant taste, and an odour like the fragrance of violets. It consists chiefly of palmitin, and is solid at the ordinary temperature of the air. It melts at 41° or 42° C., and solidifies at 38° C. The S.G. is 0·893 at 50° C., or 0·920 to 0·945 at 15° C. ; the iodine number is 53 to 55.

Palm oil or butter is used largely by the natives in districts where the trees are grown, and to a less extent by European residents of the same areas. The native method of extraction is crude, and oil obtained in this manner soon becomes rancid from the presence of fermentable and easily oxidizable matters. More careful preparation and refining result in the production of better oils, which are bleached by ozone, bichromate of potash, or mere exposure to the air. The " soft oils " of fine quality are obtained by simple pressure of the fresh fruit. The " hard oils " are obtained otherwise. The nuts are heaped together or placed in a hole in the ground until they are partially decomposed ; the substance is then reduced to a pulp, squeezed through bags to remove fibre and other coarse materials, and afterwards boiled in water, from which the oil is removed by skimming. The fat obtained in this manner is usually of the best quality and fit for human food, the common and unrefined oils being used chiefly for candle or soap making and other industrial purposes.

Palmnut-Oil is obtained from the kernels after the removal of the fleshy portion of the fruit. It is a solid substance, soft, white, of neutral reaction, pleasant odour, and agreeable nutty taste. According to Wiley, it contains 3 to 13 per cent. of free acids, the chief of which is lauric acid. It becomes solid after the removal of the more liquid portion by hydraulic pressure. The stearin thus obtained is used in the manufacture of margarine and other butter substitutes similar to those obtained from coconut-oil, and sold as vegetable butter under the names of " Palmine," " Nucoline,"

" Laureol," " Kermol," etc. It is also used for the adulteration of genuine butter.

Peanut-Oil, Nut-Oil, Arachis-Oil.—This oil is obtained from the underground fruit of *Arachis hypogæa*, N.O. Leguminosæ, which is called indifferently " peanut," " groundnut," " earthnut," etc. The nuts are grown in Southern Europe, America, West Africa (Congo, Senegal, etc.), East India, China, Japan, and nearly all tropical countries. The oil is edible, of nutty taste and aroma, and the finest quality is sold as salad-oil. It contains 5 per cent. of arachidic acid which imparts to it characteristics, besides hypogæic, lignoceric, and linoleic acids and arachin. It has a S.G. of 0·919 at 15° C., solidifies at −2·5° C. (+27·5° F.), has a saponification number 185 to 195, iodine value 87 to 100, and refractive index at 25° C.= 1·4690 to 1·4707. The oil is obtained and refined in the same manner as palmnut, olive, and other oils. The finest quality is obtained by cold pressure or " cold-drawn " from the dried seeds, and this constitutes a portion of the salad-oil in various markets, and is used for culinary purposes, or even to adulterate olive-oil. It is colourless, palatable, and has an odour similar to kidney beans. The second grade of oil is obtained after moistening and heating the residue from the former. This oil is of pale yellow or greenish colour, of inferior quality, not so palatable as the former, and is chiefly used for making margarine, and to some extent by confectioners, to whom it is sold as " Butterine " oil. A third quality of oil, which is still more crude, is obtained by steaming and submitting to hot pressure the residue from the second grade. It is chiefly used in the manufacture of soap.

Peanut-oil is refined by allowing it to stand for some time, and afterwards filtering the clear supernatant liquid. It is rendered colourless or nearly so by mixing it with fuller's-earth and animal charcoal before filtration. Even the superfine oil may be of a yellowish-green colour unless bleached in this manner.

The cake which remains after the extraction of the oil contains a large percentage of protein, and is highly nutritious. It is used chiefly in the manufacture of cattle foods and land fertilizers.

The detection of peanut-oil in olive-oil and other fats depends upon the reactions showing the presence of arachidic acid and the bean-like odour which is peculiar to it, and to a less extent to maize-oil. Peanut-oil itself may be adulterated by cottonseed-oil, rape-seed-oil, poppy or sesamé oils.

Rapeseed-Oil.—The name of " rape-oil " is applied indifferently to the oils obtained from the seeds of varieties of Brassica, N.O. Cruciferæ. Correctly speaking, *B. campestris* yields colza-oil, *B. napus* rape-oil, and *B. rapa* rübsen-oil.

The cold-drawn oil is used as an edible oil in India, and occasionally by confectioners in Europe, when better-flavoured oils are scarce or too expensive. It is light yellow in colour, and is either odourless or has a slight characteristic odour. Its S.G.= 0·914 to 0·917 at 15° C., and it solidifies at −4° to −6° C. (+21° to +25° F.).

The second quality of oil is obtained from the seeds by hot pressure —that is, after heating them in a steam-jacketed pan—and still more oil is obtained by extracting the marc with petroleum-ether or carbon bisulphide, but the latter is only used for technical purposes.

Refined Oil.—The oil contains mucilaginous and other matters which can be removed by refining. This process consists in allowing the oil to settle, sometimes after mixing it with water, decanting the supernatant oil, mixing it with fuller's-earth, and filtering it. Such oil is used for domestic purposes. When it is not desired to be used for domestic purposes, the refinement consists in the deposition of the mucilaginous substances by sulphuric acid, afterwards washing the oil in an alkaline water to neutralize the acid. Such oil, however, should only be used for technical purposes.

Varieties.—" English refined oil " is a well-known quality obtained from seeds imported from the East Indies. " Brown or sweet oil " is that obtained by pressure of the seeds. " Refined oil " is that made by refining the crude oil obtained after extraction of superior cold-drawn oil by treatment with sulphuric acid. Rape, colza, and rübsen oils are distinguished on the Continent and elsewhere, but little practical interest attaches to this distinction. When such distinction is made, the name **colza** should be applied to the finest and lightest quality. These oils are produced mainly from seeds grown in France, Germany, Belgium, and Russia. Ravison rape is a variety obtained from Ravison seed grown in the Baltic regions.

Adulterations.—The presence of cottonseed-oil would be detected by the Halphen reaction, but such addition would not spoil colza-oil for human consumption. The presence of hempseed-oil, linseed-oil, paraffin, rosin-oil, and fish-oils, however, would render it unfit for human consumption, and their detection in oil intended for that purpose is a matter of difficulty.

Salad-Oils.—The oils used for salad dressings, also called " sweet oils," are olive-oil, peanut-oil, cottonseed-oil, and sesamé-oil.

Sesamé-Oil. — *Synonyms:* Teel-oil, Gingilé-oil. This oil is obtained from the seeds of *Sesamum orientale, S. indicum,* and *S. radiatum,* grown in India, China, Japan, and other hot countries. It is used in Japan in place of butter. The cold-drawn oil is considered quite equal to olive-oil as a salad or edible oil, and by some persons is preferred for its agreeable flavour. The seeds yield 50 to 57 per cent. of oil of a light amber colour, pleasant grain-like odour, and bland taste. It has S.G. = 0·922 to 0·923 at 15° C., iodine number 103 to 110, saponification value 189 to 193, refractive index 1·47 at 25° C., and it solidifies at −5° C. (+23° F.). It contains chiefly olein, with smaller proportions of stearin, palmitin, and linolein. It also contains sesamin, $C_{18}H_{18}O_5$, sesamol, phenol, and phytosterol. The solid fat amounts to about 12 or 14 per cent., and the liquid oil to about 70 per cent.

Cold-drawn sesamé-oil is used for edible purposes in many places, and is especially useful in the manufacture of margarine. Inferior

grades are used for various industrial purposes, especially soap-making. It is adulterated by cottonseed, poppyseed, and rape-seed oils. In Germany it is compulsory that margarine should contain not less than 10 per cent. of sesamé-oil, in order that the adulteration of butter by margarine may be easily detected. This detection is brought about by the crimson colour which any fat containing more than 2 per cent. of sesamé-oil will give when shaken up with hydrochloric acid and sugar or furfurol (Baudouin's test). The Butter Regulation Committee recommended to the British Board of Agriculture in 1903 the adoption of a similar rule.

Sunflower-Oil.—Oil from the seeds of *Helianthus annus* is used for edible purposes in Russia, India, Germany, and Italy. The finest grade of oil is obtained by cold pressure of the "hulled" seeds, inferior grades being obtained from the marc after heating in a steam-heated pan. The best oil is pale yellow, has S.G. 0·925 at 15° C., iodine number 120 to 130. It is considered by some authorities to equal olive-oil for edible purposes, and largely replaces it in Russia.

PART III

MATERIA ALIMENTARIA DERIVED FROM THE VEGETABLE KINGDOM

THE natural orders of plants and the botanical sequence of those from which materials are derived for human food are as follows :

CLASS

1. ALGÆ.
2. FUNGI ; and subgroup, Lichenes.
3. HEPATICÆ.
4. MUSCI.
5. FILICINÆ.
6. EQUISITINÆ.
7. LYCOPODINÆ.
8. GYMNOSPERMÆ : *Cycadaceæ, Coniferæ.*
9. MONOCOTYLEDONES.
   - (1) *Arales.*
   - (2) *Palmales :* Date-palm, sago-palm, coconut.
   - (3) *Graminaceæ :* Wheat, rye, rice, oats, barley, maize, millet.
   - (4) *Liliaceæ :* Onions, shallots, leeks, garlic, asparagus.
   - (5) *Dioscoreaceæ :* Yams.
   - (6) *Bromeliaceæ* : Pineapples.
   - (7) *Musaceæ :* Bananas.
   - (8) *Zingiberaceæ :* Ginger, curcuma, cardamoms.
   - (9) *Marantaceæ :* Arrowroot.
   - (10) *Orchidiaceæ :* Vanilla.
   - (11) *Amaryllidaceæ :* American agave.
   - (12) *Iridaceæ :* Saffron.
10. DICOTYLEDONES :
    - (1) *Piperaceæ :* Pepper.
    - (2) *Moraceæ :* Mulberry, fig, bread-fruit.
    - (3) *Corylaceæ :* Hazelnuts ; *Fagaceæ :* Chestnuts ; *Juglandaceæ :* Walnuts.
    - (4) *Chenopodiacea :* Beet, spinach.
    - (5) *Magnoliaceæ :* Star-anise.
    - (6) *Anonaceæ :* Sweet-sop, sour-sop.
    - (7) *Nymphaceæ :* Lotus.
    - (8) *Myristicaceæ :* Nutmeg, mace.
    - (9) *Polygonaceæ :* Rhubarb, buckwheat.
    - (10) *Cruciferæ :* Watercress, cabbage, cauliflower, mustard, turnip, radish.
    - (11) *Caparidaceæ :* Capers.
    - (12) *Ternstræmiaceæ :* Tea.
    - (13) *Sterculiaceæ :* Cocoa, kola.
    - (14) *Erythroxylaceæ :* Coca.
    - (15) *Aurantiaceæ :* Citron, orange, lemon, lime.

Class
10. Dicotyledones (*continued*) :
(16) *Ampellidaceæ :* Grapes.
(17) *Euphorbiaceæ :* Cassava, tapioca.
(18) *Umbelliferæ :* Parsley, carrot, parsnip, fennel, caraway, etc.
(19) *Papayaceæ :* Papaw.
(20) *Cucurbitaceæ :* Cucumber, melon, water-melon.
(21) *Cactaceæ :* Prickly pear.
(22) *Myrtaceæ :* Brazil nut, pomegranate, cloves.
(23) *Rosaceæ :* (*a*) *Prunus :* Sloe, plum, damson, apricot, peach, almond ; (*b*) *Rubus :* Blackberry, raspberry, dewberry ; (*c*) *Fragaria :* Strawberry ; (*d*) *Pomus :* Apples, pears ; (*e*) *Cydonia :* quince ; *Photinia :* loquat ; *Mespilus :* medlar
(24) *Leguminosæ :* Pea, bean, groundnut, carob-bean, cassia.
(25) *Saxifragaceæ :* (*a*) *Ribes :* Currant, gooseberry.
(26) *Labiatæ :* Basil, mint, thyme, sage, marjoram, savory, balm.
(27) *Convolvulaceæ :* Sweet-potato.
(28) *Solonaceæ :* Potato, tomato, capsicum.
(29) *Oleaceæ :* Olives.
(30) *Ericaceæ :* Arbutus (strawberry-tree).
(31) *Vaccineaceæ :* Whortleberry, bilberry, cranberry.
(32) *Rubiaceæ :* Coffee.
(33) *Caprifoliaceæ :* Elderberry.
(34) *Compositæ :* Artichoke, Jerusalem artichoke, chicory, endive, salsify, scorzonera, lettuce.

The foregoing list gives abundant examples of the foodstuffs of vegetable origin ; but completeness is not claimed, nor will the order given above, which is botanical, be adhered to in the following pages, as it is believed that it will suit the purposes of the reader better to have them discussed in groups of allied materials.

CHAPTER XIV

THE CEREALS (N.O. GRAMINACEÆ)

WHEAT : *Triticum sativum*, with the following cultivated varieties—
Triticum vulgare : Distinguished by long glumes which have no keel.
Subvarieties : *T. hybernum :* Winter wheat.
T. æstivum : Summer wheat.
Triticum turgidum : Egyptian wheat, with short-keeled glumes.
Triticum compactum : Dwarf wheat, with short stout spikes.
Triticum durum : Hard wheat, awned and unawned.
Triticum polonicum : Polish wheat, also hard.
Triticum spelta : Ripe seeds enclosed in the paleæ.
T. spelta : The common spelt.
T. dicoccum : Starch wheat.
T. monococcum : Little spelt.

RYE—*Secale cereale :* Five or six species.

OATS—*Avena :* Cultivated species of—
Avena sativa : Common oats, with panicles in various planes.
Avena orientalis : Eastern or Tartarian oats, with the panicles in one plane.
Avena strigosa, with a hairy floral axis.
Avena nuda, the spikelets of which consist of three flowers.

BARLEY—*Hordeum :* Cultivated varieties—
Hordeum distichon, bearing two rows of flowers.
Hordeum distichon nudum, in which the fruit is bare.
Hordeum vulgare, bearing four rows of flowers.
Hordeum hexastichon, bearing six rows of flowers.

RICE : *Oryza sativa* and numerous varieties.

MAIZE : *Zea maïdis, Zea everta, Zea saccharata.*

MILLET—*Chætochlea (setaria) italica :* Italian and Japanese millet. *C. Germanica*, German millet, etc.
Panicum colonum : Shama millet, or jungle rice.
Panicum miliaceum : The common millet of Europe.
Sorghum vulgare : Sorghum, or durra.
Sorghum saccharatum : Sweet sorghum.

Other seeds, *not grasses*, used as cereals :

BUCKWHEAT : *Fagopyrum esculentum.*
QUINOA : *Chenopodium quinoa.*

The Cereals.—All cereals belong to the natural order of *Graminaceæ*, or Grasses. Most cereals are cultivated in all parts of the earth, but it is a matter of doubt whether the cereals so much esteemed at the present day have been evolved by natural selection and cultivation from the wild grasses now known, or whether they are distinct species having their origin in grasses which no longer exist. The part consumed is the seed or *grain*, which consists of the germ, forming 1·5 per cent., and the endosperm with its coverings,

forming 98·5 per cent. of the entire seed. The endosperm is the part chiefly used for human food. These divisions will be more fully considered under the head of Wheat and other grain.

Wheat.

Latin, *Triticum vulgare;* French, *Blé;* German, *Weizen.* Wheat is by far the most important cereal used by the Western races. It occupies the same position as a dietetic article for Europeans and Americans occupied by rice for the Oriental peoples. The species of wheat now cultivated are unknown in a wild state, neither is there any grass which can be regarded as its parent form. It has been found in prehistoric lake-dwellings, was cultivated by the ancient Egyptians and Chinese, and it was introduced into Britain by the Romans. It is not known whether the present form of wheat is its natural condition, or whether it is derived from a wild plant subject to cultivation and improvement by art. De Candolle infers that the natural home of this cereal is Mesopotamia.

The consumption of wheat in Great Britain averages about 6 bushels per head per annum, but only a comparatively small proportion of the grain, or about one-fifth, is grown in the United Kingdom, the country being very largely dependent upon foreign sources of supply. The supplies of wheat are as follows:

UNITED KINGDOM WHEAT SUPPLIES.

In Millions of Hundredweights, and in Round Figures to the Nearest Million.

	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.
1. Home-grown ..	37	34	27	27	29	24	19	30	30	28
2. Foreign imports:										
Argentina ..	6	12	19	8	5	14	22	24	19	22
Austria	1	1	2	1	1	1	1	1	1	1
France	1	1	1	1	1	1	2	1	1	1
Germany ..	1	1	2	1	—	—	1	1	—	—
Roumania ..	—	—	1	1	2	3	1	2	4	3
Russia	6	3	4	3	7	17	24	24	15	11
U.S.A.	62	60	58	67	65	47	18	14	36	33
Total foreign	77	78	87	82	81	83	69	67	76	71
3. Colonial imports:										
Australia ..	—	3	3	6	4	—	11	11	9	8
New Zealand ..	—	1	1	1	—	—	—	—	—	—
Canada	8	9	8	9	12	14	9	8	14	16
India	9	8	—	3	9	17	26	23	13	18
Total colonial	17	21	12	19	25	31	46	42	36	42
Total imported ..	94	99	99	101	106	114	115	109	112	113
Total supply ..	131	133	126	128	135	138	134	139	142	141

THE WORLD'S WHEAT-SUPPLY, 1910-11.

	Quarters.
U.S.A.	87,000,000
Canada	15,000,000
River Plate and Chili	19,500,000
Australasia	10,000,000
Russian Empire	84,000,000
United Kingdom	6,500,000
France	32,000,000
Austria-Hungary	32,800,000
Italy	18,000,000
Balkans	19,400,000
Germany	17,730,000
Rest of Europe	29,000,000
India (forecast)	35,500,000
Total	406,430,000

The Varieties of Wheat.—(A) In **Wheat,** properly so called, the seed separates itself naturally from the husk. The varieties are innumerable. These, however, have been classed by Vilmorin into four species or modifications of the common wheat. The history of these grains supports the theory of their common origin.

1. **Common Wheat** (*Triticum vulgare*, with its species, *T. hybernum*, the winter or unbearded wheat; and *T. æstivum*, the summer or bearded wheat).—All wheats, says Tozier, are spring or autumn sown, according to the country or climate in which they are grown, and readily pass from one state to the other. But among the immense number of varieties are some which feel the cold of winter more than others, whence it has become the custom to sow them in the spring.

The cultivation of wheat is prehistoric in the Old World.[1] Ancient Egyptian monuments, before the Shepherd Kings, and the Hebrew Scriptures, show its cultivation already established. The Egyptians and Greeks attribute its origin to mythical personages—Iris, Ceres, Triptolemus. The remains of the earliest lake-dwellings of Switzerland contain small hard grains which Heer describes as *T. vulgare antiquorum*. The early lake-dwellers were contemporary with the Trojan war, or earlier. Another variety, called by Heer *T. vulgare compactum muticum*, was found in the remains of less ancient lake-dwellings of the earliest Stone Age in Switzerland and Italy, and an intermediate variety cultivated in the Stone Age was found in Hungary. None of these, however, are identical with the more profitable wheat cultivated at the present day. Unger found wheat in a brick of the Egyptian pyramids, to which he assigns the age 3359 B.C. The Chinese grew wheat 2700 B.C., and considered it a special gift from Heaven. It was classed with rice, sorghum, and the soy-bean, which the Emperor Chin-nong ordered to be sown annually with sacred rites. The region in which wheat arose is

[1] De Candolle's "Origin of Cultivated Plants," pp. 354-367.

indefinite. The species now cultivated are descendants of a wild form which no longer exists. According to Herodotus, wheat was mentioned by Berosus, a Chaldean priest, as being wild in Mesopotamia, and the Hebrew writings show that it was cultivated abundantly in Canaan. According to Homer's "Odyssey," wheat grew in Sicily without the aid of man, and Diodorus Siculus says the same thing. It is not to be found growing wild in Sicily to-day. Strabo, 50 B.C., says, according to Aristobulus, it grew wild on the banks of the Indus; but no mention is made by botanists of wheat growing wild to-day in India, China, or Mongolia. It is remarkable that wheat has been twice asserted to be indigenous to Mesopotamia—viz., by Berosus 2,300 years ago, and again by Olivier in the present day. De Candolle concludes that it arose in Asia, and that the principal habitation of wheat in prehistoric times was the belt of cultivation which formerly extended from China to the Canaries, and particularly the valley of the Euphrates. This area may have extended into Syria, but to the east and west of Western Asia it has probably never existed except as a cultivated plant. Wheat, however, was widely cultivated anterior to all known civilization, and the history of the great races of wheat is, says De Candolle, in favour of their derivation from the small hard-grained wheat cultivated by the Egyptians and by the lake-dwellers of Switzerland and Italy. The separation of wheat—that is, wheat with free grains—from spelt, or wheat in which the ripe grains remain covered by the husk, must have taken place before all history, and probably before the beginning of agriculture.

2. **Turgid and Egyptian Wheat** (*T. turgidum et compositum*).—This form has never been found in a wild state, and is considered to be a modification of common wheat. It is the great or miraculous wheat referred to by ancient writers, and so called from the large number of grains it bears. It is ancient, and the grains have been found in the sarcophagi of ancient mummies and the lake-dwellings of the Stone Age in Switzerland.

3. **Hard Wheat** (*T. durum*) has also never been found wild, but is believed to be a variety of common wheat which originated in Spain and North Africa at an unknown date, probably within the Christian era.

4. **Polish Wheat** (*T. polonicum*) also bears hard grain, somewhat longer than the former, and is much cultivated in Eastern Europe, where, De Candolle says, it cannot be doubted it originated by cultivation from common wheat at a recent epoch.

B. **Spelt** consists of those wheats whose ripe seeds are closely contained in their envelope or husk, and require a special operation to separate them. Vilmorin enumerates three forms:

1. **Common Spelt** (*T. spelta*), which contains only two grains in each ear. The grain is not naked, as in ordinary wheat, but remains like barley or oats, enveloped in the *paleæ*, which cannot be removed by agitation, as in winnowing the corn; consequently the flour is coarse, and resembles barley meal. Spelt is therefore not of the commercial value of wheat. It

is also inferior in flavour to wheat, but is not much different in composition, excepting that it contains more celluose and somewhat less protein, as shown by the following table :

COMPOSITION OF SPELT—PERCENTAGES.

Water	..	15·0 to 16·0
Albuminoids : Soluble.. ..	..	1·5 ,, 2·5
Insoluble ..	..	7·5 ,, 8·5
Carbohydrates : Starch ..	..	60·0 ,, 65·0
Sugar.. ..	..	1·0 ,, 1·5
Dextrin ..	..	1·5 ,, 2·0
Cellulose	..	3·5 ,, 5·0
Mineral substances	..	1·5 ,, 2·3

Spelts are not grown now upon soils which are suitable for the production of wheat ; but they are grown largely in Germany and Switzerland and in other elevated regions, where the soil is too poor for wheat. The origin of spelt, like that of common wheat, is uncertain. History and philology point to Eastern temperate Europe and the neighbouring countries of Asia as its natural home. Olivier found it growing wild in Mesopotamia, and Michaux in temperate Persia. De Candolle thinks that spelt was derived from common wheat or from an intermediate form ; but botanical considerations are against this hypothesis. Other cereals—barley and oats—are, when ripe, enveloped in their husks like spelt. There is not sufficient evidence to show that common wheat was naturally free from the husks ; it is not found in a wild state. It is therefore not impossible that wheat arose from spelt, or that both had a common origin in a wild stock which no longer exists. Spelt has not been found in the Egyptian monuments, but it is referred to by Homer and Herodotus, and is believed to be the *semen* which Pliny says was used by the Latins for 360 years before they knew how to make bread.

2. **Starch Wheat** (*T. dicoccum*), like common spelt, only has two grains in each ear. It is grown chiefly in Switzerland for making starch, and is believed to be a variety of true spelt.

3. **One-Grained Wheat**, or **Little Spelt** (*T. monococcum*), contains but a single grain in each ear. It thrives in the poorest and most stony soil, and is sown chiefly in the mountainous districts of Spain, France, and Eastern Europe. It is a true species, and a native of Servia, Greece, and Asia Minor, from which De Candolle believes the other spelts have arisen by cultivation and development through several thousands of years.

The Composition of Wheat.—Wheat grows readily in all temperate regions, and is cultivated in almost all regions of the earth. Winter wheat is sown in the autumn of one year, and garnered the uext ; but summer wheat is sown in the spring of the year in which it is garnered. The names *red* and *white* merely refer to the colour of the grain. The soil best adapted for it is a heavy loam or rich clay, and the differences in the grain mainly arise from the soil and the mode of its cultivation. Some of the chief subvarieties grown in England are named as follows—(*a*) *White Wheat:* Talavera, Chiddam, Taunton Dean, Hunter's, Rough Chaff, Smooth Chaff, etc. (*b*) *Red Wheat:* Spalding, Burrell, Lammas, Golden Drop, Nursery, April (bearded), Revett's (bearded), and others. Red wheat is more hardy, but the yield is smaller and the quality poorer than that of white wheat.

Innumerable analyses of wheat grown in different parts of the earth have been made. The reports show a slightly different com-

position of the grain, just as analyses of different samples of other foodstuffs give a different report, owing to differences in kind or quality and the soil on which they are grown.

COMPOSITION OF WHEAT—AVERAGE OF 250 SAMPLES (KÖNIG).

Water	13·56 per cent.
Nitrogenous matters	12·42 ,,
Fat	1·70 ,,
Sugar	1·44 ,,
Dextrin and gum	2·38 ,,
Starch	63·85 ,,
Cellulose	2·66 ,,
Ash	1·97 ,,

PERCENTAGE COMPOSITION OF WHEAT FROM VARIOUS COUNTRIES (KÖNIG MOSTLY).

Source.	Water.	Protein.	Carbo-hydrate.	Fat.	Cellu-lose.	Salts.
England	—	10·99	69·21	1·86	2·90	1·67
Scotland	—	10·58	72·77	1·73	—	1·55
France	—	12·64	68·92	1·41	2·00	1·66
Germany	—	12·29	67·96	1·71	2·82	1·85
Russia	—	16·75	64·40	1·58	2·19	1·71
India	—	10·99	70·19	2·08	1·92	1·45
Australia	—	10·16	—	1·39	—	—
North America—504 samples	—	11·61	69·46	2·07	1·70	1·79
All Europe except Russia—208 samples	13·7	12·30	67·90	1·80	2·50	1·80
All Countries—948 samples, average	13·3	12·03	68·67	1·85	2·31	1·77
Winter wheat, average	—	11·64	69·07	1·72	2·34	1·86
Summer wheat ,,	—	11·38	69·29	2·00	1·81	1·94
East Indian wheat[1]	12·5	13·50	68·40	1·20	2·70	1·70
American wheat:[2]						
Average of 407 samples	10·2	12·20	71·70	2·20	1·80	1·90
Highest	12·5	18·00	78·70	3·60	3·10	3·60
Lowest	7·7	7·70	64·80	1·40	·40	·80

The entire and uncrushed grain is now rarely eaten. It was, however, formerly common to soak the grain in water and boil it until the external coverings were burst and the endosperm swollen by the absorption of water. The grain, being then mixed with sugar and milk, formed a nutritious dish called **frumenty.** It is rarely heard of now. Whole-wheat meal has a similar composition to that of the grain, but for various reasons it is not commonly used. This matter, however, is deferred until we discuss flour and bread.

The grain of wheat consists of various parts. As these are important from a dietetic point of view, they must be briefly discussed. Every grain has an external covering or skin, internal substance or kernel, and the germ.

[1] Church. [2] Richardson.

(*a*) The **Skin,** or "hull," can be removed after soaking the grain in water for several hours. It consists of five layers. The first three layers form the **bran,** to which are added the hyaline and cerealine coats. Boussingault found that the amount of bran varied from 13 to 38 per cent. of the entire grain, according to its quality; but in grain of average quality the bran usually forms 13·5 per cent. of the total. The various layers are in the following order:

1. The *epidermis*, or cuticle, consists of two or three layers of flattened elongated cells with beaded edges, which fit into the edges of other cells. A few cells of the most external layer and near one extremity are characterized by bearing a "hair," which is a prolongation of the cell substance. The latter are recognizable under the microscope, and serve to distinguish wheat meal from other meal, and may be present in the finest wheat flour.

2. The *epicarp*, consisting of a layer of coarse cells arranged longitudinally along the grain at right angles to those of the epidermis.

3. The *endocarp* is a layer of finer cells arranged transversely around the grain.

4. The *episperm* or *testa* is the true envelope or hyaline coat of the grain. It consists of long narrow cells containing the colouring matter distinguishing red from white wheat.

5. The *aleurone* or **cerealin** layer consists of a single layer of cubical or polygonal cells immediately beneath the testa. It is really a portion of the endosperm or kernel, but the cells are rich in fat, contain amorphous protein granules, and are considered to have an influence upon the process of leavening which is more or less deleterious to the quality of the bread. The fat also tends to become rancid, and gives a bad flavour to the flour. These reasons are considered to be sufficient for the removal of the cerealin layer with the bran.

(*b*) The **Kernel,** or internal substance, consists of the endosperm, and forms 85 per cent. of the total substance of the grain. It is this portion which is ground into fine flour. It consists of a large number of compartments or divisions which are filled with the starch grains, soluble and insoluble proteins, sugar, and salts. The divisions forming the compartments are made up of cellulose. The chemical composition of the endosperm will be considered below.

(*c*) The **Germ** is embedded at one end of the grain, and forms 1·5 per cent. of the total weight. Like the germ of other seeds, it consists of the *plumule*, or primary shoot, of the embryo plant; the radicle, or root-centre, around which is a single seed-leaf, or *cotyledon*, the central part of which forms the *scutellum*, or sheath, which invests the endosperm. The entire germ of an ungerminated grain consists of pale yellow cells, containing a considerable quantity of fat and protein, but *no starch*. The presence of starch grains in a section of the germ, seen under the microscope, would be evidence that the grain had germinated; the flour from such grain does not make satisfactory bread. The germ cells are rich in

enzymes, which transform the insoluble starch and protein of the endosperm into sugars, dextrins, and amides, capable of being absorbed by the embryo plant during germination.

Table A, p. 378, is given by Professor Church[1] as the proportion and composition of the bran, endosperm, and germ, of wheat grains.

Table B, p. 378, however, shows more fully the proportion of constituents which is contributed by each part in the formation of the entire grain.

The Proteins of Wheat.—The nitrogenous matters or proteins of wheat vary from 10 to 14 per cent. There are lower and higher points than these, but an examination of a large number of analyses leads to the conclusion that these figures represent the average variation. Léon Boutroux[2] states that Polish wheat ranks highest, by containing 21·5 per cent.; Egyptian wheat next, with 20·6 per cent.; while white provincial wheat has only 9·8 per cent. König also found Russian wheat had the highest protein percentage. According to Rubner, however, only 72 per cent. of the nitrogen exists in form of protein; he therefore reckons the protein of wheat = N × 5·7, and it averages about 12 per cent. The germ of wheat is particularly rich in nitrogen; according to Frankfurt,[3] it amounts to 6·44 per cent., of which 0·8 per cent. is in the form of amides; therefore the protein in the germ is 36·7 per cent. The kernel of wheat, or endosperm, contains 8·5 to 10·5 per cent. of protein, and, according to Osborne, averages 10 per cent.

The term **Gluten** has been used to cover all the proteins of wheat; it is obtainable by kneading flour into a paste with water, and afterwards washing away the starch: the remnant is gluten. It is a yellowish-grey or greyish-brown substance, which is very elastic and adhesive, insoluble in water and saliva, and tasteless when removed from the flour. If dried at a low temperature in the open air it becomes brittle, and has a glossy sheen, like gelatin. Dried gluten can be ground into a powder, which retains its original properties. When heated at a temperature between 212° and 260° F. it softens and spreads out, but ultimately toughens, and finally dries hard. If the temperature is raised to between 350° and 440° F., gluten expands owing to the generation of steam in its interior, while the exterior sets into a hard and brittle crust, which is similar to the condition of gluten in the crust of bread. If gluten be boiled in water it expands slightly, but forms a tough, inelastic grey substance. This is the condition of gluten in the interior of a loaf, where it forms slender threads and meshes which hold the starch and other substances in a compact mass. The condition of gluten is slightly altered by fermentation; this is seen by a comparison of gluten obtained by washing unleavened dough with a piece obtained in a similar manner from dough which has properly matured in the usual mode of bread-making, the gluten from

[1] "Grain Foods of India."
[2] "Le Pain et la Panification," Paris, 1897.
[3] *Länder-Versuchs-Stat.*, 1896, xlvii. 449.

A.—COMPOSITION OF THE PARTS OF WHEAT GRAIN—PERCENTAGES.

	Proportion of Grain.	Water.	Nitrogenous.	Fat.	Starch and Sugar.	Cellulose.	Mineral Matter.
Bran	13·5	12·5	16·4	3·5	43·6	18·0	6·0
Endosperm	85·0	13·0	10·5	·8	74·3	·7	·7
Germ	1·5	12·5	35·7	13·1	31·2	1·2	5·7

B.—COMPOSITION OF ENTIRE WHEAT GRAIN—PERCENTAGES.[1]

	Proportion of Whole Berry.	Moisture.	Nitrogenous.	Carbohydrate.			Fat.	Lignin, or Fibre.	Mineral Matter.
				Sugar.	Starch.	Cellulose.			
Cuticle (epidermis, endocarp, and epicarp) ..	4·2	·475	·362	—	—	—	—	3·309	·080
Episperm	1·1	·131	·178	—	·723		—	—	·060
Aleurone layer	8·2	1·115	2·048	—	—	3·997	·748	—	·452
Germ	1·5	·173	·538	·332	—	·144	·187	—	·070
Endosperm	85·0	11·050	8·925	1·506	61·635	·590	·680	—	·590
Total	100·0	12·944	12·051	1·838	61·996	5·093	1·615	3·309	1·252

[1] *Cf.* "The Modern Baker," vol. i., p. 34.

leavened dough being paler than that obtained from flour before fermentation.

Gluten does not exist as such in wheat or flour, but it is formed when the flour is mixed with water, out of two other proteins, gliadin and glutenin, which together form all the protein of wheat excepting 1½ per cent., as seen in the following analysis by Osborne :

Composition of Gluten in the Kernel of Wheat.

(*a*) *Insoluble proteins*	Gliadin	.. ..	4·25 per cent.
	Glutenin	.. ..	4·37 ,,
(*b*) *Soluble proteins*	Albumin	.. ..	·40 ,,
	Globulin	.. ..	·70 ,,
	Proteose	.. ..	·30 ,,
			10·00 ,,

Gliadin is an albuminoid substance of known stability. It is soluble in dilute acids, alkalies, alcohol (70 per cent.), and slightly in sodium chloride solution, and it softens in distilled water. It contributes the property of elasticity and tenacity to gluten. *Glutenin* gives to gluten the property of stability, which, like elasticity and tenacity, are essential for making good bread. Glutenin is not dissolved in alcohol or saline solution, nor is it readily softened by distilled water ; but it dissolves in dilute acids and alkalies. It is not a single or simple substance, but a combination of *mucedin*, *gluten-fibrin*, and *gluten-casein*.[1]

Amino-Acids in Wheat Proteins.

	100 Grammes yield on Hydrolysis—		
	Gliadin.	Gluten-Casein.	Gluten-Fibrin.
Ammonia	4·10	2·64	3·89
Histidine	1·20	1·56	1·53
Arginine	2·75	4·54	3·05
Lysine	nil	2·00	nil
Tyrosine	2·09	2·75	3·43
Glycocine	18·54	9·00	13·07

According to Osborne, the following is the composition of gliadin : C 52·72, H 6·86, N 17·66, O 21·62, S 1·14, per cent. ; and glutenin : C 52·34, H 6·83, N 17·49, O 22·26, S 1·08, per cent. Little is known of the action of gliadin and glutenin upon one another, nor in what way they combine to form gluten ; they are probably oppositely-charged proteins which neutralize one another. But whether their union is chemical or physical remains unknown. In the former case the gluten would present properties entirely distinct from either of the constituents, and neither of the latter could be

[1] Mann, " Chemistry of Proteids," p. 71.

separated out, whereas the usual method of determining the ratio of the two is by dissolving out the gliadin with alcohol. The idea of a physical union of the proteins is therefore probably correct, and is accepted by many authorities. According to the ionic theory, gliadin and glutenin consist of electrically-charged proteins, which attract each other, and the reaction of gluten is the algebraical sum of the reaction of the components. The characteristic properties of gluten depend upon the action of gliadin; and the power of wheat to make good bread varies in different samples, according to the ratio of gliadin to glutenin. This ratio is not constant, but varies, being as 2 : 1 in the best bread flours, and about equal in inferior flours; therefore as the proportion of gliadin to glutenin varies, so do the characters of the gluten and the bread produced. Gliadin is more abundant in wheat than in any other grain—hence the superiority of this cereal for bread-making. This fact is well illustrated in the following table by Fleurent,[1] where he compares the proportion of gluten or insoluble protein of wheat, and the ratio of gliadin to glutenin, with the same principles in other cereals:

RATIO OF GLIADIN AND GLUTENIN IN CEREALS.

	Gluten, or Insoluble Protein, per Cent.	Ratio of Gliadin to Glutenin.
Wheat	6 to 14	62·68 : 37·18
Rye	8·2	8·17 : 92·83
Maize	10·6	47·50 : 52·50
Barley	13·8	15·60 : 84·40
Rice	7·8	14·30 : 85·70
Buckwheat	7·2	13·00 : 86·90

The **Soluble Proteins** of wheat are **edestin**, a globulin, **leucosin**, an albumose, and a proteose; together with a smaller proportion of amides, including asparagin, leucin, tyrosin, and others. They are soluble in water. Their presence in wheat is of more importance during bread-making than their actual food value, seeing that their total is only about 1·5 per cent. of the grain. They have an action upon the other proteins of the flour, and they change soluble starch into sugar. The soluble proteins vary in amount, but in order to secure good bread it has been shown that a definite ratio must exist between the soluble and insoluble proteins (gluten). If the proportion of soluble proteins is excessive, the flour is invariably soft, and does not make good bread; this is due, not only to the disproportion between the gliadin and glutenin, but to the action of the soluble proteins upon them. During growth the soluble proteins of wheat increase at the expense of the insoluble proteins, by hydrolysis of the latter, but there is no increase in the total

[1] *Compt. Rend.*, 1901; *cf.* "Modern Baker," vol. i., p. 33.

amount of protein. Again, as the wheat ages, by storage of the grain, the flour produced from it undergoes slight changes, due in part to the transformation of albuminoids into albumoses and globuloses (soluble proteins); and such flour is also softer than the normal standard flour, and makes inferior bread.

There is, however, an alternative theory of the cause of such softening of the gluten during fermentation, which may conveniently be mentioned here. It is that the change is produced by an acid or acids developed in the dough, and which have the same softening effect upon gluten which is attributed to the soluble proteins. It is true that the percentage of acid in flours increases, not only from age, but also as the quality decreases. The acidity of "red dog" flour is seven times as much as that of first or second patent flour. An acid is developed during the fermentation of dough, and as the dough made from some flours requires a longer time to mature than that from others, a larger amount of acid is produced. It is also believed that more acid is produced in the dough when the fermentation occurs at a temperature higher than 70° F. This argument, that the softening of gluten is due to the action of acids, and not to the soluble proteins, is upheld by the fact that a loaf of normal size and appearance can be made from good flour after the soluble proteins have been removed.[1] On the other hand, when flour is raised to a temperature of 100° C., its bread-making properties are much impaired, which appears to be due to the destruction of unorganized ferments, particularly the enzymes of the flour, rather than to any chemical change produced by the heat in the insoluble proteins (gliadin and glutenin). Bourquelot[2] has shown that the enzymes normally existing in the seeds of all cereals are destroyed by a temperature ranging from 50° to 70° C. The inferiority of heated flour is therefore presumably due to the destruction of the enzymes; and as the bread produced from such flour results in the formation of smaller loaves, the importance of these enzymes, which are soluble proteins, is thereby established.

The **Carbohydrates** of wheat, according to König, are as follows:

Starch	63·87 per cent.
Sugars	1·44 ,,
Dextrin and gum	2·38 ,,
Cellulose	2·66 ,,
	70·35 ,,

To these must be added 3·3 per cent. of lignin, or woody fibre, in the bran. The starch consists of granules having the ordinary laminæ, but the striæ, or markings, and the hilum (near the centre), are only visible under a high-power microscope and the most favourable conditions. The granules are oval or round, and vary much in

[1] Bulletin 67, "Bread and Bread-making," p. 67, U.S. Department of Agriculture.

[2] "Les Ferments Solubles," p. 140.

size, but are usually divided into large and small ones, appearing in size to vary from the merest point to $\frac{1}{1000}$ inch in diameter; in modern terms, the large ones have a diameter of 30 to 40 μ, and the small ones 2 to 8 μ, with an average of 4 μ. The cellulose and lignin are only of interest from the point of digestibility. But the carbohydrates include cane-sugar and maltose in about equal proportion, and some dextrin. As regards the sugars, some authorities affirm their presence; others declare they have been unable to discover them. Both may be correct. The presence of sugar depends upon the quality of the wheat, the harvesting and grinding of the grain. It arises from the action of a diastatic enzyme upon the starch and dextrin; consequently the presence or absence of maltose depends upon the existence of the enzyme and conditions favourable or unfavourable for its action.

The **Fat** in wheat is somewhat deficient; it consists of oleic acid, palmitic acid, and a little stearic acid in combination with glycerine, and also a little cholesterin and lecithin. One-half of the fat is in the aleurone layer, slightly less than half in the kernel, or endosperm, and the remainder in the germ; the total averages about 1·615 per cent. of the grain.

The Mineral Substances.—König found that the ash from 1,000 grammes of wheat was 19·7 grammes, including potash 6·14, soda 0·44, lime 0·66, magnesia 2·36, ferric oxide 0·26, phosphoric acid 9·6, sulphuric acid 0·07, silica 0·42, and chlorine 0·04, grammes. Johnston[1] found the composition of the ash to be as follows:

Composition of the Ash of Wheat.

Potash	31·54 per cent.
Soda	2·66 ,,
Magnesia	12·10 ,,
Lime	3·14 ,,
Ferric oxide	trace
Phosphoric acid	48·50 ,,
Sulphuric acid	·08 ,,
Silica	1·88 ,,
Chlorine	·10 ,,
	100·00 ,,

Phosphate of potassium forms the largest proportion of the salts; then follow phosphates of magnesia and lime, with traces of phosphate and sulphate of alumina. The sodium is small in quantity, but, according to König, the proportion of iron is good. The bran is the richest in mineral matters; their condition therein is discussed in the section on Bran. The minerals in wheat serve two useful purposes: they give the electrical charge to the proteins, whereby they are enabled to react upon one another and form gluten; they confer "stability" upon the gluten, and render it less liable to become soft and "runny" during bread-making. They also supply the mineral matters required by yeast for the

[1] "Agricultural Chemistry," p. 272.

formation of new cells during fermentation of the dough. Finally, the bread being consumed, they supply minerals which are essential for the formation of solids and fluids in the human organism.

Wheat Flour.—The quality and character of flour depends upon the nature of the grain, care in its selection and blending, and on the method of milling and grinding. Analyses of various parts of the grain show that the greatest portion of the food material lies in the endosperm, or kernel, which is the part used by the miller. What is called **hard** wheat is the richest in gluten. It is produced in the warm countries of the South upon the most fertile soils. The grain has a dry, horny, semi-transparent appearance, and a hardness throughout. It is drier, keeps better, and gives a larger proportion of flour, than any other wheat ; but the flour is not so white. **Soft** or white wheat contains less gluten and more starch ; it is more farinaceous, more easily ground, and yields a fine white flour. The **semi-hard** or intermediate is that which, when used alone, is the best for bread-making. But wheat is blended, the produce of various countries being mingled, and experience has shown that a judicious blend of grain results in the production of the best bread flour. The composition of the entire grain and the amount of each principal foodstuff contributed by its various parts is shown in the foregoing tables. **Bran,** which is usually removed, includes the cuticle (consisting of three coats), the episperm or testa, and the aleurone or cerealin layers. The cuticle consists almost entirely of cellulose and lignin, with 0·5 per cent. of nitrogenous matters and mineral salts. The aleurone layer is removed because the fat contained in it is apt to become rancid and give a bad flavour to the flour ; it is also believed that the peculiar proteins contained in it exert an unfavourable influence upon the process of leavening, and especially upon the gluten, which it causes to become " soft " or " runny," and in consequence of which the bread which contains it is not of such good quality as when the aleurone is absent. The **germ** contributes to the wheat 0·5 per cent. of protein, 0·3 per cent. of sugar, and 0·18 per cent. of fat ; it does not materially increase the proportion of these substances in the flour ; on the other hand, it exerts the same deleterious influence as the aleurone layer, and is usually removed with the bran.

Grinding the Wheat, or " Milling."—Primitive methods consisted in powdering the wheat by bruising it between two stones, or with one stone in the hollow of another, from which arose the pestle and mortar. The **quern,** or hand-mill, formerly much used in the British Isles, consists of two circular stones, the upper one pierced in the centre, and revolving on a pin inserted into the lower ; the grain is dropped with one hand into the central opening, while with the other the upper stone is revolved by means of a wooden handle inserted near the outer border. Later on came the stone mill, which consists of a fixed nether millstone, upon which the upper millstone is made to revolve. Both stones have the grinding surface cut in radiating lines. The top stone has a central aperture

through which the grain is poured, and gets between the stones. The meal escapes at the periphery, and requires to be **bolted,** or passed through a sieve, to remove the bran. There are certain advantages and disadvantages in this method of milling. The chief advantage is that the entire grain is ground, and the flour contains some of the bran, germ, and cerealin layer, which the finest silken sieve or bolter cannot remove. Such flour when new has a sweet flavour, which is partly due to the fact that the meal becomes heated during grinding, and the flavour or essential oil is extracted from the germ and distributed through the flour. The disadvantages are that the flour is darker in colour than roller-milled flour ; it contains the germ and cerealin layer, whence it happens that such flour does not keep so well, and is apt to become lumpy ; and the softening effect of the cerealin and germ proteins upon the gluten is evident. Dough made from the new meal is soft—*i.e.*, it has not a proper degree of stability. It is true that it improves in this respect as the flour ages ; but although the dough has more stability, the flavour is deteriorated, and the flour soon has an old taste, or even a slight mustiness.

Roller Milling.—Stone mills are now in little use, except in old-fashioned establishments. In practically all large mills the grain is ground by steel rollers. Roller milling dates from 1840, but the modern chilled-steel rollers came into operation in Hungary in 1874, and gradually spread over Western Europe from 1878 to 1880. They consist of rollers, 10 or more inches in diameter, whose surface is fluted or cut into grooves, set at different angles and revolving at different speeds. But rollers whose surface is smooth are used for the final grinding. The wheat undergoes a preliminary treatment, being washed, brushed, and separated from stone, grit, offal, and cockle, by special machinery ; it is then dried and conditioned. So prepared the wheat is passed between the *first* pair of fluted rollers, where the grooves are comparatively large and the rollers wide apart, so that they crack the grain and partially set free the kernel ; the material resulting from this is divided by a rotary sifter into three parts : (*a*) **Break flour,** which is of somewhat dark colour, from its containing small particles of bran, and is reserved to be mixed in lower-grade flour or "middlings" ; (*b*) "semolina," consisting of coarse particles of the endosperm, or kernel ; and (*c*) coarse wheat particles. The coarse wheat particles are passed through a *second* pair of fluted rollers, which are closer together and whose grooves are not so coarse ; the result is the separation of more semolina, middlings, and coarse wheat particles, consisting chiefly of bran. The latter is, however, put through a *third* pair of fluted rollers, where the remaining particles of wheat are scraped from the bran, and afterwards separated in a dressing machine.

The **Semolina** is separated after each passage of the grain between the fluted rollers by means of a rotary sifter. It is then passed between the *first* pair of **smooth rollers,** where it is reduced to a much

finer meal, being afterwards separated by means of a dresser into flour and offals, or tailings. The coarse material is then *degerminated*, and the unreduced portion sent through a pair of smooth rollers a second and a third time ; the flour is extracted by a dressing machine until nothing is left but " sharps," offal, or " thirds." The " middlings," consisting of the third product, being a mixture of fine middlings and flour, is also redressed, and the coarse particles sent back to be ground with semolina by the fluted rollers, and again redressed until nothing but sharps or thirds remains.

We thus see that the fluted rollers are fed first with the entire " berry," which is stripped of bran without pulverizing the kernel ; this is effected by the different angle of the grooves, and the different speed of the rollers, or by the different size and differential of the rollers. This process is repeated several times, each succeeding pair of rollers having finer grooves, so that the bran is removed in flakes free from flour, and the semolina, released from the berry, is collected and assorted according to size.

" High Ground " and " Low Ground " Flour.—The semolina or pellets derived from the kernel are ground between the smooth rollers. The resulting fine flour is now granular or " high ground " and " low ground," according to the distance the rollers are set apart. High ground or granular flours were formerly made mostly from a large proportion of *hard* wheat, the rollers being set some distance apart. Such flour requires a longer time to hydrate, and therefore a longer time to ferment, but this led to no appreciable result in bread-making. Almost all flours are now " low ground," the rollers being kept close together. By such a method the hardest wheat yields a fine soft and smooth flour. The flour is, however, not of a uniform size as it leaves the rollers, and must be sent through a " dresser," that most in favour consisting of a cylinder covered with fine Swiss silk, which has 12,100 meshes to the square inch. Flour which is not fine enough to pass through these meshes is sent back to the rollers, and dressed again, until nothing but a little fluffy tissue remains, which is used in cattle foods.

The Amount of Flour obtained.—A good deal of discussion has taken place recently concerning the supposed superiority of so-called " standard flour." It is claimed that the latter contains a greater proportion of the nutriment from the grain, and especially a greater amount of the protein and phosphorus. It is asserted by the advocates of so-called " standard bread " that the flour from which it is made should contain 80 per cent. of the entire grain, or " wheat berry," including the semolina and germ. But this is not in accordance with the findings of practical millers and bakers. It is possible, of course, to get 80 per cent. of flour out of the grain, but it will not be that technically known as " standard patent flour," nor should it be confused with it. Thus, the endosperm from which semolina is obtained forms 85 per cent. of the entire grain or berry, and the germ 1·5 per cent., making a total of 86·5 per cent. But it is not possible to get 80 per cent. out of a bushel of wheat—the

reason being that the wheat which is received by the miller is often dirty, mingled with other seeds and refuse. It would be possible to get 80 per cent. if the wheat was clean and free from refuse. But it is cleanliness of the product which is far more important than the proportion obtained from it. The yield of flour from the British roller mill varies from 70 to 73 per cent. The old-fashioned stone mill yields 70 to 80 per cent., but a certain proportion of the flour is little better than offal. The presence of the cerealin and germ in the flour really increases the total percentage of nitrogen and phosphorus very little. Adequate reasons have been given for their exclusion (see Germ and Cerealin). It remains for the advocates for their inclusion to show good reasons for doing so, such as will be in keeping with modern physiological knowledge. But at present such reasons are not forthcoming. The only known reasons for retaining the germ are those given in the paragraph on Germ Bread; but in this case considerably more germ is used than exists in the grain, as much as 20 or 25 per cent. being added to the flour.

As a result of the careful study of practical milling and analysis of the products of wheat in *roller grinding*, Aimé Girard[1] says: "It appears distinctly that the limit of the yield of flour fit for the manufacture of white bread, porous, well risen, easily digestible, as modern consumption requires, is between 60 and 65 per cent. of the weight of the wheat. Beyond this point it also yields about 5 per cent. of a mealy product, which is decidedly acid, and calculated to yield only compact loaves, with a greasy crumb, dark-coloured, loaded with water, and difficult of digestion." Continuing his observations, he says:[2] "The alimentary value of bread depends on the fineness of sifting. Wheat yields 60, 65, or 70 per cent. of flour, according to fineness. The rule for a truly economical use of wheat is to reserve at most 70 per cent. for human consumption in the form of bread, and at least 30 per cent. for feeding cattle. What man does not take in the form of bread, he then recovers as meat."

The results of roller milling are shown more fully in the following table from "Bread and Bread-making":[3]

One Hundred Bushels of Wheat produced—	
Standard patent flour	72·6 per cent.
Second clear (low-grade flour)	·5 ,,
"Red dog" flour	1·9 ,,
Shorts or middlings	11·6 ,,
Bran	13·4 ,,

The various qualities of American flour resulting from the milling are known by the following names, and are so defined:[4]

1. (*a*) **First Patent Flour.**—Produced by roller process of milling. This is the highest grade of patent flour manufactured. The

[1] *Compt. Rend.*, 1895, cxxi. 25. [2] *Ibid.*, cxxiii. 23.
[3] Bulletin 101, p. 7, U.S. Department of Agriculture, 1901.
[4] *Ibid.*, p. 8.

gluten from it has a greater power of expansion than that of any other grade, and the flour also absorbs the most water and produces the whitest and largest loaf of bread.

(*b*) **Second Patent Flour,** sometimes called "Minneapolis patent flour." It is similar to first patent flour, but the bread produced is a shade darker in colour, and the gluten does not possess quite so high a power of expansion.

(*c*) **Standard Patent Flour** is made up of the sum of the first and second patent and the first clear or baker's grade of flour, and is **the ordinary bread flour** most frequently found on the market. About 72·6 per cent. of the screened wheat is recovered as standard patent flour.

2. **First Clear Grade Flour.**—After the first and second grades of patent flour are removed, about 11·8 to 12 per cent. of first clear grade is obtained. It contains slightly more protein than either first or second patent flour ; but the protein does not contain gliadin and glutenin in the right proportions to make so good a quality of bread as the patent grade flours.

3. **Second Clear or Low Grade Flour.**—After removing those portions which are included in standard patent flour, there is obtained about 0·5 per cent. of flour, called "second clear or low grade," which contains a high percentage of protein. The gluten, however, is of poor quality for bread-making purposes.

4. "**Red Dog**" **Flour.**—This is the lowest grade of flour produced. It is dark in colour, and has but little power of expansion. It consists largely of the germ and adjacent portions of the wheat, and therefore contains a relatively high proportion of protein. A loaf of bread made from it is small and dark in appearance compared with one made from the same weight of better quality of flour.

5. **Middlings or Shorts.**—About 11·6 per cent. of the wheat is recovered in the middlings, which consists of fine bran that has been more or less completely pulverized. When this product contains a large part of the germ, it is much richer in protein than ordinary shorts, and is called "shorts-middlings." This term "middlings" is not to be confused with the same term applied to material obtained when wheat is milled by the old process. The middlings of the old process are now sent back to the rollers, and are reduced and recovered in various grades of patent flour.

6. **Bran** consists of the "hull," or outer coverings, of the wheat kernels.

7. **Entire-Wheat Flour.**—This is the product obtained by *removing a portion of the bran,* and grinding the remainder with the kernel; it contains all the constituents of the grain except the cuticle. The flour is of a coarser texture than the patent or clear grades. It is sometimes called "purified Graham" or "natural flour."

8. **Graham Flour** is coarse unbolted flour, consisting of the entire grain ground into meal, including the bran, cerealin layer, and germ. It is practically **wheat meal,** containing all the proteins, fat, and minerals. No sieves, bolters, or dressers, are used in its manu-

facture. The presence of bran prevents the product from being very fine, consequently many coarse particles of bran and unpulverized kernel can be detected in the finished product.

9. **Gluten Flour.**—This is flour containing as high a percentage of protein as it is possible to obtain by the roller method of milling. It is not composed entirely of gluten, but simply contains a high percentage of gluten. No flour can be composed entirely of gluten. Wiley says ("Foods and their Adulteration") it should contain not more than 10 per cent. of moisture or less than 5·6 per cent. of nitrogen (= 32 per cent. of protein); it is, however, frequently sold with a high percentage of starch in its composition, as shown in the analyses following. Gluten flour should be made by washing most of the starch from ordinary flour.

In the English milling trade the products of roller-ground wheat are sold under the following grades:

(*a*) **Straight Run.**—This consists of about 70 per cent. of the entire weight of the grain used, and corresponds with the standard patent flour of the American millers; it contains *all the fine flour* produced from the wheat.

(*b*) **Patent Grade**; (*c*) **Baker's Grade.**—The flour, however, is frequently divided into two qualities—one known as "patent grade," consisting of about 57 per cent. of the entire flour produced; and the other called "baker's grade," consisting of about 43 per cent. of the total production. Sometimes a third grade is made, consisting of flour of very poor quality. In other mills these terms are replaced by "short patent" flour, which is the first or highest quality of flour, consisting of 30 to 40 per cent. of the total production; and "long patent," or second quality, consisting of 50 to 60 per cent. of the product. Again, the highest quality of flour is known in London as "town whites," and the second quality as "town household" flour; while the term "country whites" is used to indicate the highest quality of flour made by country millers and sold in London. There is therefore no acknowledged classification of flours according to quality in the United Kingdom. The British supplies of wheat are derived from all quarters of the globe, and practically every miller in the kingdom blends his own wheat, and grades the product according to his own method. There are, however, advantages in the American system, and the following analyses show the composition of flour classified by their method. The wheat used for this purpose consisted of 1,000 pounds of hard Scotch Fife wheat, weighing 60 pounds to the bushel; it was plump and of good quality, and *all the grades of flour were obtained from the same sample.* Their composition was found to be as given in the table on p. 389.

The Composition of Flour.—Fine flour is the product of milling wheat which has been properly cleaned, scoured, and polished, and is obtained by **bolting** or "dressing" the wheat meal. Roller-milled flour is whiter than the stone-milled product, even when of a "straight grade." The chief reason for this is, however, owing

THE COMPOSITION OF FLOUR AND MILLING PRODUCTS—PERCENTAGES.[1]

Roller-milled Products.	Water.	Protein (N×5·7).	Fat.	Carbo-hydrates.	Ash.	Phosphoric Acid.	Acidity calculated as Acetic Acid.	Heat of Combustion : Calories per Gramme.	
								Calculated.	Determined.
Wheat, cleaned and polished ..	8·50	12·65	2·36	74·69	1·80	·75	·18	4·114	4·140
First patent flour	10·55	11·08	1·15	76·85	·37	·15	·08	3·989	4·032
Second patent flour	10·49	11·14	1·20	76·75	·42	·17	·08	3·992	4·006
"Straight run," or standard patent flour	10·54	11·99	1·61	75·36	·50	·20	·09	4·022	4·050
First clear grade flour.. ..	10·13	13·74	2·20	73·13	·80	·34	·12	4·087	4·097
Second clear grade flour ..	10·08	15·03	3·77	69·37	1·75	·56	·27	4·153	4·267
"Red dog" flour	9·17	18·98	7·00	61·37	3·48	—	·59	4·349	4·485
Shorts	8·73	14·87	6·37	65·47	4·56	—	·14	4·219	4·414
Bran	9·99	14·02	4·39	65·54	6·06	2·20	·23	3·988	4·198
Entire-wheat flour	10·81	12·26	2·24	73·67	1·02	·54	·32	4·026	4·032
Graham flour	8·61	12·65	2·44	74·58	1·72	·71	·18	4·123	4·148
Wheat *ground in laboratory* ..	8·50	12·65	2·36	74·69	1·80	·75	·18	4·114	4·140
Gluten flour	8·57	16·36	3·15	70·63	1·29	—	·14	—	—

[1] "Bread and Bread-making," by H. Snyder, p. 9, Bulletin 101, U.S. Department of Agriculture, 1901.

to the greater care exercised in washing and scouring the grain, and removing foreign bodies, than was possible in the old-fashioned mills. Roller flours keep better than stone-milled flours ; age does not produce such a marked change in them, consequently there is not much difference between bread made from an old and a new roller flour. The chief changes in flour on keeping are that it becomes more or less bleached, and absorbs a little more water. Such changes are believed to be due to the action of enzymes or soluble ferments existing in the flour, whereby changes occur in some of the proteins, which are disintegrated to form new and more or less complex compounds. Another suggestion is that the change is due to the action of the ordinary lactic and acetic-acid-producing bacteria, which is supported by the fact that the flour increases in acidity during keeping.

There are many reports of analyses, but those in Table A, p. 391, are fairly representative.

Table B, p. 391, shows the composition of the flour obtained from other common cereals, and is added for comparison.

Other estimations have led to the following important conclusions by Wiley : that fine flour should contain not more than 13·5 per cent. of moisture, nor less than 1·25 per cent. of nitrogen, or more than 1 per cent. of ash or 0·5 per cent. of fibre.[1] Balland,[2] after examining 250,000 samples in the laboratory of the French War Department, concluded that flour had—Water varying from 9·40 to 16·20 per cent. ; fatty matter, 1·30 per cent. ; acidity, 0·013 per cent. ; and it yielded an average of 47·50 per cent. of moist gluten. The conclusions of Aimé Girard are as follows :

Variations in the Percentage Composition of Flour.

Water		10·74 to 15·58
Soluble in water :		
Glucose	·09 to ·21	
Saccharose	·96 ,, 1·70	
Nitrogenous	1·02 ,, 1·28	
Galactin, etc.	·52 ,, ·99	
Inorganic	·22 ,, ·60	
Total soluble		3·12 to 4·00
Insoluble in water :		
Nitrogenous	7·45 to 8·32	
Starch	69·88 ,, 71·22	
Fat	·84 ,, 1·12	
Inorganic	·20 ,, ·40	
Cellulose	·22 ,, ·25	
Total insoluble matter		79·84 to 80·94

The Nitrogenous Matters.—The protein of flour averages 11 or 12 per cent., estimated as N × 5·7, from Rubner's conclusion that only 72 per cent. of nitrogen is in form of protein. The insoluble

[1] Wiley's " Foods and their Adulteration," p. 253.
[2] *Compt. Rend.*, 1894, cxix. 14

A.—COMPOSITION OF VARIOUS GRADES OF FLOUR—PERCENTAGES.

	Water.	Protein.	Fat.	Starch.	Sugar and Dextrin.	Fibre.	Ash.	Authority.
Fine flour (town whites) ..	13·00	10·50	·8	74·30		·70	·70	Professor Church.
Best household (town Household)	12·70	13·00	1·2	71·70		·70	·70	Dr. Bell.
Country whites	11·10	10·90	1·2	62·30	3·80	·80	·90	Lawes and Gilbert.
Seconds	15·00	10·80	2·0	66·30	4·20	—	1·70	Smith's "Foods."
Seconds (London)	14·73	10·31	2·0	65·48	5·01	1·43	1·04	Dr. Grace Calvert.
Wholemeal (London) ..	14·33	19·87	2·0	48·27	4·01	11·86	1·66	

B.—COMPOSITION OF THE FLOUR OF CEREALS—PERCENTAGES.

ANALYSES BY LAWES AND GILBERT.

	Old Wheat.	Barley.	Oats.	Rye.	Maize.	Rice.
Water	11·1	12·0	14·2	14·3	11·5	10·8
Starch	62·3	52·7	56·1	54·9	54·8	78·8
Fat	1·2	2·6	4·6	2·0	4·7	·1
Cellulose	8·3	11·5	1·0	6·4	14·9	·2
Gum and sugar	3·8	4·2	5·7	11·3	2·9	1·6
Albuminoids	10·9	13·2	16·0	8·8	8·9	7·2
Ash	1·6	2·8	2·2	1·8	1·6	·9
Loss, etc.	·8	1·0	·2	·5	·7	·4
	100·0	100·0	100·0	100·0	100·0	100·0

protein varies from 7·5 to 9·5 per cent., and the soluble protein averages 1·25 per cent. The insoluble proteins are gliadin and glutenin, in the ratio of 63 to 37 per cent. These substances have been described in the section on Wheat. The nitrogen in 1 pound of flour is usually about 120 grains, and represents 640 grains of protein. The **amount of carbon** in 1 pound of flour is 2,656 grains, but this is not all carbohydrate ; the carbohydrate in 1 pound of flour is about 5,760 grains, reckoned as 75 per cent. The **acidity** of flour is equal to 0·20 per cent. of phosphoric acid, and 0·09 per cent. reckoned as lactic acid. The latter increases as the quality of the flour decreases ; wheat of high acidity invariably produces an inferior quality of flour, which keeps badly and makes inferior bread. It is said to be due to ordinary lactic and acetic acid bacteria. But Professor Hall[1] considers that the acidity of flour is not due to lactic and acetic acids, but to the presence of acid potassium sulphate, which gives it an amphoteric reaction ; *i.e.*, it behaves as an acid towards one reagent, and as an alkali towards another.

The Analysis of Flour.—In non-homogeneous substances and cereal products it is impossible to determine the proportion of gluten cells and starch cells, for both are broken by grinding, and their contents mingled together. The starch cells do not show the crossed hilum in an ordinary light, and gluten cannot readily be distinguished from starch by the microscope.

To Determine the Gluten.—The method adopted by Parkes, Ritthausen, Von Bibra, Millon, Rivot, etc., has become established as customary. Take 10 or 100 grammes of flour, mix it with water into dough, and let it stand for half an hour ; then stir it in a porcelain vessel (mortar and pestle) with successive quantities of water until all the starch is washed away. The few small corpuscles of starch which remain entangled in the gluten can be differentiated by adding a drop of iodine solution, which gives the blue reaction with starch, but dyes the gluten a yellow-brown tint. The gluten is then nearly pure ; it is dried at a temperature of 110° C. and weighed.

The Fat.—Treat a known quantity of flour—say 2·5 grammes—with ether ; boil it gently over a water-bath ; decant the ether, and filter it through paper into a weighed dish. Repeat this process two or three times. Evaporate the ether and weigh the fat.

The Mineral Substances.—Burn 50 grammes of flour in a weighed dish until it ceases to lose weight ; cool the dish and weigh it ; extract the residue with hot water, filter, dry, and weigh again. The difference represents the soluble salts. Moisten the residue with nitric acid ; add the filter-paper and contents ; dry and burn again ; cool and weigh. The net weight represents the insoluble salts.

The *Carbohdyrates* are now determined by difference. This, however, is an incomplete analysis, and it can be carried farther by the method recommended by Cairn,[2] in which he determines the soluble and insoluble constituents. It is as follows : Digest 5 grammes of flour in 100 c.c. of cold water for two or three hours, with frequent agitation ; filter it through a paper previously exhausted with hydrochloric acid, washed and dried ; wash the precipitate with 100 c.c. of cold water. We thus have a solution and a residue. The *solution* contains albumin, gum, sugar, and soluble salts ; the *residue* contains starch, cellulose, gluten, and fat. Deal with the solution first :

1. *Albumin.*—Boil the solution and filter it ; the precipitate consists of albumin ; dry it at 100° C., and weigh it ; burn it, and deduct the weight of the ash. The net weight is the albumin.

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1 " Modern Baker," vol. i., p. 55.
2 " Quantitative Analysis," p. 255.

2. *Gum.*—Take the filtrate from the albumin; evaporate it nearly to dryness. Add a large excess of alcohol; warm, and allow it to cool; filter through a weighed paper. The precipitate consists of gum. Wash it with alcohol, dry it at 100° C., weigh it; burn it, and deduct the weight of the ash. The net amount is the weight of the gum.

3. *Sugars.*—Take the alcoholic filtrate from the gum; evaporate it to a small bulk, add water, and boil out the alcohol. Concentrate the solution to 50 c.c., and divide into two equal parts. In the first half determine the amount of reducing sugar by Fehling's solution. To the second half add a few drops of acetic acid, and boil; neutralize the acid with KHO, and determine the amount of reducing sugar as before. Thirdly, boil the second part of solution with a little H_2SO_4, and determine the amount of reducing sugar again.

The first test shows the amount of dextrose and levulose.
The difference between the first and second test shows the cane-sugar.
The difference between the second and third test shows the dextrin.

The residue is then examined, first of all washing it from the paper into a beaker by means of a jet of water. The filter is then weighed, dried, and the original weight of the paper deducted from it. The balance represents the substance adhering to the filter, and must be accounted for.

4. *Cellulose.*—To the substance in the beaker add fifty times its weight of water containing 1 per cent. of H_2SO_4; heat it for several hours, until all the starch is dissolved. A white flocculent precipitate is left—*it is cellulose.* Filter off the solution, wash the precipitate until all H_2SO_4 is removed; dry it at 100° C., and weigh it. It is not always *pure* cellulose, but may contain unruptured starch and undissolved albumin, whence the proportion of cellulose appears excessive.

5. *Starch.*—To the filtrate from the cellulose, diluted to 400 c.c., add 30 c.c. of strong H_2SO_4; heat it over a water-bath at 95° C. for several hours—*i.e.*, until a drop of the solution no longer gives any coloration with iodine or a precipitate with alcohol. The conversion of starch to glucose is then complete. The acid is neutralized by KHO, and the proportion of sugar ascertained. According to Leeds, 95 per cent. of the starch is transformed. Sachse recommends HCl, which transforms 98 per cent.

6. *Nitrogenous.*—Determine the total nitrogen in 1 gramme of flour, and calculate the protein from it. $N \times 5{\cdot}7$ represents the albuminoids per cent. Deduct from this the amount of *soluble* albumin previously determined, and the remainder is gluten.

Terms used by Dealers and Bakers to define the Qualities of Flour—"Hard" and "Soft" Flour.—A "hard" flour is one which gives to dough the qualities of strength and stability. "Softness" is liable to gradations. A "soft" flour may be of a dead or putty-like character; it is stable, but inelastic; it makes shapely loaves, but they are not bulky. Other "soft" flours produce small and flat loaves, the dough being decidedly "runny." All "soft" flours are non-resistant to fermentation—that is, the dough rises quickly, and does not require a long time for fermentation. But there are many degrees or shades of softness.

"**Strength,**" as applied to flour, means the property of making a bulky loaf; it is due to hardness.

"**Straight grade**" flour, also called "long patent" or "standard patent" flour, is a little stronger than "baker's grade" or "short patent" flour, because it contains a little more gluten. All "strong" flours require to be fermented a longer time than "soft" flours to produce bulky bread; therefore the property of resistance to fermentation with a given quality of yeast is a true indication of strength.

"**Stability**" implies stability, or the property of dough to keep its shape instead of running flat.

"**Runniness.**"—When the dough tends to become flat, instead of retaining its shape after moulding, it is said to be "running"; flours show various gradations of weakness according to the degree this runniness is exhibited.

I am indebted to "The Modern Baker and Confectioner," vol. i., for the foregoing explanation of terms, and for the following characteristic points of wheat and flour from various sources.

English Wheats are soft, and contain 8 or 10 per cent. of gluten. Dough made from the flour has a tendency to *runniness*. Flour made from English wheat alone does not make the kind of bread now appreciated; but if it is mixed with a harder or stronger wheat it makes excellent bread. Used alone, it is good for making cakes, scones, etc.

Scotch Wheat of an average quality also yields a soft flour, which alone is unsuitable for making bread; it is, however, excellent for making biscuits, shortbread, etc.

French Wheat seldom contains more than 8 or 9 per cent. of gluten; it yields a flour which is not unlike that of English wheat, being more suitable for biscuits than bread-making.

Belgian and German Wheats contain 9 or 10 per cent. of gluten. They also yield a rather soft flour; but it is stronger than French or English, and is used for bread-making.

Hungarian Wheat.—The flour from this wheat is by far the most important Continental wheat product. It is chiefly imported from Budapest. Its quality, however, varies greatly, and its reputation was made by the highest grades produced. Hungarian flour is moderately strong, absorbs much water, and the dough requires a fairly long time to mature—*i.e.*, it is resistant to fermentation. The gluten varies from 7 to 11 per cent., good samples usually having 9 or 10 per cent. The gluten is yellow and elastic, but not tough; it possesses a fair degree of stability, and does not run. It makes good bread having a fine texture, "the crumb having a yellowish colour and bright sheen, and the crust a golden bloom. There are no better wheats in the world than those of Austria-Hungary."[1] Great care is used in the milling to produce the finest flour, which consequently obtains a better price than the highest grade flour made in English mills. The grain has been used for cultivation in America, Australia, and New Zealand, but after two or three years the quality of the cereal declines, and it does not produce such good flour, owing to differences in the soil and climate.

Australian Wheat yields flour which is not unlike Hungarian. The flour is stronger than that from English wheat, and compares favourably with that of the hard winter wheat of Kansas. It contains 10 or 11 per cent. of gluten, makes a fairly stable dough, and yields a white and bulky loaf. The flour, however, varies with the region in which the grain is grown. South Australian flour, shipped from Adelaide, makes a strong and stable dough, and yields a bulky loaf. But Victorian flour, shipped from Melbourne, is softer, and yields a dough which is inclined to be runny. That from Geelong is stronger, and makes a more stable dough. New South Wales flour is weaker than other Australian flours; the

[1] "Modern Baker," p. 57.

Sydney millers frequently mix it with strong American flour to increase its strength.

Canadian Wheat also varies in quality according to the region where it is grown. That of Manitoba is hard and contains as much as 15 per cent. of gluten, which is tough and stable in character. The flour from it resists fermentation, and a long time is required for the yeast to soften the gluten and the dough to mature. It, however, makes a large loaf of pleasant flavour and good keeping qualities. This wheat is much used by millers to give strength to the flour from English wheat, and it is imported into the United States for the same purpose.

American Wheat is well represented by the hard wheats of Dakota and Minnesota, and the soft white wheats of the Western States. *Minnesota flour* is that best known in the United Kingdom, and is the strongest flour sold in the English markets. It is too strong by itself for bread-making ; the gluten ranges up to 16 per cent., but is usually 11 to 13 per cent., probably from the admixture of some soft wheat in it. Like Canadian flour, it resists the softening effect of yeast, and requires long fermentation to give it the softness and elasticity necessary to produce nice bread ; but the loaves produced are bulky. In the United States, the extreme hardness and toughness of this flour are tempered by mixing fat in the bread. *Kansas flour*, on the other hand, although containing 10 to 13 per cent. of gluten, is rather unstable ; it softens quickly under fermentation, and the dough has a tendency to be runny. *Nebraska flour* is similar. *Illinois* wheat is of the soft winter variety, which contains 8 to 10 per cent. of gluten. It makes a good cake and biscuit flour, and, when combined with a harder or stronger sort, it yields a well-flavoured bread having a soft and silky crumb. *Ohio flours* are very white and soft, being considered the softest of the American products. They contain 7 to 9 per cent. of gluten, and, although stable, yield a dough of putty-like consistence and small close loaves. Such flours are not suitable alone for bread-making, but they are excellent for making scones, biscuits, pastry, and other confectionery.

Argentina Wheat is comparatively strong, but not so strong as Russian or Minnesota wheat, and is used in combination with English and other soft wheats.

Russian Wheat and Flour is largely imported into the United Kingdom. The wheat possesses considerable "strength," and is very suitable for combination with English wheat. Flour made from Russian wheat alone contains 10 to 12 per cent. of gluten, and the dough requires much time to mature ; nevertheless, it has a tendency to become very soft, and occasionally even to become runny. This fault is said to be due to the presence of a small proportion of rye among the grain, which could only be eliminated with great difficulty. The proteins of rye have a softening action upon the gluten of wheat ; consequently wheat flour containing rye can only be made with difficulty to produce a bold and crusty loaf.

Indian Wheat has little favour with bakers because, while absorbing much water, like a strong flour, the dough becomes soft during fermentation. It is, however, much used owing to its cheapness, especially in combination with other grain. Two distinct sorts of Indian wheat are used : (1) Kurrachee wheat yields flour which is moderately strong, but softens during fermentation ; it yields a large loaf, but the crumb has little flavour, and the crust wants bloom. (2) Calcutta wheat is even less stable than the former ; the flour makes very flat loaves, with a harsh crumb and a tough or brittle crust.

British millers, however, always use a mixture of wheat from various sources, and the blending of the grain to suit the various requirements is part of the miller's business. Bread-making flours are produced from a combination of hard and soft wheat, blended in such proportion that the flour contains 10·5 to 11·5 per cent. of gluten, and is of moderate strength and stability, not harsh in working, but producing a bulky loaf, of pleasant flavour and whiteness, and with a blooming crusty exterior.

The blending of opposite types of wheat results in the flour being of better quality ; the gluten in the dough having different physical qualities than would result from either wheat alone, and this in turn is the result of altering the gliadin-glutenin ratio. It has been shown[1] that a deficiency of gliadin destroys the bread-making properties of the flour, that gliadin is extremely important in bread-making, and that the highest quality of bread flour contains a definite ratio of gliadin to glutenin which is 2 to 1. Many kinds of wheat contain a large amount of gluten, and possess a high food value, but do not yield the best bread because of the defective ratio of these proteins. A study of such flours shows[2] that this fall is due to an excess or deficiency of gliadin—an excess causing the dough to be soft and sticky, a deficiency causing it to lack the necessary expansion. Experiments were undertaken to ascertain the effect of blending two grains of unlike character, one containing a large and the other a small proportion of gliadin. One sample consisted of **hard** Fife wheat containing a high percentage of gluten, composed of gliadin 58·3 and glutenin 41·7 per cent. The other was a very soft wheat, the gluten of which contained 70·1 per cent. of gliadin and 29·9 per cent. of glutenin, and was typical of soft wheat. They were analyzed separately, blended in equal proportions, and again analyzed, and the proportion of gliadin to glutenin in each sample ascertained. Bread was also made from each sample, care being taken to use exactly the same proportions of flour, yeast, etc., in each case. The results are shown in the following table :[3]

[1] Experimental Stations Bulletin 67, p. 23, U.S. Department of Agriculture.
[2] " Proteids of Wheat," Minnesota Experimental Station, Bulletin 63.
[3] " Bread and Bread-making," Bulletin 101, p. 62, U.S. Department of Agriculture.

COMPARISON OF FLOUR MADE FROM HARD AND SOFT WHEAT AND A MIXTURE OF THE TWO—PERCENTAGES.

	Hard Wheat.	Soft Wheat.	Mixture of the Two.
Water	9·7	10·1	9·9
Protein, N × 5·7	12·7	11·4	12·1
Total nitrogen as gliadin	58·3	70·1	64·2
,, ,, glutenin ..	41·7	29·9	35·8
Fat	1·2	—	1·2
Carbohydrates	75·9	—	76·4
Ash	·4	·4	·4
Quality of gluten	Hard	Soft	Medium
Dry baker's gluten .. ·..	13·2	12·0	12·5
Capacity to absorb water ..	62	60	62
Granulation	Fine	Medium	—

The hard wheat alone produced a good-sized loaf, but not so large as might be expected from the high percentage of gluten. The soft wheat produced a soft, sticky dough, which expanded while fermenting, but collapsed during baking, and produced a smaller loaf than the hard wheat. The blended flour produced the largest loaf, but the hard wheat produced the heaviest. The undesirable properties of each kind of grain were counterbalanced by blending, and the flour produced a better quality of bread. These experiments confirm the experience of centuries, that a flour of high food value but poor bread-making qualities may be improved by blending it with a grain of the opposite quality of softness or hardness, so as to produce a better-balanced gluten. But the bread produced from such blended wheat is not equal in quality to that produced from unblended wheat which normally contains a well-balanced gluten.[1]

Some flours are naturally white or have a creamy yellow tint ; others are pinkish, and some have a darker colour. The highest grade, or first patent flour, is the whitest, as it is the most expensive. The lower grade, or second patent flour, is darker, and does not fetch such a high price ; and the same remark applies to " straight run " or standard patent flour. It is, however, distinctly to the miller's advantage if he can transfer some of the second to the first patent grade. This is done by **bleaching the flour.** It is performed by exposing it for a few minutes to the action of oxygen, ozone, or peroxide of nitrogen (NO_2). These gases are prepared in the usual manner, or by sending an electric charge through the atmosphere. The flour is carried through a cylinder into which the gas enters, the supply of the latter being regulated by a stopcock. The operation appears to produce no other effect than that of whitening the flour, but the *modus operandi* is not clearly understood. It is a process of oxidation, and it is con-

[1] "Bread and Butter-making," Bulletin 101, p. 63, U.S. Department of Agriculture.

tended by various authorities that some substance in the flour has a stronger affinity for oxygen than the nitrogen has. Fleurent contends that the bleaching is due to some change in the oil of wheat ; but the small proportion of oil is insufficient to give any colour to the flour, and is even smaller in roller-milled flour than in stone-milled flour ; therefore the argument that bleaching the flour is due to decolorization of the oil fails on that score. The starch is pure white, and remains unaffected. The gluten, however, is changed in colour from yellow or brownish to a grey or nearly a black colour ; and it is contended by other authorities that the whitening effect is due to change in the gluten, *and is merely optical*, just as the addition of a trace of ultramarine blue to yellow sugar produces the appearance of whiteness. It is remarkable, however, that low-grade flours, which contain a high percentage of gluten, are not bleached, but turned to a dirty grey colour, by these gases. Other effects produced by the bleaching process are that the flour is dried and sterilized. There is no advantage in drying the flour, and it is not certain that there is any advantage in sterilization, because anything which increases the resistance of the flour to the natural enzymes in it or to those of yeast would not be beneficial. A further effect of the action of the gases is to produce a slight diminution of gluten, which is probably due to the conversion of insoluble into soluble proteins. This is not a beneficial change, as the strength and stability of the flour are reduced to that extent, it does not stand quite so much fermentation, and the dough has a tendency to become soft or runny.

CHAPTER XV

BREAD

BREAD is the food made by moistening flour with water, adding yeast to ferment it, kneading it into a dough, maturing the dough, and baking it. It is usually made from the flour of wheat, but rye, barley, oats, maize, millet, and buckwheat are also used, and in times of scarcity the fecula derived from other plants.

History.—Ching-Nong is reputed to have been the first who taught men (the Chinese) the art of husbandry and the method of making bread from wheat (1998 B.C.). The Greeks attributed its invention to the god Pan, but bread was in use among the Chaldeans and Egyptians before they came into existence. Bread is a very ancient food, its origin being lost in the mists of antiquity. Its earliest form was probably unleavened bread, consisting of bannocks made from bruised cereals mixed with water or water and oil. The discovery that bread could be leavened was probably accidental. A mixture of meal and water undergoes spontaneous fermentation if allowed to remain for some hours in a moderately warm place. It derives yeast and other micro-organisms from the air, especially the lactic acid and acetic acid-producing bacteria, so that the paste becomes sour. The fact that fermented dough resulted in the formation of bread having different characteristics from unfermented bread would soon become obvious. Such paste or dough, being added to fresh dough, started fermentation in the latter and produced similar changes, whence the fermented paste was called **leaven,** and bread so made **leavened bread.**

It is probable that the climatic conditions of Oriental countries would lend themselves to the early use of fermented or leavened bread, and to the discovery of various points of importance in producing good bread, not over-fermented, but sufficiently leavened to produce a loaf having such excellencies as would show the advantages of using leavened rather than unleavened bread. At any rate, history shows that the art of leavening was known in the patriarchal ages, certainly by the Egyptians before the Israelitish captivity ; for Sarah, the wife of Abraham, mixed flour and water together, kneaded it, and covered it with ashes on the hearth. It probably became almost universal in the early civilizations of humanity.

The discovery that yeast or barm would leaven bread might also

be as accidental as the discovery that dough spontaneously changes under suitable conditions, just as the juice of grapes ferments. The ruins of ancient cities show that bakeries existed at the period of their destruction. The ancient Romans had their bread made on the domestic hearth, but baking became a profession in Rome, 170 B.C. ; captive bakers were brought to Rome from Greece in the second century B.C. ; and after the conquest of Macedon (148 B.C.) numbers of Greek bakers came to Rome, had special privileges conceded to them, and soon obtained a monopoly. Undoubtedly, the Romans brought a knowledge of fermented bread with them into Britain, but after their departure from the island it probably ceased to be used. We know that King Alfred allowed the unfermented cakes to burn in the neatherd's cottage, and that even in the sixteenth century unfermented cakes were the only kind of bread known in Norway and Sweden. But to give the history of bread down to the present time would necessitate many pages, and would involve the history of nations and peoples, for which we have no space.

Pliny in his "Natural History" gives an account of both methods of leavening bread—viz., by the spontaneous fermentation of barley meal or spelt, afterwards to be used as leaven ; and by the use of wine-must in Greece and Rome, as well as by barm from beer in Gaul and Spain. The Greeks and Romans obtained their supplies of wheat from many countries, and the fact that the flour obtained from different varieties of wheat yielded more bread than others early became known. In fact, the colour of the flour and its yield of bread was an important consideration even in those days. Pliny says : "It is a rule universally established by Nature that the bread exceeds the weight of the grain by one-third ; and it is generally considered the best kind of wheat is that which will absorb during kneading one congius of water to the modius of wheat." The discovery that some kinds of wheat were more suitable than others for bread-making, or gave better results, naturally led to the mixing the wheat from various countries to produce a more uniform result, and to raise the value of such flours which produced the least bread or an inferior quality of the article. Examples of such differences are given by Pliny. Blending of the wheat therefore is an ancient custom. "Bolting" the flour is also an ancient custom ; but Pliny mentions that the Gauls were the first to employ the bolter, made of horsehair, whilst the people of Spain made theirs of flax, and the Egyptians of papyrus and rushes. The colour of the flour and of the bread produced from it was equally important to the ancients, for comparisons of colour are noted by the same historian. Therefore the art of bread-making, the use of leaven, blending the grain, bolting the flour, and a preference for white bread, were matters of consideration for some time before the Christian era, and probably from a far more ancient period.

Bread is made by mixing flour with about 60 per cent. of water, some salt and yeast, the whole being kneaded by hand or machinery and left to ferment. During fermentation, alcohol and carbonic acid gas are produced, which make the mass vesicular and cause the dough to rise. The dough swells more and more as the gas is developed throughout the mass, until it is mature ; during this period some of the insoluble becomes converted to soluble protein, and the gluten "sets" so that it cannot be separated from the starch. The manufacture of good bread depends upon the flour

containing a fair percentage of gluten. It is the proportion of gluten rather than that of starch which determines the character of the bread ; and the character of the gluten is even more important than its proportion. Stability of the gluten is necessary to form a porous and spongy bread which will retain moisture. The flour which will produce good bread in the hands of a skilled baker does not always produce the best results in domestic baking. Flour is improved by being kept a few weeks after grinding it. New flour is the most palatable, but is at first too adhesive to make good bread. It should also have a definite power to absorb water, in order to make a dough of proper consistency ; for unless the dough have a proper viscosity, the flour is not satisfactory from the baker's point of view.

The amount of bread produced from a sack of flour also depends upon the percentage of water absorbed in making the dough ; this capacity varies, but is normally about 60 or 62 per cent. of the weight of flour. Now, if 20 pounds of flour, when made into dough, weighed 30·5 pounds, the water absorbed would be 10·5 pounds, from which it is ascertained that a sack of flour would absorb $(280 \div 20) \times 10{\cdot}5 = 147$ pounds of water, from which "The Modern Baker" (p. 72) forms the following example for bread-making :

WEIGHT OF DOUGH FROM A SACK OF FLOUR.

Flour	280 pounds.
Water	147 ,,
Yeast	1 pound.
Salt	3 pounds.
Total	431 ,,

Dough usually loses 2·8 to 3 per cent. of moisture during fermentation ; therefore, when mature, this weight of dough would yield 191 two-pound loaves. If made into *tin* bread, the dough could be made a little softer, a higher percentage of water being used, and the yield of bread would be correspondingly higher. It is usually baked in a temperature of 240° C. (464° F.).[1]

Bread which is unfermented or very little fermented is nearly tasteless ; while fermented bread, unless too much fermented, has a pleasant sweetish taste, which increases up to a maximum, but declines with the age of the bread, and ultimately disappears, giving place to a flavour which is less agreeable. It has been argued that the sweetness of bread is due to the sugar in the flour ; but it cannot very well be so, because unfermented bread has not the same sweetness, and in fermented bread the sugar is transformed into alcohol and carbonic acid gas. Since the flavour improves as the sugar diminishes, while a softening change is concurrently going on in the gluten, the latter evidently has a greater effect in producing flavour in bread than the sugar in the flour. Flavour

[1] I am indebted to "The Modern Baker and Confectioner" for a considerable amount of information in this chapter.

therefore is the result of blending the products resulting from fermentation.

The changes produced during fermentation of flour in bread-making are as follows: The soluble substances of the flour—viz., sugar, soluble proteins, and mineral substances—are dissolved by the water used for mixing the dough. An enzyme (*invertase*) excreted by the yeast cells converts the cane-sugar into dextrose and lævulose; and the dextrose is transformed by the yeast cells into alcohol, carbonic acid, a small amount of glycerine, and succinic acid. Another enzyme converts some of the soluble proteins into peptones, which, together with mineral substances, are needed for the nourishment and growth of new yeast cells. Some of the gluten becomes softened by the action of the soluble proteins, and in turn exercises the same effect upon other gluten.

The amount of sugar in wheat varies from 1 to 1·5 per cent., or, roughly, 2·75 to 4·0 pounds in a sack of flour. Now, 100 grammes of sugar, when fermented with yeast, produce 820 cubic inches of CO_2, and the total sugar in a sack of flour would, at ordinary temperature and pressure, produce 15 cubic feet of this gas. The saccharine materials of the flour, therefore, are quite sufficient to account for the proper expansion of the dough, and the vesicular appearance so familiar to us.[1]

The losses during baking are due to the conversion of sugar to alcohol and CO_2, and the destruction of fat and protein. Jago[2] estimates the loss at 1·3 per cent. of the total nutritives; but in the Pittsburg observations they were found to be 5 per cent. of the caloric value—thus:

Losses during Bread-making.

Protein	1·3	per cent. of total.
Fat	71·2	,, ,,
Carbohydrates	3·2	,, ,,

The protein is used as a yeast food, fat is volatilized during baking, and the carbohydrate is transformed to alcohol and CO_2. Most of the alcohol is volatilized, but Bolas considers that new bread contains 0·22 to 0·40 per cent. of alcohol; and another calculation is that new bread contains about 16 grains of alcohol in a quartern loaf.

Fermentation of Bread.—The theory of **panary fermentation** is briefly summed up thus: It consists essentially in the alcoholic fermentation, by means of yeast, of the sugar pre-existing in the flour.[3] The yeast is one of the saccharomyces, *Torula cerevisiæ*. This fungus consists of cells with walls of cellulose and an interior substance of protoplasm, which contains an unorganized ferment (*zymase*), emulsin, and nuclein, which is a combination of nucleic acid with albuminates and carbohydrates. When surrounded by a

1 "The Modern Baker and Confectioner," vol. i., p. 48.
2 "Science and Art of Bread-making."
3 Léon Boutroux, "Le Pain et la Panification," Paris, 1897.

medium containing a sufficient supply of nutritive material, the activity of these cells is shown by the production of alcohol and CO_2 and an increase in their numbers, reproduction being very rapid and by the simple process of budding. The pabulum must contain sugar, nitrogenous and mineral substances. When the nutritive supply fails, three or four small round spores are formed in the interior of the cell, which, becoming dried up and broken, liberates the spores, and permits their being carried by currents of air. Such spores are inert, but retain their vitality for years, and when they alight upon a suitable material develop into the form of the original cells and become active. The spores, however, require from two to fourteen days for their full development, and therefore take no part in the ordinary manufacture of bread.

We have seen that when leaven was made by a spontaneous fermentation of the dough—*i.e.*, by inoculation with bacteria from the atmosphere—the process of leavening was accompanied by the formation of an acid or acids. This acidity was undesirable. The next step in advance, therefore, was to obtain fermentation with a minimum of acidity. This took place with the introduction of barm from fermented liquors as the means of leavening the bread in France, Belgium, and Spain, where beer yeast was used, and in Greece and Rome from that of wine. In more recent years German or compressed yeast has been used. It is the barm collected usually from distillers' vats after the fermentation of grain for the manufacture of spirits. The barm is mixed with water, passed through a series of sieves, washed, decanted and again washed several times, and passed through finer and finer sieves. Finally it is allowed to settle, put into cloths, and pressed. The best samples are free from starch, but many yeasts are mixed with starch before they are compressed, on the supposition that they keep better, retain their vitality, and remain active for a week or two. The product is a pasty, putty-like mass having an odour and taste of beer yeast, and containing zymase, nuclein, emulsin, and yeast fat. Beer yeast has the following composition : Cellulose and mucilage 37·0, albuminoids 36·0, soluble in alcohol 9·0, peptones 2·0, fat 5·0, leucin, tyrosin, etc., 4·0, ash 7·0, per cent.[1]

Perfectly dry yeast has not yet been obtained, but certain sun-dried **yeast cakes,** consisting of meal and yeast, are in use in the United States, and in other countries, in the parts distant from towns where a fresh supply of yeast is unobtainable. Such cakes produce fermentation very slowly, and are only suitable for domestic use. Similar yeast cakes were used by the Romans in the first century. It has been suggested that the activity of the yeast cake is due to the development of spores rather than the activity of the actual cells.

The activity of yeast depends upon the intracellular enzymes, *zymases,* or soluble unorganized ferments. There are several, notably *invertase,* which converts cane-sugar into dextrose and

[1] Nägeli and Loew, Thorpe's "Dictionary of Chemistry," ii. 109.

lævulose by catalytic action, or, according to some authorities, by radiant energy, the zymase itself not being used up in the process. Cane-sugar is converted into dextrose or glucose *outside the cell*, but it is transformed into alcohol inside the cell by a special enzyme. The enzymes also include one which has a slight diastatic action, and is supposed, like malt diastase, to convert starch into dextrin and maltose. Some textbooks state that yeast changes some of the starch into sugar, and then ferments it ; but this idea is scarcely acceptable, because of the very slow action of diastase upon unburst starch granules. There is, however, a diastatic enzyme in the germ and cerealin layer of wheat, and the same property is attributed to some of the soluble proteins of the endosperm. The diastatic power of the soluble proteins is very feeble, but when they act in conjunction with yeast they are capable of considerable activity in transforming starch into sugar.[1]

Yeast Foods.—In order to perform its functions, it is necessary that the yeast should grow vigorously ; if the action is not vigorous, the fermentation is slow, and sour, unpalatable bread will result. The yeast must therefore be supplied with food which it can assimilate in order to build up its own structure and reproduce its species. Like all other plants, it requires air, water, protein, carbohydrate, and mineral matters. It has been shown by Dr. H. Brown that yeast is active in proportion to the amount of soluble proteins—albumoses, peptones, asparagin, leucin, tyrosin, etc.—in the medium ; that these bodies are essential for yeast growth ; that the fungus ceases to grow, and its activity declines, or fermentation ceases, as the supply of these substances becomes exhausted, even when unfermented sugar and insoluble proteins are present. Therefore the amides and amino-acids are important yeast foods. Such foods are used, consciously or unconsciously, by the baker every time he makes a ferment, or " sponge." One of the commonest materials used for this purpose is a mixture of flour and boiled potatoes. The potatoes contain peptone, xanthin, asparagin, leucin, and tyrosin, in recognizable quantities, besides traces of other protein bodies. The most important of these is **asparagin,** an amino-acid and powerful stimulant of enzymic action. It was found by Effront that the addition of 0·05 gramme of asparagin to a solution of starch and diastase resulted in the production of 61·2 per cent. of maltose in the same time as 8·63 per cent. of maltose without the added asparagin. Potatoes contain 0·3 per cent. of asparagin ; therefore when 7 to 12 pounds of potatoes are used to make a ferment for a sack of flour (a common example), the baker adds about half an ounce of this stimulating substance, besides other amides and amino-acids useful to the yeast.[2]

There is, however, no necessity for the addition of yeast foods ; such is the conclusion drawn from analyses of flour. Dumas

[1] Jago, " Science and Art of Bread-making," p. 219.
[2] " The Modern Baker and Confectioner," vol. ii., p. 226.

showed that the amount of CO_2 required for the vesiculation of the dough made from 100 pounds of flour can be produced by less than 1 pound of sugar ; and average flour contains from 2 to 3 pounds of sugar in every 100 pounds in equal proportions of sucrose and maltose. It is also shown that the amount of soluble proteins in flour varies from 1·5 to 2·5 per cent. ; therefore a sack of flour would contain from 4 to 7 pounds of soluble nitrogenous materials available as food for the yeast cells. Abundant materials are therefore present, and most bakers have discarded the addition of potatoes, although many of them still use scalded flour, rye flour, malt flour, malt extract, malt culms, wheat germ, and cane-sugar or glucose.

Scalded Flour is not a yeast food in the sense indicated above, for by scalding it some of the soluble proteins become insoluble, and enzymes are destroyed ; on the other hand, some of the starch becomes transformed to soluble starch, which is more readily acted upon by diastatic ferments introduced with the yeast, so that maltose (a good yeast food) is produced. Within moderation, the use of scalded flour is a " bread-improver," the crust being better, the crumb whiter, and the retention of water greater.

Rye Flour as a Yeast Food.—The soluble proteins of rye flour amount to 3·33 per cent., which is large compared with the 1·5 per cent. in wheat flour. Rye is never so carefully milled as wheat, and it possibly contains a larger proportion of aleurone or cerealin from the bran. The use of 3 pounds of rye flour to a sack of wheaten flour is a material aid to fermentation, which is attributed to the amides ; and the amount of CO_2 produced is double that produced by the fermentation of wheat flour alone.

Wheat Germ as Yeast Food.—Wheat germ contains 6 to 10 per cent. of soluble proteins, including albumoses, peptones, asparagin, leucin, tyrosin, and other amides. It likewise contains 10 to 18 per cent. of sugar. A substance so rich in materials essential for the growth of yeast cannot fail to stimulate fermentation. Kirkland[1] found by experiment that an increase in the amount of CO_2 exactly proportionate to the added wheat germ is produced. He recommends the use of 2 pounds to each sack of flour ; this is infused for one hour in water at 160° F., strained, and the liquid added to the yeast. It contains all the stimulating properties of a potato ferment, but none of the bacteria which infest the latter.

Malt Culm as a Yeast Food.—During the preparation of malt the grain germinates, and is dried in a kiln. During the latter part of the treatment the acrospires, or young sprouts, called the " culms," are broken off. Collectively they are called " malt coombings." They contain 12 to 15 per cent. of nitrogenous matter, and about the same amount of carbohydrates. The soluble proteins are similar to those of the wheat germ, 60 per cent. being albumoses, peptones, and amino-acids. The carbohydrates are mostly sugar in a fermentable form, produced during the germination of the grain

[1] " The Modern Baker and Confectioner," vol. ii., p. 269.

from starch of the endosperm. An infusion of malt culms in the proportion of 2 pounds to each sack of flour is a valuable stimulant to the yeast.

Various other yeast foods and bread-improvers are used, such as malt flour, malt extract, cane-sugar, glucose, and milk. The soluble carbohydrates of these materials are capable of rapid transformation into CO_2 and alcohol. Cane-sugar is a gas-producer pure and simple, and has the disadvantage that it must be converted into a monosaccharide by invertase of the yeast before it can be fermented; 2 pounds to a sack of flour will yield all the gas necessary to leaven the dough and give a rich bloom to the bread, besides adding something to its nutritive qualities. "Glucose" consists of monosaccharides, and is therefore directly fermentable; the dextrose and dextrin are not true yeast foods, but the dextrose is rapidly transformed into CO_2. Kirkland finds the limit is 2 pounds per sack of flour; if an excess is used, the tenacity of the gluten is destroyed, and it may cause over-fermentation, when the bread will be dry and crusty. Malt extract and malt flour are used as yeast foods and bread-improvers; they contain a good proportion of soluble proteins, including amines, together with the enzymes diastase, maltase, invertase, peptase, and cytase. Great care is necessary in the preparation of malt flour or extract. If they are mixed with very hot water or kept at too high temperature, the soluble proteins will be coagulated and thrown out of solution, and the enzymes destroyed. Malt flour is commonly used, but the extract may be used in the proportion of 5 or 6 pounds to the sack. If more were used, it would simply act as other sugars do, by making the bread short and crumbly and of very dark colour. Kirkland says the main reason for the use of malt extract or flour is to provide the nutty flavour which is lost through the removal of the cerealin layer in milling the wheat. The maltose is speedily fermented by yeast. Very little starch is converted to sugar by the diastase of malt during fermentation; but when the loaf is in the oven and its temperature rises, a good deal of sugar may be formed. This sugar will remain unaltered by yeast, because the fungus is destroyed at 125° F., whereas the diastase is most active when the temperature ranges from 140° to 180° F. Therefore malt flour or extract, if it contains a fair proportion of diastase, is a genuine bread-improver.

Milk is also a valuable bread-improver. It is used fresh or dried. Dried milk is considered the best for baking, being less liable to deterioration; when mixed with eight times its weight of warm water, it forms a liquid having the composition of average milk. It is necessary that the powder be obtained from entire milk, and not from skim milk. The former improves the flavour, colour, and texture, of the bread; the latter, being deficient in fat, is of little value. Lactose is not fermentable by ordinary yeast, and therefore no leavening effect results from it; but it is transformed into lactic acid by the *Bacterium acidi lactici*. The soluble proteins, though small in amount, furnish food for the yeast. The casein

adds nutriment, and the fat contributes to the silkiness and improved appearance of the bread.

The Amount of Yeast used to each sack of flour varies with the length of time the dough is fermented. This is shown in the following table of details collected from "The Modern Baker and Confectioner," pp. 66-103 :

FERMENTATION OF DOUGH BY COMPRESSED YEAST.

Duration of Fermentation.	Flour.	Compressed Yeast.	Salt.	Kind of Sugar.	Water.
	Pounds.	Ounces.	Pounds.	Ounces.	Gallons.
12 hours	280	6	4½	Cane-sugar 6	13
8 ,, ...	280	11	4	Glucose 12	13½
6 ,, ...	280	16	3¾	Malt extract 8	13¾
5 ,, ...	280	20	3½	,, ,, 12	14
4 ,, ...	280	24	3½	,, ,, 12	14
3 ,, ...	280	28	3½	,, ,, 16	14
2 ,, ...	280	38	3½	,, ,, 16	14
1 hour	280	64	3½	,, ,, 20	14

Prior to the advent of compressed yeast bakers were very often thrown upon their own resources for "leaven," or they had to make their own barm or rely upon a local brewery. They therefore adopted the method known as making a **sponge,** by which means a small amount of yeast did the work of a large amount. It was found that a sack of flour can be fermented as well with 4 ounces as with 4 pounds of yeast, providing time is given for the yeast to develop. The following examples of the proportions used are also derived from "The Modern Baker," pp. 115-119 :

THE SPONGE METHOD OF LEAVENING.

Duration of the Leavening.	To make the Sponge.				Added afterwards.			
	Flour.	Yeast.	Salt.	Water.	Flour.	Salt.	Glucose.	Water.
	Pounds.	Ounces.	Ounces.	Gallons.	Pounds.	Pounds.	Pounds.	Gallons.
12 hours' sponge	120	6	6	6½	160	3¼	1	8¼
10 ,, ,,	120	9	6	6½	160	3¼	1	7½
8 ,, ,,	120	12	6	6½	160	3¼	1	7½
1½ ,, ,,	25	16	sugar 8	2½	255	3½	—	12

The method consists in mixing the yeast with only a part of the flour and some water. The fungus grows throughout the mass ; the gluten of the sponge is so changed that it has a softening effect upon other gluten ; and acids are developed which accelerate the

ripening of the dough in the second stage of the process. Many bakers still use this and consider it the best method to make a sweet loaf which is at the same time soft and bulky. Two-fifths of the flour are mixed with the yeast, some salt and water. It is fermented for a period of eight or twelve hours, during which the "sponge" will rise and fall twice. It is then mixed with the remainder of the flour, salt and water, with some sugar or other saccharine material. The "sponge" drops because the tension of the gluten is overstrained, and the vesicles burst and the gas escapes; this is taken as a rough test of the quantity and of the energy of the new yeast formed within it. It is then thoroughly kneaded with the remainder of the flour, salt and water, and allowed to ferment for another period of one to one and a half hours before it is baked.

Other modes of cultivating yeast in the bakery are by means of scalded flour or boiled potatoes. Thus, for two sacks of flour: 16 pounds of potatoes are cooked for one and a half hours, mashed, mixed with 4 pounds of flour, 17 gallons of water, and 4 pounds of yeast; the mixture is kept for one and a half hours at a temperature of 84° F., during which time it rises and falls twice. The dough is then made by adding 7 or 8 gallons of water to the mixture, and kneading the flour with it; it is ready to be baked in one and a half hours. When flour is the medium for cultivating yeast, it is made into a "batter" and stocked with old barm.

Changes produced during Bread-making.—The proportion of protein is little altered, and may be said to represent all that existed in the flour; but some of the soluble nitrogenous matters have been used up by the yeast. The carbohydrates undergo a greater change; there is a loss equivalent to 2 per cent. of the flour; the loss may be greater than this, because 6 to 8 per cent. of the starch is converted into soluble forms—*e.g.*, dextrin—during fermentation and baking. The proportion of sugar is altered by fermentation, some at least being destroyed by conversion into CO_2; therefore it cannot be said that the amount of sugar in the bread equals that in the flour *plus* the added sugar. The proportion of ash is likewise altered by the addition of salt or other mineral ingredients. Flour contains practically no acid; but during fermentation a varying proportion of lactic and acetic acids are developed. The proportion of these acids depends largely upon the process of baking, and a small degree of acidity is regarded as being not injurious, but rather beneficial, to digestion. The amount of fat in bread is rather difficult to ascertain, owing to the trouble of separating a fatty substance from a glutinous mixture. Wiley considers that analytical data probably do not show the correct proportion of fat in bread owing to this difficulty. In any case the amount varies, being greater when milk is mixed in the dough or the baking-tins are greased. The amount of water in the bread varies with the quality of the flour, some kinds absorbing and retaining more than

others ; it also depends on the temperature and duration of baking. As a rule it varies between 30 and 40 per cent. In the District of Columbia, U.S.A., the legal standard is that the bread shall not contain more than 31 per cent. of water. When bread is submitted to a high temperature immediately it is put into the oven, the exterior becomes rapidly solidified, and the crust prevents the escape of moisture ; on the other hand, bread baked in a slow oven is drier than that exposed to a high temperature.

The interior of the loaf always rises to a temperature of 101° C. near the centre. Vesiculation is produced by expansion of the CO_2 with which the dough is intimately incorporated ; this vesiculation begun during fermentation is increased by exposure to the heat of the oven. During cooking the loaves swell up still more, owing to formation of steam from the water. But as the water in the exterior is first evaporated, this portion becomes crisp and firm, and forms a crust on the surface. A well-baked loaf should have a bottom crust which is hard and resonant, while the crumb is elastic and spongy. If the crumb is doughy or can be rolled into a ball, and remains so, either the bread is not sufficiently baked or the flour is deficient in quality. Good bread crumbles, is spongy and elastic. Freshly-ground flour is too adhesive to make good bread. It is usual to keep it for a few weeks before using it. Bakers prefer the flour to be kept three months after milling, or to consist of a mixture of new and old flour equivalent to it. The new flour is turned over and over for a few weeks until it readily falls apart in the hand.

In Dauglish's method of bread-making, however, some of these changes in the constitution of the flour do not occur, because *no yeast* or other ferment is used. This mode of bread-making was introduced by Dr. Dauglish in 1856-57 : Flour is put into a cylinder, the atmospheric air is extracted and replaced by CO_2, and the dough is made by water charged with CO_2. The machine kneads the dough, turns it out to be caught in tins, which are in the modern process placed upon an endless floor moving slowly over a fire ; the loaves, done to a turn, light and spongy, emerge from the opposite extremity. Such bread is called **"aerated bread"** ; it is made without the aid of yeast, by which fermentation is avoided and the destruction of carbohydrates and soluble protein is spared. It is also claimed that it is more cleanly prepared, because it is never touched by the hands of the baker ; contamination is therefore avoided, and such bread is highly commended.

Condition of the Starch in Bread and Toast.—Under the influence of the moist heat of the oven the starch undergoes all conditions of gelatinization and dextrination down the scale as far as amylo-dextrin, or soluble starch. The insoluble portion is, moreover, partially soluble in very dilute hydrochloric acid, also in the form of amylo-dextrin, from which it is possible to determine the degree of gelatinization. Lindet[1] shows that the composition of **crust** is

[1] *Bull. de la Soc. Chim. de Paris*, 1902, xxvii., No. 12.

invariable in both new and stale bread; it contains more dextrin than in the crumb, and the starch is broken down, but is not even partially soluble in dilute acids. The composition of the **crumb,** on the other hand, undergoes many transformations. When the bread leaves the oven, it contains about 10 per cent. of soluble dextrins, but this amount diminishes progressively, until at the end of forty-eight hours the crumb contains only 2 per cent. of soluble dextrins; it is the amylo-dextrin which has undergone a retrograde change. Many people prefer **new bread** to that which has been kept a few days. But in this condition it is difficult of mastication, owing to its softness, which favours its clogging into a close and heavy mass, which cannot readily be penetrated by saliva or the gastric juice; it is therefore not very easily digested, and is very apt to excite gastric derangements. Bread which is a day or two old is light and porous, readily penetrated by the digestive secretions, and therefore more easily digested; while **stale bread** is firm and friable, maintains its porosity during mastication, and is the most easily digested. **Toast:** When bread is cut into slices and toasted, some water is driven off, the surface is scorched, and a little starch converted to dextrin; and the whole acquires crispness, and firmness, so that mastication and digestion are more easy. The bread should be toasted so that it is crisp throughout. If the slice of bread be thick, the surface is merely scorched by the heat, while the interior becomes soft and in much the same condition as the crumb of new bread; such toast is less easily digested than ordinary bread. Buttered toast, like any other article saturated with fat, offers considerable resistance to digestion, and is apt to disagree with a delicate stomach.

Changes in Bread on Keeping.—Bread becomes **stale** by being kept. This is due in part to loss of water, which, according to Goodfellow, varies from 0·9 per cent. in twelve hours to 14 per cent. in seventy-six hours. But staleness cannot be explained merely by saying it becomes dry; for Boussingault showed that stale bread can be partly restored to freshness by submitting it to a temperature of 300° F., and yet during the rebaking it loses still more water; a simple instance of this is the change produced in a thick slice of stale bread by toasting it. There is no clear explanation of the change. Bibra, however, considers the following to be the true explanation: New bread contains **free** water, some of which unites with the starch and gluten as the bread becomes stale; rebaking sets this moisture free again and freshens the bread—*i.e.*, the water is taken up in forming amylo-dextrin. This corresponds with Lindet's statement given above, that the soluble or amylo dextrin, which amounts to 10 per cent. when bread is taken from the oven, diminishes progressively, until at the end of forty-eight hours only 2 per cent. exists, the amylo-dextrin, or soluble starch, having retrograded to ordinary starch; in changing from starch to amylo-dextrin it takes up water, in retrogressing it gives up water. Mathieu Williams offers another explanation; he says the bread

becomes stale because the fibres which form its pores shrink and the cellular walls come together, the bread being closer and harder; that rebaking causes a generation of water, and drives the walls apart again. There is no doubt about the loss of water when bread becomes stale, as the fact has been shown over and over again by chemical analysis. When the bread is fresh from the oven, the cells in its interior are expanded by gas and water vapour, whose temperature and pressure are above that of the atmosphere. When the interior of the bread attains the same temperature as that of the surrounding air, the volume of the moisture and gas in the cellular spaces will be diminished, the atmospheric pressure on the exterior of the loaf will be greater than the internal pressure, and therefore the loaf will contract, its surfaces tend to come together, and the cellular spaces will diminish in size. This contraction is resisted to a great extent by the hard crust; but the tendency is towards a diminution in the bulk of the loaf, until it becomes absolutely dry and hard. If, however, the loaf is submitted to heat, the gas and moisture in the interior will again expand, and become greater in pressure than that of the atmosphere; the cellular spaces will be reopened by such expansion, and the loaf freshened by penetration of the steam into the substance.

Changes due to Bacteria and Fungi.—Bread is very liable to undergo changes after baking, other than those due to becoming stale, owing to the growth therein of various bacteria, moulds, and other fungi. Flour is not sterile, but contains many organisms, including bacteria and the spores of fungi, some of which are not destroyed by the heat employed in baking. A series of experiments with a high-grade patent flour, obtained from carefully cleaned wheat, showed the presence of 30,400 bacteria and seven mould spores in 1 gramme of flour.[1]

The most common complaint arises from **sourness** of the bread. This is due to the development of lactic, butyric, and acetic acids. The organisms which produce these acids are always present in the leaven, whether it consists of fresh barm, dried compressed yeast, or a composite material such as potato leaven. As a rule these organisms do not develop greatly in the dough, providing care is taken to prevent over-fermentation; if, however, the fermentation is continued too long, the yeast fungus becomes exhausted, and other micro-organisms gain the field. Bread has a faintly acid reaction, which is due to small proportions of the aforementioned acids produced by these organisms. A small amount of such acids is not considered detrimental, but assists in producing flavour, and increases the digestibility of the bread by modifying the gluten. But under certain conditions unfavourable to the yeast, such as prolonged fermentation or alteration of the temperature, the acid-producing bacteria get the upper hand, and the bread is sour as the result of their production. Lactic acid is produced by *Bacillus lactis*, of which about one hundred varieties have been recognized.

[1] "The Modern Baker and Confectioner," p. 45.

They are most active at a temperature of 35° to 42° C., which is the temperature favourable to the normal fermentation of the dough. Lactic acid is therefore most likely to be produced before baking the dough. These bacteria do not produce spores; their growth is stopped by the presence of 2 per cent. of lactic acid, and they are readily destroyed by the temperature used in ordinary baking. Butyric acid is produced by *Bacillus butyricus*, of which there are numerous species; the best known of these is the *Clostridium butyricum* of Fragmowski; it thrives best at about 40° C., and produces butyric acid by the transformation of lactic acid. Acetic acid is produced by the transformation of alcohol into that substance by *Mycoderma aceti*. Bread leavened with yeast always contains a small number of these acetic-acid-producing microbes. Various other bacteria have also been found in the flour, dough, or bread; but they are mostly of little importance. The acid reaction of bread, although faint, is sufficient to prevent the development of many bacteria. It is, however, favourable to the growth of moulds, and two other bacteria also find in it a condition favouring their development; these are *B. mesentericus* and *B. prodigiosum*.

Rope in Bread, or "ropy bread," is due to the development in it of the *B. mesentericus* (Flügge), a short, sporing organism commonly found on potatoes. The spores are very resistant to heat, and are not destroyed by boiling for one hour nor by the temperature of the interior of a loaf during baking. The flour or yeast becomes contaminated by these bacilli, and under certain conditions the spores develop in the bread. These conditions appear to be a neutral or nearly neutral reaction of the bread; for, according to Watkins,[1] the normal degree of acidity is a sufficient protection against its development. Ropiness occurs in bread during moist, warm weather, especially in the autumn. It makes its appearance about twelve hours after baking, the interior of the bread presenting small brown spots, which gradually spread throughout the loaf and give to it a disagreeable odour and flavour. The spots are moist and gummy; when the bread is broken they can be drawn out into strings or threads, whence the name "ropy bread."

Coloured Bread.—The *Bacillus prodigiosus* or *Bacterium prodigiosum* is an organism which produces red colouring matter; being air-borne, the bacterium alights on bread, and develops colonies which have the appearance of **drops of blood.** Like the former, it is most common in the early autumn, when the atmosphere is warm and moist. It formerly gave rise to a superstitious dread, being called the Bleeding Host or the Bloody Sweat. Such bread should not be eaten, because the proteins of the organism are considered to have a toxic action.

Moulds readily grow upon bread, and have characteristic colours; *e.g.*, *Mucor mucedo* forms a white mycelium, from which grow the spore-bearing heads having a dark brown or black colour. *Aspergillus niger* is a black mould commonly growing on stale bread.

[1] *Jour. Chem. Soc. Ind.*, 1906, p. 350.

Penicillium glaucum is the sage-green or blue mould also growing on stale bread. *Oïdium aurantiacum* is a red fungus which may grow throughout the bread, and produce in it an orange colour.

The Varieties of Bread.

Unleavened Bread.—This is made from wheat flour with water and salt, mixed together by kneading. It becomes "lighter" after prolonged kneading, owing to the action of the natural enzymes of the flour, and possibly to the inclusion of yeast spores from the atmosphere. It is made into thin layers, which when baked are hard and crisp. This variety of bread therefore contains very little moisture, is very compact, and of a high nutritive value. It is used at the ceremonial observances of certain religious sects. As a ration for men during military and other expeditions, it has been used from time immemorial. The name of "damper" is applied to unfermented bread in Australia and Africa; other examples are found in various biscuits and cakes. (See also Graham Bread.)

Where bread is referred to without any qualification of the term, some variety of fermented or leavened bread is as a rule intended. These varieties are somewhat numerous, owing to the inventive genius or fads of various people. The principal varieties of leavened bread are three, and correspond to three grades of flour—viz., white bread from fine flour of different qualities; brown bread and Graham bread from brown or Graham flour; and whole-wheat bread from the entire-wheat flour.

White Bread is generally regarded as being superior to that made from whole-wheat meal. The removal of the bran, which consists chiefly of cellulose, is an advantage, because it is indigestible. But by its removal the bread is deprived of valuable phosphates and some proteins. The proportion of phosphates in the mineral substances of cereals is very high. This is shown in the following table by Berthier:[1]

Phosphates in One Hundred Parts of the Ash of Vegetables.

Nature of Phosphate.	White Wheat.	Rye.	Barley.	Oats.	Rice.	Maize.	Lentils.	French Beans.	Green Peas.
Potassium ..	50·0	48·5	52·5	7·5	24·1	41·5	61·7	42·7	66·7
Calcium ..	22·0	29·2	15·0	16·5	24·1	18·5	6·5	8·5	22·2
Magnesium ..	28·0	—	25·0	20·0	24·1	38·0	19·6	14·3	6·6
Manganese ..	—	18·3	—	—	—	—	—	—	—
Total ..	100·0	96·0	92·5	44·0	72·3	98·0	87·8	65·4	95·5

The phosphates of bran are, however, enclosed in cells surrounded by lignin or cellulose; and as the latter is indigestible, those valuable salts are not available for use. Patten and Hart[2] conducted a

[1] "Fermentation," by Schultzenberger, p. 88.
[2] *Chemical News*, 1904, ii. 112.

series of experiments upon wheat bran, and derived from them the following conclusions:

1. Practically all the phosphorus of wheat bran is combined in an organic form.

2. The combination is in the form of a magnesium-calcium-potassium salt of a phospho-organic acid.

3. This acid corresponds to the formula $C_2H_8P_2O_9$, and is probably identical with anhydro-oxy-methylene-diphosphoric acid. This acid and its salts are widely distributed in the vegetable kingdom, and has been isolated from cereals, peas, beans, potatoes, other tubers and bulbs, pumpkin and other seeds.

A comparison of the amount of phosphorus in wheat bran, oats, and malt culms, is as follows:[1]

	Total Phosphorus per Cent.	Soluble Phosphorus per Cent.		Percentage of Total Phosphorus soluble in—	
		Water.	HCl.	Water.	HCl.
Wheat bran	1·220	1·056	·960	86·5	77·8
Oats	·355	·180	·096	50·0	27·0
Malt culms	·677	·548	·477	81·0	70·0

Wheat bran is therefore richer in phosphorus than oats or malt culms, and 86·5 per cent. of it is soluble in water. It was at first supposed that the phosphorus of bran was all in combination as nuclein or salts of nucleic acid, but this is not the case as regards the whole of it; for determinations of the amount of soluble nitrogen showed that only 33 per cent. of the phosphorus can be accounted for in this way. By far the greater proportion of phosphorus is linked up in some other organic combination, while the inorganic phosphorus is very small. As a matter of fact, Patten and Hart found that the chief phosphorus compound of bran has the following composition: C 17·3, H 3·63, P 16·38, Ca 1·13, Mg 5·8, K 2·6, per cent.

The **germ** and **cerealin,** removed in milling, are far more important than bran; they contain much valuable food material, especially proteins and fat, as shown in an earlier table, given in discussing the composition of wheat and flour. But they give a dark colour to the flour, and the soluble proteins and other constituents exercise an unfavourable influence upon the gluten during bread-making. These are considered sufficient reasons for their removal. What remains, in the modern process of milling, is the fecula almost entirely derived from the endosperm—a fine, white, and almost fat-free powder. Soft wheat makes the whitest flour, but for reasons already given it is usually mixed with hard wheat. The addition of potato and other forms

[1] Bulletin 250, New York Experimental Station.

of starch also makes the bread whiter. Alum also makes the bread whiter; but it converts the phosphates of the bread into **insoluble alumina phosphate.** Alum normally exists in bread to the extent of 6 to 8 grains in a quartern loaf; any quantity above this proportion is usually an addition, and is deleterious to the consumer by causing constipation, besides being a prolific source of dyspepsia.

In addition to the ordinary loaves of white bread weighing 2 or 4 pounds, there are various smaller loaves, cakes, etc., made of the same dough; such are penny loaves, twists, cakes, and various fancy breads.

Rolls consist of small masses of fancy bread of various shapes, to be eaten hot or cold, such as small round cakes or long rolls. They are made of a medium strong white flour, with a large proportion of yeast, a little sugar, salt, and lard or other fat. The duration of fermentation is one and a half hours.

Vienna Rolls as a rule consist of fine white bread having a crisp exterior of a light amber colour; they are not eaten hot as a rule in the British Isles. They are made of a strong flour of the highest grade, with a large proportion of yeast, and moulded into various shapes. They are baked in an atmosphere made moist by steam of 310° F., which is forced into the oven at a pressure of 80 pounds per square inch.[1] A film of water forms upon the surface of the rolls, which quickly boils and gelatinizes the starch in the external layer, and causes the glazed appearance of the finished roll. Where steam-glazing is not carried out, it is imitated by brushing the surface of the rolls with egg-wash before putting them in the oven.

Milk Rolls are formed of flour 200, water 65, milk 50, salt 2½, parts, and dry yeast 1 part. They are highly nourishing, and contain the elements of a typical food when eaten with butter or as part of an ordinary meal. Milk bread is not so satisfactory, from the baker's point of view, as ordinary bread. It makes a rather small, close loaf; this is probably due to coagulation of the casein. Milk bread is usually of a rich creamy colour, even texture, and thin crust. Any beneficial effect which the milk may have from the baker's side of the question is due to the milk-fat. Skim milk is not suitable for bread-making, first because of the absence of fat, and secondly because of the greater proportion of lactose and its association with lactic acid bacilli. Much lactic acid is produced, which softens the gluten, and results in the bread being drier and more crumbly than that made with water. This effect might be obviated by using one of the commercial dried milks or milk-powders.

Scotch Baps or breakfast rolls are soft, spongy cakes of oval shape. They are not crisp or crusty like English or Vienna rolls. *Irish baps* are similar, excepting in shape.

Currant Bread and **Sultana Bread** usually contain 1 pound of

[1] "The Modern Baker and Confectioner," vol. i., p. 133.

currants or sultanas and 4 ounces of sugar to 16 pounds of bread dough, with or without flavourings, such as orange or lemon peel or caraway seeds. The dough is sometimes mixed with equal parts of milk and water, and is then especially rich in nutriment.

Muffins or **Pyclets** are usually made of a soft flour, water, and yeast, into a liquid paste or batter, some carbonate of soda and cream of tartar being added to assist in aeration. They are baked in rings upon an iron plate heated by gas, coke, or steam. They have a golden-brown appearance on the plate side, but are yellowish-white and "holey" on the upper surface. They are light and spongy, but of tough consistence. They are toasted and buttered, and eaten hot. They are very trying to the stomach.

Crumpets, which are also made on a hot-plate, are distinct from the former. They are of about the same size, but very much thicker, and are neither tough nor "holey." They consist of extremely "light" dough cakes, made of a moderately strong flour mixed with milk and water, and fermented with a large proportion of yeast. They are eaten hot or cold.

English Pancakes are made of a batter consisting of flour, eggs, and milk, which are beaten together until the whole is perfectly smooth and of the consistency of cream. They are fried in fat or butter, and eaten immediately they are taken from the fire. *Scotch pancakes* are similar to crumpets.

Scotch Scones are small cakes, usually made of a soft, white flour, salt, carbonate of soda, and cream of tartar, mingled together and made into dough with buttermilk; they are conveniently baked on a hot-plate.

Sweet Milk Scones are made of the same substances, but lard is mingled with the flour, and the dough is made of fresh milk to which is added the sugar and salt.

Home-made Rolls frequently partake of the character of pastry, similar to that of which tarts and pies are made. They form "the hot cakes" so highly esteemed in Yorkshire, Lincolnshire, etc. They are usually a combination of flour, water, milk, salt, and lard or butter for "shortening," leavened with baking-powder or yeast. Such rolls have a composition which varies with the materials used. The following is a fair statement of the average composition: Water 30·27, protein 7·19, fat 3·82, carbohydrate 56·71, salt 0·72, ash 1·29, per cent.

Brown Bread.—It was formerly a custom of bakers to mix a few handfuls of bran with the white flour in order to produce brown bread. This, of course, was not genuine whole-meal bread. It is now replaced by various kinds of bread made from what is more or less the actual product of entire grain.

Entire-Wheat Bread.—It was for a long time the custom to grind the wheat into a coarse meal, which was more like broken wheat than flour. This produced bread of a pleasant heaty flavour, which when properly made was a valuable food, and was good for promoting the activity of the intestinal canal. Now,

however, the grain is ground into a very fine meal, and the bread is not so useful for the subjects of intestinal atony. The present custom of millers is to make entire-wheat meal from grain which has been decorticated by the removal of a portion of the bran. This abstraction is made up in many cases by the miller adding to the meal a quantity of "middlings," "shorts," or "pollards," equal to that which is removed in the process of making patent flour—viz., 11·6 per cent. of the entire wheat product; this material contains a large part of the germ, and is rich in protein. Other millers, who make a speciality of whole-wheat meal, have millstones specially dressed for making this meal, and use a superior quality of soft wheat. The entire-wheat meal naturally contains the germ of the cereal (removed in making white flour), which is of a high nutritive value, and gives a sweet, pleasant flavour to the bread.

Brown bread, however, is not always a simple bread made from decorticated or entire-wheat meal. Special meals are prepared by millers for making patent or proprietary breads. Some of these are mixtures of entire wheat and additional germ, others contain *malted wheat or barley*, and another class contain a certain proportion of oatmeal, rye, rice, or maize flour. Thus, Daren bread contains rye meal and germ. Kermode's patent bread contains maize. Triagon bread contains both rice and maize.

Entire-wheat or brown bread is usually made on the short-dough system, because of the softening influence which the germ and cerealin exercise over the gluten, and also because long fermentation develops in it an undesirable acid flavour. The following method is recommended by "The Modern Baker" (vol. i., p. 127): Take of coarse meal 6 pounds, fine flour 2 pounds, salt 2 ounces, sugar 1 ounce, lard 2 ounces, yeast 2 ounces, water 5½ pints at temperature of 102° F. Mix the flours together, rub in the lard; dissolve the sugar, salt, and yeast, in the water, and knead the whole into a dough. Cover it over, and keep it at a temperature of 80° or 90° F. for one hour; knead it again, and put it into moulds; allow it to stand forty-five minutes, and bake it in an oven at 430° F. The duration of baking is thirty-five minutes for one-pound loaves. Such bread should retain its natural wheaty flavour, and be neither holey nor crumbly. When fine meal from decorticated wheat is used there is no necessity to add white flour; but the addition of 3 ounces of malt flour gives a rich colour and bloom to the bread.

The Colour of Brown Bread.—Bread made from entire-wheat meal or Graham flour has a darker colour than that made of fine white flour. This coloration, according to Bertrand and Mutermilch,[1] is due to the action of enzymes in the bran, which takes place in two stages: a protease, called *glutenase* by the investigators, sets free a colourless chromogen having the characteristics of tyrosin; in the second stage atmospheric oxygen combines

[1] *Bull. de Soc. de Chem.*, 1907, i. 1048-1051.

with the chromogen and produces a brown colour. The observers state that glutenase, which is only active in neutral or acid solutions, hydrolyzes some of the proteins of the flour and casein of milk, and results in the production of tyrosin.

Malted Brown Bread is made by adding 2 ounces of malt flour to every pound of wheat meal in the recipe given above. The following mode of preparation was also introduced by Pooley and Oliver[1]: A decoction of malt is made by mixing 1 pound of ground malt with 1½ pints of water, and placing it in a water-bath in the oven for five hours. As water evaporates from it, more is added to maintain the original bulk. It is cooled by being mixed with water. The following recipe is then used: Take of entire-wheat meal 8 pounds, fine white flour 2 pounds, lard 8 ounces, yeast 3 ounces, salt 2½ ounces, bicarbonate of soda 1 ounce, cream of tartar 1½ ounces, water 5½ pints. Mix the meal and flour together, rub in the lard, dissolve in the malted flour mixture with enough water to make 5½ pints, and combine with it the salt, soda, etc., and make a dough. The diastase of the malt is destroyed by long heating in the oven; but the decoction brings to the dough glucose, maltose, and dextrin, which give a sweet and nutty flavour to the bread. Some bakers prefer to use **extract of malt** in the proportion of 12 to 16 ounces to the above recipe, instead of the decoction; the extract is mixed with the water. The cream of tartar and carbonate of soda assist in the aeration of the bread. It is made in one-pound loaves, which must be thoroughly baked owing to the large proportion of sugars; but an exposure for thirty-five minutes to a temperature of 430° F. is considered sufficient for the purpose.

Some of the proprietary breads contain malted wheat, barley, oats, or rye. Thus, Triagon bread contains malted rice and maize; Triticumina, malted wheat, etc.; Bermaline was formerly made of semolina, extract of malt, and various chemicals, but, owing to the irregular results obtained by bakers, it is now prepared from the company's own special meal and extract of malt. Carr's Malt Bread is prepared from a special meal and syrup; it has a nutty flavour.

Softened Wheat Bread.—Various patent breads are made without grinding the wheat at all. The process consists in soaking the grain in water until it becomes soft enough to be reduced by machinery to a thick paste, which is then partially fermented. The loaves are close and heavy, more or less pasty and sticky. Nevertheless the bread had a pleasant flavour and high nutritive value. It has not gained popularity, because the people prefer bread which is light, porous, and easily masticated.

Graham Bread.—What is known as "Graham flour" is, strictly speaking, entire-wheat meal, whence it might be supposed that bread of this name is made. Possibly entire-wheat bread is so called by some people. But Graham bread took its name from

1 "The Modern Baker and Confectioner," vol. i., p. 128.

Dr. Graham, an American, who had it made by a process similar to that for softened wheat bread. The more recent mode of manufacture is described by "The Modern Baker" (vol. i., p. 125) thus: *Bruised wheat* is soaked in lukewarm water sufficiently long to enable it to be made into dough. This is at once divided into loaves of about 1 pound, moulded, and allowed to rest for three or four hours, and then baked for one and a half hours in an oven at 400° F. No yeast is used, but the loaves rise a little owing to the expansion of the water or steam imprisoned within.

Germ Bread.—Bread made of Graham flour, decorticated or entire-wheat meal, necessarily contains the germ. But we have seen that the germ is removed from by far the largest proportion of flour on the market, for reasons which have been explained. The germ, nevertheless, is a highly nutritious substance, rich in fat and proteins, and therefore should not be rejected as useless. It contains 6·44 per cent. of nitrogen, including 0·80 per cent. of amides.[1] Taking advantage of this value, bakers have introduced another class of bread, called **germ bread**, in which a certain amount of the germ separated from other grain is mixed with fine flour at the time of making the bread.

THE GERM COMPARED WITH FINE FLOUR—PERCENTAGES.

	Germ.		White Flour.	White Flour plus 20 per cent. Germ.
	(*a*)	(*b*)		
Water	8·7	11·5	14·74 to 15·58	14·00
Proteins: Soluble ..	6·6	10·5	1·02 ,, 1·28	2·58
Insoluble	26·5	12·6	7·45 ,, 8·32	10·12
Fat	15·0	12·0	·84 ,, 1·12	3·52
Starch	10·0	30·5	69·88 ,, 71·22	60·10
Sugar and dextrin ..	23·0	9·7	2·47 ,, 3·00	5·53
Cellulose	1·7	5·9	·22 ,, ·25	·90
Mineral salts	5·4	3·9	·42 ,, 1·00	14·8

The above table shows that the dietist has reason for his desire to make use of the germ as a food, in spite of its deleterious action upon the dough. As a general rule this deleterious influence is avoided by not allowing enough time during fermentation for the enzymes and soluble proteins of the germ to exert their usual influence upon the gluten. Thus ordinary germ bread is made as follows:[2] Take 6 pounds of fine white flour, 2 pounds of germ, 3 ounces of yeast, 2 ounces of salt, and 4½ pints of water at 104° F. Make a dough, and knead it thoroughly in order to toughen it. Allow it to stand twenty minutes, cut it into loaves of about ½ pound, allow them to stand again for forty-five minutes, and bake them in an oven at a temperature of 430° F. Various

[1] Frankfurt-*Länd. Versuchs-Stat.*, 1896, xlvii. 449.
[2] "The Modern Baker and Confectioner," vol. i., p. 132.

makers of germ bread give special names to it—*e.g.*, Hovis, Daren, Opmus, Cytos, Vagos, etc.

A discussion[1] on the "Nutritive Value of Flours" arose out of the account of some feeding experiments on rats with flours of various grades, including fine white flour, entire-wheat meal, so-called "standard flour," and Hovis flour. The report of Hill and Flack showed infinitely better results when the animals were fed on flour containing cerealin and germ than on fine white flour. It was claimed that the superiority of standard and Hovis flours was due to the inclusion of the germ by increasing the percentage of protein and organic phosphorus. The writer of this article urged that the exceedingly poor results of feeding rats on fine white flour were chiefly due to the absence of cellulose. It is usually considered that cellulose in the food of rodents is a *sine qua non* of proper nutrition. Fine flour is not the food of rats, but grain is. Entire-wheat meal and so-called "standard flour" gave far better results than fine white flour, because they approximate more nearly to the composition of grain, especially in the cellulose content. Hovis flour gave infinitely better results than either, but it must not be overlooked that Hovis flour contains from 20 to 25 per cent. of germ, a proportion which far exceeds the amount of germ in entire-wheat flour or standard flour. There is no doubt whatever about the great nutritive value of the germ. What we want to know is what the superior results of feeding with germ bread and flour are due to. It cannot be due merely to the increased protein. The total protein of the grain averages 12 per cent., including 0.538 per cent. in the germ. It is evident, therefore, that the presence of the germ in standard flour and entire-wheat meal does not materially enhance the protein value. Reasons have already been given which the bakers consider sufficient for the removal of germ and cerealin from ordinary flour. But germ bread, such as Hovis, is made from flour containing 20 per cent. or more of germ, and therefore it has a somewhat higher nutritive value than bread made from entire-wheat meal, which contains only 1·5 per cent. of germ. The amount of protein in ordinary white bread varies from 4·8 to 8·69 per cent., in miscellaneous bread from 7 to 13 per cent., Vienna or French bread 8·87 per cent.; and, according to Hutchison,[2] the protein in Hovis, Daren, Cytos, and Vagos germ-breads varies from 7·7 to 10 per cent. The amount of protein in germ bread, therefore, is not so much greater than in white and entire-meal breads. If the influence of the germ on the nutrition of animals is really greater than that of ordinary flour or bread, to what is it due? Hill and Flack consider it is due to germ bread and flour containing more of the organic phosphorus compounds which are essential to the growth of animals. But this is indefinite. Moreover, it has been shown that only one-third of the phosphorus is in the form of organic compounds. The organic phosphorus

[1] *British Medical Journal*, 1911, ii., 597, 861, 949, 1137.
[2] "Food and Dietetics."

compounds are nucleo-proteins, basic proteins, nuclein, and lecithin. But I do not think the difference in the proportion of phosphorus is sufficient to account for the superior results obtained by feeding rats on flour containing 20 per cent. of germ. In addition to the proteins and lecithin, germ and cerealin contain a considerable amount of amino-acids and enzymes. The enzymes in the food are of extreme importance to growing animals, but it is important they should be in an active condition. It should be observed that they are readily destroyed by heat. Animals fed on fresh raw milk, in which the enzymes are active, increase in weight more rapidly than animals fed on boiled milk. The same results may be expected from experiments with cooked and uncooked meal containing germ. When the meal is cooked the enzymes are destroyed. But the amino-acids are as important as the enzymes to cellular activity, and they form 0·8 per cent. of the germ. Among the most important are asparagin, leucin, and tyrosin. Tyrosin is more abundant in brown than in white flour, and it is derived from the germ and cerealin. The brown colour of bread made from entire meal, or even from mixture of bran and white flour, is due to the action of tyrosin on the gluten. Asparagin and leucin are also more abundant in entire-wheat meal than in white flour, and still more abundant when the flour is composed of 20 per cent. of germ and 80 per cent. of other flour. What influence these amino-acids have on animal growth is not quite clear. But as stimulants of cell formation their action is well known. Every time the baker uses potato leaven he stimulates the growth of yeast cells by asparagin. The germ and malt-culm used as yeast foods by the baker owe their stimulating action to the presence of amino-acids in the germ and acrospire respectively. As stimulants of enzymic action in the alimentary canal they are also well known, the digestion of food being more rapid and complete in their presence than in their absence. It is therefore probable that the greater amount of these amino-acids in bread made from flour containing a large percentage of germ accounts for the superior results obtained by feeding animals with such flours. Moreover, these experiments tend to show the advantage which might accrue from feeding children largely upon bread made from flour containing an excess of germ. But our knowledge of this subject is in a nebulous condition, and requires to be settled by analytical data and experiments on human beings.

Rye Bread.—For the sake of convenience rye bread is introduced into this section. It is largely eaten in many countries owing to the more extensive cultivation of this cereal because of climatic conditions, the formation of the soil, and other causes. It is stated that Germany, with a population of 60,000,000, produces only 16,000,000 quarters of wheat annually ; but the production of rye amounts to 42,000,000 quarters per annum, or two and a half times as much as wheat. In Germany and other countries rye-milling has become a great industry, and the meal or flour is sold in various grades of fineness. Rye bread is also sold of

various qualities, and the best rye bread is made of a mixture of rye and wheat flours. They are as follows—**Knüppel**: bread or rolls used by the Imperial Family for breakfast; they are usually small cakes or doughnuts made of a mixture of rye and wheat flours. **Pumpernickel**: the typical dark rye bread of Germany. The loaves are made by kneading rye meal into dough with boiling water. It ferments spontaneously, but the process is hastened by kneading with the mass some dough from a previous batch, as in the ancient custom of leavening wheaten bread. The loaves are usually about 6 pounds in weight, and require baking for three or four hours. **Schwartzbrod** of Rhenish Prussia is a very *black bread*, made from a coarser flour than that used for pumpernickel. **Kommisbrod**, or soldier's bread, is another quality made from a mixture of rye meal and rye flour. It is fermented by means of a "sponge" left from the previous baking. The loaves usually weigh $1\frac{1}{2}$ kilos, or $3\frac{3}{10}$ pounds. **Hausbrod** or **Tafelbrot** is a whity-brown bread made from a mixture of wheat and rye flours. Like other rye breads, however, the loaves have a dark red crust; they usually weigh $3\frac{1}{2}$ kilos, or $6\frac{1}{2}$ pounds. Rye bread was formerly a common article of food in England. It is now extensively used in Belgium, Holland, Germany, Russia, and other countries in the North of Europe, especially where poverty most prevails and agriculture is least advanced. In some of these countries it forms the staple food of the people, occupying the same position that wheaten bread does in England and America.

Rye bread falls little short of the nutritive value of wheaten bread. But it is dark-coloured, and acid, owing to the development of lactic and other acids by the mode of fermentation. Its colour and taste render it unpleasant or unpalatable to those who are not accustomed to it. It is apt to occasion diarrhœa, but custom soon overcomes this defect. This property, however, renders it a useful dietetic article for those who suffer from habitual constipation. All cereals are liable to become the seat of a parasitic fungus, which gives to the grain deleterious properties, but none are so prone to be attacked as rye. The special fungus which attacks rye is *Claviceps purpurea*, which causes the grain to swell up and turn black, or become ergotized; the seed is, in fact, replaced by a homogeneous mass charged with an oily fluid, which develops the herring-like odour of propylamine when liquor potassæ is added to ergotized flour. On account of the excessive growth of the grain when thus affected, it should be sifted from the unaffected seed, and unless this is done serious consequences may arise from the consumption of the crop. At sundry times the inhabitants of various districts on the Continent have been stricken with fatal illness from this cause. Two classes of symptoms are produced, called the *convulsive* and *gangrenous* forms of ergotism. In the first the phenomena consist of weariness, giddiness, twitchings or painful cramps of the extremities, formication, loss of sensibility, dimness of sight, voracious appetite,

COMPOSITION OF BREAD—PERCENTAGES.[1]

Breadcrumb made from—	Water.	Protein (N ×6·25).	Fat.	Carbo-hydrate.	Ash.	Heat of Combustion: Calories per Gramme.	
						Determined.	Calculated.
Standard patent flour (sample No. 53)	44·13	7·75	·90	46·90	·32	2·450	2·503
Entire-wheat flour	49·16	7·45	1·14	41·73	·52	2·166	2·291
Graham flour	47·20	7·76	1·27	42·82	·95	2·060	2·367
Standard patent flour (sample No. 77)	44·89	7·58	·88	46·35	·30	2·417	2·468
Second patent flour	42·10	7·75	·72	49·16	·27	2·492	2·581
First patent flour	44·40	7·48	·71	47·14	·27	2·384	2·480
Bread, composite sample	38·50	8·35	·14	52·56	·45	2·598	2·705
	38·10	8·36	·12	52·99	·43	2·601	2·723
	37·50	8·40	·10	53·57	·43	2·637	2·746
	34·64	6·96	·11	57·73	·56	2·713	2·839
	36·25	8·51	·10	54·70	·44	2·690	2·800

[1] "Bread and Bread-making," Bulletin 101, U.S. Department of Agriculture.

COMPOSITION OF VARIETIES OF BREAD—NUTRIENTS PER CENT.

	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Salt.	Ash.	Authority.
Wheaten bread :								
Vienna or French bread	38·71	8·87	1·06	53·72	·62	·50	1·19	Bureau of Chemistry, Bulletin 13, part ix., U.S. Department of Agriculture.
Home-made bread	33·02	7·94	1·95	56·75	·24	·50	1·05	
Graham bread	34·80	8·73	2·03	53·40	1·13	·60	1·59	
Miscellaneous bread	34·41	7·60	1·48	56·18	·46	·49	1·00	
Rolls	27·98	8·20	3·41	59·82	·60	·69	1·31	
,, home-made	36·12	7·10	2·14	55·53	·26	·50	1·00	
White bread : Minimum	26·39	4·81	·10	39·75	·33	—	·84	König.
Maximum	47·90	8·69	1·00	64·45	·90	—	1·40	
Best, Average	38·51	6·82	·77	43·34	·38	—	1·18	
Coarse, Average	41·02	6·23	·22	50·72	·62	—	1·09	
	40·00	6·50	1·00	51·50	—	—	1·00	Rubner.
	37·00	8·10	1·60	51·00	—	—	2·30	Smith.
	40·00	8·00	1·50	49·20	—	—	1·30	Parkes.
High-class	35·00	8·00	·75	54·30	—	—	·50	Wiley.
High-grade patent flour	32·90	8·70	1·40	56·50	—	—	·50	Atwater and Bryant, Bulletin 28, U.S. Department of Agriculture.
Regular patent flour	34·10	9·00	1·30	54·90	—	—	·70	
Baker's flour	39·10	10·60	1·20	48·30	—	—	·90	
Low-grade flour	40·70	12·60	1·10	44·30	—	—	1·30	
Cheap grade	33·20	10·90	1·30	53·60	—	—	1·00	
containing butter	32·20	7·90	1·10	57·70	·40	—	1·10	
,, cream	33·20	9·80	·90	55·00	·20	—	1·10	
,, milk	36·50	9·60	1·40	51·10	—	—	1·40	
Vienna	34·20	9·40	1·20	54·10	·50	—	1·10	
Quaker	35·80	8·30	1·10	53·70	·30	—	1·10	
New England	36·60	9·10	1·20	52·10	—	—	1·00	
Home-made : Minimum	29·80	6·80	·40	47·60	·10	—	·40	
Maximum	40·40	11·00	3·50	58·00	·30	—	2·00	
Average	35·00	9·10	1·60	53·30	·20	—	1·00	

Miscellaneous : Minimum	25·80	7·00	·00	42·00	·30	—	·60	
Maximum ..	49·10	13·90	3·70	61·50	·90	—	3·00	
Average	35·60	9·30	1·20	52·70	·50	—	1·20	
Toasted Bread : Minimum .. .	15·30	10·60	·60	56·70	—	—	1·40	
Maximum . ..	28·60	12·80	3·20	67·10	—	—	2·00	
Average	24·00	11·50	1·60	61·20	—	—	1·70	
Torrified bread[1]	—	10·50	1·20	85·50	1·00	—	1·80	
Zwiebach, Average	5·80	9·80	9·90	73·50	—	—	1·00	Ditto.
Rolls : Plain	25·20	9·70	4·20	59·90	·30	—	1·00	
Water	32·60	9·00	3·00	54·20	—	—	1·20	
French	32·00	8·50	2·50	55·70	·60	—	1·30	
Vienna	31·70	8·50	2·20	56·50	·40	—	1·10	
Large and cheap	29·40	9·40	·80	59·40	—	—	1·00	
All analyses	29·20	8·90	4·10	56·70	·60	—	1·10	
Doughnuts	18·30	6·70	21·00	53·10	·70	—	·90	
Brown bread	41·02	6·23	·22	50·82	·62	—	1·09	Bauer.
	45·00	6·30	1·20	46·30	—	—	1·20	Rubner.
	41·02	6·23	·22	50·82	·62	—	1·09	König.
Whole meal	41·15	11·33	·32	45·86	—	—	1·34	Hassall and Clayton.
Brown bread : Minimum	40·00	5·00	1·20	43·60	—	—	1·90	
Maximum	47·00	5·80	2·40	50·70	—	—	2·20	
Average	43·60	5·40	1·80	47·10	—	—	2·10	
Whole-wheat : Minimum	33·20	8·10	·40	37·20	—	—	·80	
Maximum ..	51·00	11·70	2·70	56·20	—	—	1·90	Atwater and Bryant, Bull. 28.
Average	38·40	9·70	·90	46·90	1·20	—	1·30	
Graham bread : Minimum ..	27·80	6·80	·40	38·60	·60	—	·70	
Maximum ..	42·40	10·90	3·80	59·10	1·80	—	3·00	
Average	35·70	8·90	1·80	52·10	1·10	—	1·50	
Gluten bread	38·20	9·30	1·40	49·80	—	—	1·30	
Barley bread	12·39	5·90	·90	71·00	5·63	—	—	Blyth.
Maize : Johnny cake	38·90	7·90	4·70	46·30	—	—	2·20	Atwater.

[1] Tarlton, *British Medical Journal*, i. 1628, 1900.

COMPOSITION OF VARIETIES OF BREAD—NUTRIENTS PER CENT.—*Continued.*

	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Salt.	Ash.	Authority.
Rye bread : Minimum	35·49	3·49	·10	40·03	·29	—	·86	König.
Maximum	48·57	9·22	·83	55·68	·39	—	3·08	
Average	44·02	6·02	·48	47·85	·30	—	1·31	
Minimum	20·60	6·40	·10	45·60	·10	—	·60	Atwater and Bryant.
Maximum	44·00	11·10	1·40	65·80	1·00	—	2·70	
Average	35·70	9·00	·60	53·20	·50	—	1·50	
Black bread	36·90	9·60	·60	48·90	—	—	4·00	
Entire grain	50·70	11·90	·60	35·90	1·20	—	·90	
Proprietary breads :								
White : Neville's	37·50	7·20	—	54·60	—	—	·70	Hutchison's "Food and Dietetics" (Protein = N × 5·7).
Maltina	44·50	5·90	—	48·90	—	—	·70	
Vis Vita	40·40	7·50	—	51·60	—	—	·59	
Kermode's	46·80	5·70	—	46·80	—	—	·58	
Triagon	39·00	6·40	—	53·90	—	—	·70	
Brown : Cyclone	47·90	7·10	—	43·60	—	—	1·40	
Opmus	43·00	6·50	—	49·20	—	—	1·30	
Seatree's	43·40	6·80	—	48·70	2·20	—	1·10	
Manhu	42·60	7·20	—	49·90	—	—	1·30	
Neville's	41·50	8·00	—	49·30	—	—	1·20	
Malted : Maltina	45·10	7·00	—	46·00	much	—	1·90	
Bermaline	38·00	8·10	1·70	50·30	—	—	1·90	
Triticumina	43·60	7·30	—	47·60	3·50	—	1·50	
Germ : Hovis	45·00	9·90	1·60	42·30	—	—	1·20	
Cytos	42·30	8·10	—	48·30	—	—	1·30	
Daren	46·60	7·90	—	44·50	—	—	1·00	
Vagos	46·00	7·70	—	45·10	—	—	1·20	

yellow countenance, convulsions, and death. In the other form there is also a voracious appetite, formication, coldness of the extremities, insensibility, followed by dry gangrene of the extremities.

Barley Bread was formerly a common food in England, but has been little used for centuries. It is made in a similar manner to rye bread. It has a sweetish taste, but is less palatable and nutritious than wheaten bread. A recipe formerly much used by the Cornish miners and labourers of many districts was as follows: 44 pounds of barley meal were mixed with salt, water, and yeast, divided into eight loaves, and thoroughly baked in a hot oven. Such bread, however, was heavy, and many people lightened it by making a sponge of wheat flour and mixing the former with it; others added rice or potato, sufficient time being allowed for leavening.

Rye and Rice in the proportion of four parts of rye meal and one of rice, fermented with yeast and salt, forms an excellent bread.

Oat Bread.—Dr. R. Pierson recommended the following: Mix together equal parts of oatmeal and seconds flour, one-fourth the amount of boiled and mashed potatoes; knead into a dough with water, salt, and yeast; make into loaves, and bake in the usual way. The Scotch peasantry frequently leaven their bread with sour leaven, even the oat cakes being made with it, by which means it becomes more spongy and easy of digestion.

Rice Bread is made of equal parts of rice flour and seconds wheat flour, fermented with yeast in the usual way. According to another authority, rice is boiled until it is soft, and then mingled with an equal weight of wheat flour and mashed potato, kneaded into a dough with yeast, salt, and warm milk, and baked in the usual way.

Indian Corn Bread is made of maize meal with a leaven formed of one-fifth its weight of wheat flour. It is made into a dough and allowed to ferment half an hour, and then baked.

Buckwheat Bread is made in the following manner: The meal is gradually added to boiling water, and mixed by constant stirring until a batter is formed. Some salt is then added, and the mixture boiled. It is then baked like pancakes, or is mixed with wheaten flour and yeast, well kneaded, allowed to ferment for two hours, and baked like ordinary bread.

Bean or Pea Bread is made by soaking the meal in water before using it for making bread. The water is drained away; the paste is then mixed with salt and yeast, fermented, and baked. Better bread is made by combining the paste with an equal quantity of wheat flour, kneading with salt and yeast into a dough, and allowing time to ferment before baking it.

Potato Bread is made in a similar way with mashed boiled potatoes.

Bibra showed by numerous analyses that the composition of bread and its reaction vary considerably, which is partly owing to the variation in the capacity to retain moisture, and partly to differences in the composition of the flour. White bread usually has a faintly acid reaction, but some are neutral—*e.g.*, St. Petersburg bread; that of rye bread is acid. It is usual to reckon the protein content of bread as equivalent to $N \times 6{\cdot}25$ per cent.; but the nitrogen is not all in the albuminoid form. According to Rubner, only 72 per cent. of the nitrogen exists as protein; he therefore estimates the protein of bread as $N \times 5{\cdot}72$ per cent. The

carbohydrates in bread are not entirely starch; Atwater found as follows:

CARBOHYDRATES IN BREAD—PERCENTAGES.

	Sugar.	Dextrin.	Starch.
White bread	2·3	4·2	48·2
Graham bread	3·2	3·1	40·8
French rolls	2·9	2·8	48·6
Home-made biscuit ..	2·7	5·5	41·5
Maryland biscuit	3·9	2·8	52·2
Sugared bun	7·9	3·2	47·0

The crust and crumb of bread are naturally different in composition. The following table is by Barral:[1]

CRUST AND CRUMB OF BREAD—NUTRIENTS PER CENT.

	Crust.	Crumb.
Water	17·15	44·45
Protein, soluble	5·70	·75
,, insoluble	7·30	5·93
Sugar and dextrin	4·88	3·79
Starch	62·58	43·55
Fatty matters	1·18	·70
Ash	1·21	·84

According to König, the sugar and dextrin in wheaten bread varies from 0·82 to 4·47 per cent., with an average of 2·37 per cent. in white bread, and 2·13 per cent. in brown bread; the same authority gives the percentage of sugar and dextrin in rye bread as varying from 1·23 to 4·55, with an average of 2·54 per cent.

Analysis of Bread, Biscuits, and Farinaceous Foods.—The proportion of *water* is ascertained by drying a known quantity over a water-bath until it ceases to lose weight; the loss represents the moisture. The *ash* is estimated by incinerating the dried substance after estimating the amount of water. The amount of *nitrogenous matter* is then ascertained by finding the total nitrogen in a small definite quantity by the Kjeldhahl method: $N \times 5{\cdot}7 =$ protein. The *carbohydrate* is ascertained by difference, or more particularly by the methods detailed for the analysis of flour. Cane and grape sugar are differentiated as in the case of flour; and cane and milk sugar can be determined by the method recommended by Stokes and Bodmer,[2] thus: A solution containing the soluble carbohydrates is used, as in the analysis of flour (*q.v.*), and tested with Pavy's ammonio-cupric solution, 10 c.c. of which equal 0·005 gramme of glucose. The solution is well diluted, and put into a burette having a tube and screw clip. (*a*) Forty c.c. of Pavy's solution is put into a flask and boiled, and the sugar-containing fluid run in until the colour disappears. (*b*) Another portion of the sugar solution is boiled for ten minutes with 2 per cent. of *citric acid*; this completely inverts the cane-

[1] *Cf.* Hutchison's "Food and Dietetics," p. 199.
[2] *Chemical News*, 1885, ii. 193.

sugar, but does not affect the lactose. The liquid is then cooled, neutralized with ammonia, and titrated with Pavy's solution as before. We have thus—(*a*) First reading, due to milk-sugar alone ; (*b*) second reading, due to milk-sugar and glucose (inverted cane-sugar) ; (*c*) the difference between the two is due to cane-sugar. Milk-sugar has only 52 per cent. of the reducing power of glucose, which must be allowed for in the calculation.

The *ash* of bread should not exceed 3 per cent., and the excess over that in flour is due to common salt. An excess of ash in bread over 3 per cent. would be proof of adulteration, which might be due to chalk, gypsum, or magnesium salts, added to improve colour or increase the weight. *Alum* normally exists in bread and flour as *silicate of alumina*, even in excessive quantities ; but it is added to bread to check excessive fermentation, which gives rise to glucose, and causes a somewhat unpleasant taste and discoloration. It therefore improves the appearance, flavour, and porosity, of the bread. It is used in proportions varying from 15 to 40 grains in a four-pound loaf, and even 100 grains have been discovered. Its presence is shown by the **colour reaction** with logwood. For this purpose a *freshly-made* tincture is used ; it is made by macerating 5 grammes logwood in 100 c.c. rectified spirit ; 5 c.c. of the tincture is then mixed with 5 c.c. of a 15 per cent. solution of carbonate of ammonia and 1 ounce of distilled water. A piece of breadcrumb is soaked in this solution for five minutes, then drained and gently dried. The presence of alum is shown by the bread receiving a colour which varies from lavender to violet, in proportion to the amount of alum in it. If no alum is present, the bread is first bright red, and then changes to a dirty brown. This, however, may be insufficient, and a quantitative analysis be required ; but the latter is tedious and difficult. It is usually considered that if a four-pound loaf contains more than 10 grains, the alum has been added. But a pure flour may contain that amount ; therefore the amount of silica must be determined, for the normal alum is taken up as silicate of alumina, and if the alum greatly preponderates over the silica, it is a reasonable presumption that the alum has been fraudulently added.[1]

Cakes.

Cakes are mixtures of flour with eggs, butter, sugar, and various flavourings, such as currants, raisins, ginger, and other materials. Considerable variation occurs in the composition, shape, and appearance, of cakes, according to the ingenuity of the cook ; but the following represents the average composition of many which have been examined : Water 30·27, protein 7·19, fat 3·83, carbohydrate 56·71, salt 0·72, ash 1·29, per cent.

The table on p. 430 of the composition of cakes is from Atwater and Bryant.

The complex character of cakes permits of various kinds of adulteration, especially by using flavouring essences, colouring matters, and preserved eggs. The use of aniline dyes for colouring is especially to be deprecated, as being detrimental to the health of the consumer. The consumption of large quantities of such fancy articles as sweet cakes is never conducive to a healthy appetite for the ordinary articles of food. On the other hand, they cloy the appetite, and render necessary the use of various condiments to stimulate it. This is not as it should be. Nor are articles of food in the manufacture of which much fat is used so easily digested as those from which fat is nearly absent. All cakes have not a superabundance of fat, but the mode of their manufacture

[1] Bell's "Chemistry of Foods."

tends to hinder digestion. The fat is rubbed into the flour, which becomes practically saturated with it. This close connection of fat with the farina prevents the digestive juices from attacking the particles of starch until such fat is separated from them. The best cakes for an invalid, when any are permitted, are madeira and sponge cakes, which are light and free from indigestible fruit, seeds, and peel. These are very nutritious, and form a good means of introducing extra nutriment into the body in a form which is usually relished by the patient. They should, however, be made from fresh eggs and butter.

CAKES—NUTRIENTS PER CENT.

	Water.	Protein.	Fats.	Carbo-hydrate.	Cellulose.	Ash.	Calories per Pound.
Baker's cake ..	31·4	6·3	4·6	56·9	—	·8	1,370
Chocolate layer cake	20·5	6·2	8·1	64·1	—	1·1	1,650
Coffee cake ..	21·3	7·1	7·5	63·2	·4	·9	1,625
Cup cake ..	15·6	5·9	9·0	68·5	·3	1·0	1,705
Drop cake ..	16·6	7·6	14·7	60·3	·1	·8	1,885
Frosted cake ..	18·2	5·9	9·0	64·8	—	2·1	1,695
Fruit cake ..	17·3	5·9	10·9	64·1	—	1·8	1,760
Gingerbread ..	18·8	5·8	9·0	63·5	·9	2·9	1,670
Sponge cake ..	15·3	6·3	10·7	65·9	—	1·8	1,795
Miscellaneous :							
Minimum ..	12·0	5·1	6·7	53·6	—	1·1	1,380
Maximum ..	33·2	7·1	14·7	64·7	—	2·3	1,940
Average ..	21·9	5·9	10·6	60·1	—	1·5	1,647
Sugar cookies..	8·3	7·0	10·2	73·2	1·1	1·3	1,920
Molasses cookies	6·2	7·2	8·7	75·7	—	2·2	1,910
Ginger snaps ..	6·3	6·5	8·6	76·0	·7	2·6	1,895
Lady-fingers ..	15·0	8·8	5·0	70·6	·2	·6	1,686
Wafers :							
Miscellaneous	6·6	8·7	8·6	74·5	·4	1·6	1,910
Vanilla ..	6·7	6·6	14·0	71·6	·3	1·1	2,045

Cheap cakes are not usually made from fresh eggs and butter, but are often made with preserved or pickled eggs and butter substitutes. The eggs are added to the cake in order to moisten and leaven the material. They should not be stale. The whites are usually beaten to a stiff froth ; the yokes are stirred up with the flour and other materials, and the egg-white added last of all. When cost is not an object, the fat should always consist of butter, but this is generally wholly or partly replaced by neutral fat, lard, or oil. The fruit usually consists of currants or sultanas, and the peel of orange, lemon, or citron, cut into shreds. The following table, compiled from details in "The Modern Baker and Confectioner," shows the composition of cakes sold at the prices stated. Some of them are coated with **royal icing**, made of finely powdered sugar, white of eggs, and acetic acid, which is moulded in various designs, and dries white and hard.

THE MANUFACTURE OF VARIOUS KINDS OF CAKE.

Kind of Cake.	Sale Price per Pound.	Butter.	Lard	Oil.	Flour.	Eggs.	Milk.	Sugar.	Glucose.	Currants.	Sultanas.	Peel.	Essence.	Other Substances.
	Pence.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Pints.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.		
Madeira	12	2	—	—	2¾	2½	½	2⅔	—	—	—	—	—	Zest of lemon.
,, ...	12	2	—	—	3	3	—	2¼	—	—	—	—	—	Ditto.
,, ...	8	1½	½	—	5	2	2	2½	—	—	—	—	Orange	Soda bicarb., ¾ oz.
,, ...	6	1¼	¼	—	5	1¼	2½	2½	—	—	—	—	Ditto	Cream of tartar, 2 ozs.; soda bicarb., 1 oz.
Genoa	14	2	—	—	2½	2¾	—	2	—	—	—	—	Vanilla or caraway	No. 1 powder, ¼ oz.
,, fruit ..	12	3	¼	—	4½	4½	—	3	—	2	3	1½	Rose-water	Almonds, 12 ozs.; No. 1 powder, 1 oz.
Fruit cake ..	12	5	—	—	7½	8	—	5	—	—	6	1½	—	—
,, ,, ..	6	2	4½	—	11	6	3¼	7	—	9	4	1½	Egg colouring	Almonds, 8 ozs.; cream of tartar, 1 oz.; soda bicarb., ½ oz.
Cherry slab ..	10	4¼	3	—	1¼	5	2¼	6¾	—	—	3	2½	Noyau	Small cherries, 7 lbs.; No. 1 powder, 1½ ozs.
Sultana slab ..	8	3	4	—	11	5	2½	6¾	—	—	7½	3	Rum; egg colouring	No. 1 powder, 1½ ozs.
Rice slab ..	6	—	6½	—	10	4	1½	8	⅛	—	—	—	Lemon; egg colouring	Ground rice, 1 lb.; No. 1 powder, 1½ ozs.
Fruit slab ..	3	—	3½	1	17½	—	8½	9	—	7	—	1	Ditto	Salt, 3 ozs.; baking-powder, 8 ozs.
Lemon madeira	3	—	3½	1½	14	—	8½	10	⅝	—	—	—	Ditto	Ground rice, 2 lbs.; corn-flour, 2 lbs.; salt, 3 ozs.
Christmas cake	8	2	2	—	14	6	6	—	6	12	6	2	—	Mixed spice, 2 ozs.

Biscuits.

Biscuits consist for the most part of an unleavened dough composed of flour, milk, fat, sugar, and sometimes eggs or other ingredients, which is baked in thin masses and highly dried, so that they can be cracked with the teeth. Biscuits are therefore not plain bread. The protein content is good, and consists, besides that of flour, of milk and egg-proteins. The amount of fat varies with the proportion used in the compound. The carbohydrates naturally form a large proportion of biscuits, consisting of starch, sugar, and dextrin. The ash varies with the amount of common salt used in their manufacture. Examples of their composition are given in the table on p. 433.

The composition of biscuits naturally varies with the amount of the components, and it would therefore be impossible to give a definite statement of their composition. The protein varies with the amount of milk or eggs used, from 6 to 15 per cent., and the fat in like manner from 1·5 to 14·0 per cent. The carbohydrates vary from 50 to 75 per cent., and consist of starch, dextrin, and sugar; Atwater found:

	Sugar.	Dextrin.	Starch.
Home-made biscuit.. ..	2·7	5·5	41·5
Maryland biscuit	3·9	2·8	52·2
White bread	2·3	4·2	48·2

The amount of sugar in fancy biscuits may be very great. Bauer found 32·3 per cent. in foreign biscuits, and 17·02 per cent. in English-made biscuits. The mode of cooking influences the percentage of dextrin. Biscuits are submitted to such a temperature that they become dry throughout, the heat favouring the escape of moisture and transforming some of the starch into higher or lower dextrins. As a rule, hand-made biscuits are made of a soft flour containing 8 or 9 per cent. of gluten and a high percentage of starch; it is chosen for the ductility of the gluten, as in English wheat, most Scotch and French wheats. **Hard Biscuits** are made without the addition of any agent of "aeration," but they "rise" a little in the oven owing to the expansion of starch and generation of steam. When finished, biscuits are thin and hard, or soft and plump, according to the manipulation of the dough. Ship and cabin biscuits are good examples of the hard variety. They consist of a simple mixture of dressed seconds or household flour, salt, and water. The dough is rolled and cut by machinery. When finished they are stored in a warm, dry room for a week or two to "cure" them. By this means they become uniformly dry and hard, able to resist atmospheric moisture to a considerable degree, which prevents them from becoming mouldy or maggoty during

COMPOSITION OF VARIOUS KINDS OF BISCUITS—NUTRIENTS PER CENT.

	Water.	Protein.	Fat.	Starch and Dextrin.	Sugar.	Cellulose.	Ash.	Authority.
Biscuits : English-made	7·47	7·18	9·28	58·08	17·02	·16	·83	Bauer.
Coarse wheaten	1·18	13·31	3·80	73·96	7·14	·25	1·00	
Fine wheaten	10·07	11·93	7·47	32·39	36·38	·75	1·14	
Plain	8 to 12	15·00	—	70 to 75	5 to 10	—	—	Parkes.
	8·00	15·60	1·30	73·40		—	1·70	
Home-made	32·90	8·70	2·60	47·00	2·70	·70	·50	Atwater and Bryant, Bulletin 28, U.S. Department of Agriculture.
Maryland	24·60	8·40	5·60	55·00	3·90	1·30	1·30	
Soda	22·90	9·30	13·70	52·60		—	1·50	
Crackers : Boston	7·50	11·00	8·50	71·10		·80	1·90	
Butter	7·20	9·60	10·10	71·60		·40	1·50	
Cream	6·80	9·70	12·10	69·70		·60	1·70	
Egg	5·80	12·60	14·00	66·60		·40	1·00	
Flatbread	9·80	14·90	·50	73·60		—	1·20	
Graham	5·40	10·00	9·40	73·80		1·50	1·40	
Miscellaneous	7·10	10·20	8·80	72·40		·40	1·50	
Oatmeal	6·30	11·80	11·10	69·00		1·90	1·80	
Oyster	4·80	11·30	10·50	70·50		·20	2·80	
Pilot	8·70	11·10	5·00	74·20		·50	1·00	
Pretzel	9·60	9·70	3·90	72·80		·50	4·00	
Saltine	5·60	10·60	12·70	68·50		·50	2·60	
Soda	5·90	9·80	9·10	73·10		·30	2·10	
Water	6·40	11·70	5·00	75·70		·40	1·20	
Fig biscuits	17·90	4·60	6·60	69·80		1·70	1·10	
Ginger-snap	6·30	6·50	8·60	76·00		·70	2·60	
Lady-fingers	15·00	8·80	5·00	70·60		·20	·60	
Macaroons	12·30	6·50	15·20	65·20		1·10	·80	
Wafers	6·60	8·70	8·60	74·50		·40	1·60	
Gluten biscuit and bread	38·20	9·30	1·40	49·80		—	1·30	
White-bread biscuit	35·20	8·00	1·40	54·30		·30	1·10	
Zwieback	5·80	9·80	9·90	73·50		—	1·00	

a long voyage; indeed, if properly made, they will keep good for years. By this mode of treatment, not only is the water used in the manufacture driven off, but also some of that normally existing in the flour. The action of heat upon starch is well exemplified in biscuit-making. *Dry heat* converts some of the starch first into soluble starch, and then into dextrin. *Moist heat* causes the starch granules to swell and burst the cellulose envelopes, by which process it is said to be gelatinized; this is well shown in making "starch" (as a mixture of boiling water and starch is called) for domestic purposes. But this change or gelatinization of starch occurs at different temperatures according to its origin, and is lower then the temperature of boiling water. Thus, Sykes[1] found that the starch of oats is gelatinized by a temperature of 186° F.; that of barley, wheat, rye, and rice, at 176° F.; maize at 167° F.; and potato at 149° F. On the other hand, starch is converted into dextrin by a dry heat of 400° F. (200° C.). Gelatinized starch is more easily affected by diastatic enzymes, but dextrin is already considerably advanced towards the saccharine form of carbohydrate.

Biscuit-making.—The manufacture of biscuits is carried out on a large scale by some firms. The flour, properly blended, is mixed in a special mixer with water, milk, etc., into dough. It is then put through a machine, called the *brake*, which consists of endless felt passing between two iron rollers; by this means the dough is rolled into sheets of the required thickness, and well dusted to prevent its adhesion. The sheets of dough are then passed to a cutting machine, where the biscuits are cut and stamped. They are put upon trays and passed to the oven, where they move along at a uniform speed by means of an endless chain, and emerge at the other end properly cooked. The duration of heating is usually twenty or twenty-five minutes, but varies with the variety. Some biscuits are baked in an atmosphere charged with steam or a fine spray of water, which gives them a glossy appearance when finished. Others are coated with sugar, chocolate, etc. It would take us too far into the intricacies of the trade to go into all these details, but a few points will be mentioned.

Cheese Biscuits and **Water Biscuits** are made in a manner similar to the ship's biscuits given above. Some cheese biscuits, however, contain a considerable amount of fat, and others are aerated by the addition of 8 or 10 ounces of yeast to a sack of flour.

Cupped Biscuits are richer than the former; they are made of a soft, fine white flour, with eggs, butter, lard, sugar, and milk or water, and a little carbonate of ammonia to aerate them. They are short, crisp, and very dry. The most common variety are **Cracknels.** They are first boiled and then baked at a high temperature; the great heat volatilizes the ammonia and moisture, and by their expansion causes the substance to assume a light and spongy substance.

[1] "Principles and Practice of Brewing," p. 70.

Abernethy's Biscuits, supposed to have been originally made on the recommendation of the famous physician, consist of French flour, sugar, salt, butter, and lard. They are very short, not unlike short-bread, because of their richness in fat.

Oliver's Biscuits consist of flour, sugar, butter, and milk ; they are also called Bath Olivers. Two kinds are made : those fermented with yeast, and an unfermented kind mixed with eggs, milk, and water.

Shorts consist of flour with one-eighth its weight of lard rubbed in, mixed with water, salt, ammonia, and yeast. The addition of caraway converts them into **Seed Biscuits**.

Parleys, or Parliament Biscuits, consist of flour, ground caraway seeds, carbonate of soda, and treacle or golden syrup. When baked they are hard, crisp, and retain this condition if kept in a closed vessel.

Gingerbread consists of flour, sugar, butter, eggs, and treacle or golden syrup. It is flavoured with ground ginger or mixed spice, and sometimes aerated by the addition of ammonia and tartaric acid. The biscuits are hard and crisp when freshly baked, and retain this condition if covered from the air ; otherwise they absorb moisture and become soft. **French Parkin** is similar in composition to gingerbread, but is lighter and made in larger pieces. **Yorkshire Parkin** is also similar to it, but contains oatmeal. **Scotch Parkin** consists of equal parts of soft flour and medium oatmeal, combined with carbonate of soda, lard, sugar, ginger, or other spice, and treacle or golden syrup.

Rusks are practically toasted or " torrified " bread. They were originally called " tops and bottoms," because they consisted of the halves of stale buns, toasted so that each side was equally brown. The tops were therefore round on one side and flat on the other ; the bottoms were of the same thickness all over. English rusks are now made from a special dough, for which " The Modern Baker " gives the following recipe : Make a leaven by mixing together 1 pint of milk and 1 pint of water at 100° F., 4 ounces of sugar, 4 ounces of compressed yeast, and 8 ounces of flour ; let them be well beaten together, and allowed to stand for twenty minutes in a warm place, during which time the mixture will rise and fall. Next take 4 pounds of flour, 4 ounces of sugar, 8 ounces of butter or lard, ½ ounce of salt, and three eggs ; mix them all together, and make them into a dough with the preceding mixture. Allow to stand fifty minutes ; divide into flat pieces 1 inch thick ; bake them and cut them into squares. They are afterwards stored for two days, then trimmed, divided horizontally, and toasted in a warm oven until they are brown all over. German and Dutch rusks are similar, but they are mixed entirely with milk and fat. **Zwiebach** is practically the same thing, and is much recommended for dyspeptics.

Pulled Bread.—The crumb of a new loaf is *pulled out* in pieces, and baked in a hot oven until the pieces are crisp ; they are after-

wards put into a drying oven for three or four hours to drive off all moisture. This constitutes a very digestible form of bread, and is very well adapted for persons with gastric ailments.

Gluten Bread and Biscuits.—Gluten bread can be made from ordinary flour thus: A piece of dough is washed in a pail of water until it is free from starch, by alternately pulling and squeezing its substance. The mass is then divided into small pieces weighing about 2 ounces, kneaded to express any excess of water, placed in a greased covered tin, and baked in a temperature of 360° to 380° F. It is, however, unnecessary to prepare gluten in this manner every time bread or biscuits are made, since gluten flour is an article of commerce. Respecting the proportion of carbohydrates, etc., in commercial gluten flour, as well as in the bread, the reader is referred to the Composition of Flour. The following recipe for making gluten bread and biscuits is from "The Modern Baker and Confectioner"[1]: 18 ounces of gluten flour is mixed with ¾ ounce of salt, 12 ounces of butter, two eggs, and 1¾ pints lukewarm water. Yeast is unnecessary. The dough is allowed to lie for half an hour, then cut into pieces weighing 3 ounces, rolled and kneaded, placed on a greased tin or dish, covered over, and baked for two hours at a temperature of 380° F. The cakes should not be touched until they are quite cold; the exterior is then hard, but the interior is stringy and tough. They are therefore cut into thin slices, and toasted until they are quite dry and crisp. They are somewhat insipid, but the flavour may be improved by sprinkling them with salt before they are toasted.

Bran Biscuits are made by mixing together 1 pound of prepared bran, ½ pound of gluten flour, a little salt, and water to make a firm dough.[2]

Almond and Gluten Biscuits are similarly made. Mix together 2 pounds gluten flour, ¼ ounce bicarbonate of soda, ½ ounce cream of tartar, and sift them; mix with it 3 pounds of fine almond meal, and make it into a stiff dough with 2 pints of milk and water or milk. It may be sweetened by the addition of saccharin, saxin, or dulcin, to the milk, or the same may be flavoured with vanilla, ginger, or other essence. Allow the dough to remain half an hour. Cut it into biscuits, and bake at a temperature of 400° F.[3] It is necessary to guard against the purchase of "almond" drops or biscuits made of ordinary wheat flour, eggs, butter, and almond flavouring, especially when almond biscuits are desired for diabetics, because of the carbyhodrates.

Almond Cake.—A recipe for this, containing 1 pound of almond meal, 12 ounces of butter, and twenty eggs, is also given by the same authority.[4] A smooth paste is made of the yokes of the eggs and almond meal; into this the butter is "worked" together with the whites of eight eggs; finally, the white of twelve eggs is beaten to a froth and mingled lightly with the foregoing paste,

[1] Vol. ii., pp. 190, 191.
[2] *Ibid.*
[3] *Ibid.*
[4] *Ibid.*

and it is cut into small cakes or biscuits, which are baked in greased patty-pans. It is a useful recipe for diabetic foods.

Ratafias consist of almonds, white of eggs, *sugar*, and a little wheat flour (about 2 per cent.).

Princess Short-Bread consists of small cakes made of ground dried cocoanut and broken almonds.

Macaroons consist chiefly of ground sweet almonds, white of eggs, *sugar*, and 2 per cent. of wheat flour. Sometimes cocoanut meal or peanut meal are used instead of almonds.

The following books on bread-making have also been referred to : "The Science and Art of Bread-making," by Jago ; "Practical Bread-making," F. T. Vine ; "The Chemistry of Bread-making," the Cantor Lectures, 1879 ; "Le Pain et la Pannification," Léon Boutroux.

CHAPTER XVI

BREAKFAST FOODS, AND OTHER PREPARED FOODS

AMONG the many progressive tendencies of civilization is one whose object is the consumption of various articles of food which are put upon the market ready or nearly ready to eat, thus saving considerable time and labour in preparation. Many of the prepared foods which are sold under various names, and lauded to the skies in advertisements, are artificial preparations of the cereals. The cereals are subjected to heat and otherwise treated, so that the preparation undergoes such changes as will save labour in cooking and spare the digestive organs part of their normal work. It is a grave question as to whether it is good for the human race to have its food partially transformed before it is consumed. It is not beneficial to the teeth to have only soft food to masticate, nor can it be beneficial to the stomach to have constantly such foods to work upon, which give it little to do. What the stomach is relieved from doing by choice may become a matter of necessity. A man who does not use his muscles will soon find that they degenerate and become unable to do laborious work, and the stomach which is given labour-saving foods will soon be unable to perform the normal digestive functions. A large consumption of prepared foods should therefore be deprecated. The economy of such materials is another matter. The cost of production naturally raises the price of the material consumed as compared with the cereals in their normal condition. Freshly ground cereals are the best and most wholesome. There are, it is true, persons whose digestive powers are weakened by disease, such as atony of the stomach and other maladies, to whom such foods may be advantageous for a time. But they present no advantage over the fresh cereals to a person with sound digestion.

Such foods have been analyzed by numerous chemists, and the analyses given on pp. 440, 441, 442, 443, 444, and 445 show their composition.

Indian Corn Foods.—The maize is ground to produce a fine white flour. This method, however, causes a loss of protein and fat, as shown by a comparison of the composition of the entire grain. The loss of protein is chiefly due to the removal of the bran, and fat to the removal of the germ. The amount of fibre is small when the material is carefully bolted. The old-fashioned method of

preparing **hominy** and other meals resulted in a flour containing more protein and fat than that produced by modern methods, and it afforded a greater degree of heat and energy. The retention of the germ was the chief cause of such meal becoming rancid, and its removal is a means of preventing such rancidity.

Wheat Foods are made from a soft, glutinous wheat, from which the germ is not removed. Soft wheat gives a food material containing a fairly high percentage of protein. The fat in wheat foods is in unusual proportions, and indicates the probable mixture of oats with the wheat. Some of the foods consist of grain, rolled and submitted to heat (parched and toasted), whereby a portion of the starch is dextrinized.

Oat Foods.—The best breakfast foods are undoubtedly those consisting of prepared oats. They contain more protein and fat than any other cereal preparation, yield more heat and energy, are exceedingly palatable and nutritious, and are usually considered more stimulating than barley or wheat preparations ; but what the exciting effect is due to is not quite clear. Such preparations are sold under various names, and possibly the methods of advertising have increased the demand for them. The oats are usually **rolled.** There can be no question as to the dietetic value of this procedure. The grains are subjected to great pressure between rollers. Being thus flattened out, they are more easily and quickly softened by cooking. Moreover, the rollers are heated, whereby the starch granules are swollen and their cellulose envelopes broken, and rendered more accessible by heat and the digestive secretions. In some foods the rolled oats are afterwards parched and toasted at a temperature of 400° F., thus converting some of the starch into dextrins of a lower or higher grade. Such dextrins are much more easily assimilated than starch. Unfortunately, the fat is subjected to the same temperature as the starch, undergoes changes by which it is likely to become easily rancid, and some of it is rendered empyreumatic or converted into substances which disturb the gastric functions.

Miscellaneous Foods.—Unmalted barley is not so commonly used for a breakfast food, but malted barley is a common ingredient in foods of a mixed character. Mixed foods consist largely of wheat, as shown by the low proportion of fat in the analyses given below. They frequently consist of entire wheat meal and oat meal, or rolled oats and wheat, which have been treated by heat and partially dextrinized. Some of them have a distinct flavour of malt, which is due to a combination of malted wheat or barley, as in " Force," with partially dextrinized cereals, such as parched and toasted wheat. Their composition necessarily depends upon the components of the food.

Starch, Arrowroot, and Tapioca, are used as breakfast foods by some people, but they form a very one-sided dietary, as they consist chiefly of carbohydrates.

Noodles, Spaghetti, Macaroni, and Vermicelli, are sometimes

TABLE I.—COMPOSITION OF BREAKFAST FOODS—NUTRIENTS PER CENT.

	Water.	Protein.	Fat.	Carbo-hydrates.	Cellulose.	Ash.	Authority.
Indian corn products	12·33	7·92	·58	78·51	·67	·66	Bureau of Chemistry, Bulletin 13, part ix., U.S. Department of Agriture.
Wheat products	10·08	12·01	1·80	75·62	1·48	1·55	
Oat products	7·66	15·32	7·46	67·61	1·20	1·79	
Barley products	10·92	7·50	·89	80·35	·67	·86	
Miscellaneous products	6·41	12·81	1·05	78·68	·99	1·06	
Noodles, spaghetti	9·66	12·02	·42	77·12	·50	·78	
Tapioca and starch	11·29	·39	·30	88·15	·13	·14	
Barley, granulated	10·90	7·50	·90	79·80	·70	·90	Atwater and Bryant, Bulletin 28.
Buckwheat, groats	10·90	4·10	·40	84·10	·20	·50	
Corn meal: Granular	12·50	9·20	1·90	75·40	1·00	1·00	
Unbolted	11·60	8·40	4·70	74·00	—	1·30	
Cerealine	10·30	9·60	1·10	78·30	·40	·70	
Hominy	11·80	8·30	·60	79·00	·90	·30	
,, cooked	79·30	2·20	·20	17·80	—	·50	
Oat meal	7·30	16·10	7·20	67·50	·90	1·90	
,, cooked	84·50	2·80	·50	11·50	—	·70	
,, gruel	91·60	1·20	·40	6·30	—	·50	

Oats, rolled	7·70	16·70	7·30	66·30	1·30	2·10	Ditto.
Rice	12·30	8·00	·30	79·00	·20	·40	
,, boiled	72·50	2·80	·10	24·40	—	·20	
,, flaked	9·50	7·90	·40	81·90	·20	·30	
Wheat: Flaked	10·90	11·00	1·40	76·30	·40	·40	
Parched and toasted	8·60	13·60	2·40	74·50	·80	·90	
Shredded	8·10	10·50	1·40	77·90	1·70	2·10	
Macaroni	10·30	13·40	·90	74·10	—	1·30	
,, cooked	78·40	3·00	1·50	15·80	—	1·30	
Noodles	10·70	11·70	1·00	75·60	·40	1·00	
Spaghetti	10·60	12·10	·40	76·30	·40	·60	
Vermicelli	11·00	10·90	2·00	72·00	—	4·10	
Grape Nuts	8·00	12·73	1·57	73·80	2·03	1·90	Slosson, Wyoming, Experimental Station, Bulletin 33.
Malta-Vita	8·93	11·84	1·55	73·19	1·82	2·67	
F.S. Rolled Avena	9·68	18·42	6·88	60·85	2·22	1·95	
Rolston's Breakfast Food	11·07	12·55	1·72	72·11	1·35	1·20	
Pilsbury's Vitos	11·09	13·08	1·08	73·44	·58	·07	
Pettjohn's Breakfast Food	10·43	12·11	2·50	71·08	2·30	1·58	
Quaker Rolled Oats	9·40	17·55	7·20	61·56	2·40	1·89	
Shredded Wheat Biscuit	8·91	11·32	·87	73·93	3·40	1·57	
Vigor	9·12	14·46	1·65	69·18	2·38	3·21	

TABLE II.—COMPOSITION OF BREAKFAST FOODS—PERCENTAGES.[1]

	Water.	Protein.	Fat.	Carbohydrate (by difference).	Ash.	Caloric Value.	Remarks.
Eustace Miles Breakfast Food	10·1	15·7	3·7	66·9	3·6	3·73	Consists principally of wheat flour.
,, ,, Proteid Food ..	9·8	30·5	5·3	48·2	6·2	3·72	Considerable proportion of potato starch and much phosphates.
Grape Nuts	5·1	11·2	·6	81·1	2·0	3·84	Consists chiefly of soluble gelatinized starch—probably wheat and barley.
Avenola	6·4	12·3	2·6	76·9	1·8	3·92	A mixture of starches changed by heat.
H.O. (steam-cooked oatmeal)..	9·6	14·4	5·8	68·6	1·6	3·94	
Hygiama..	4·1	21·7	8·9	61·7	3·6	4·25	Carbohydrates consist of starch and reducing sugar.
Stamina Food	9·7	10·8	1·4	77·0	1·1	3·73	Chiefly wheat flour.
Chapman's Wheat Food ..	7·6	10·1	1·5	79·6	1·2	3·82	Roasted wheat flour.
Cheltine Food	7·1	11·4	1·7	77·7	2·1	3·81	Much starch, a little dextrin, and probably some casein.
Allinson's Natural Food ..	6·7	12·2	2·0	77·7	1·4	3·87	Almost all wheat flour.
Dubarry's Revalenta	9·1	24·2	·8	63·7	2·2	3·68	Lentil flour.
Granose	9·5	10·9	1·8	75·8	2·0	3·72	Made from wheat.
Wheat flour, average	12·8	10·8	1·1	74·8	·5	3·61	
Lentil flour	12·6	22·3	1·1	61·7	2·3	3·55	
Glidine	12·5	82·4	·7	3·6	·7	—	Vegetable albumin and lecithin.
Winter's Prunus Food	6·7	17·2	27·6	46·4	2·1	5·17	Contains vegetable albumin only.
Roborat	10·0	73·0	4·7	9·4	2·9	3·80	Almost entirely vegetable albumin and lecithin.
Nut Bromose	11·4	21·6	29·7	35·6	1·8	5·10	Derived from nuts.

[1] *British Medical Journal*, i., 1910.

TABLE III.—COMPOSITION OF INFANTS' AND INVALIDS' FOODS—PERCENTAGES.

Analyses from Various Sources.

	Water.	Protein.	Fat.	Carbohydrate.				Ash.	Remarks.
				Soluble.	Starch.	Glucose.	Cane-Sugar.		
Albany Food	8·60	9·50	2·11	79·40		—	—	·40	Much unchanged starch.
Allenbury's Milk Food :									
No. 1	1·82	10·79	16·79	65·51	1·10	—	—	4·08	—
No. 2	2·24	10·23	14·94	67·54	1·24	—	—	3·81	—
Allenbury's Malted Food, No. 3	3·00	10·23	1·05	22·21	62·91	—	—	·60	—
Allenbury's Diet, No. 4 (substitute for milk) ..	4·00	15·05	11·60	56·50	7·60	—	—	4·45	—
American Swiss Food ..	5·68	10·54	6·81	45·35	30·85	5·78	36·43	—	Acid reaction.
Anglo-Swiss Food ..	6·54	10·26	2·72	46·43	34·56	23·29	21·54	—	Slightly acid.
Baby Sup No. 1	5·54	9·75	1·28	14·35	61·99	2·20	11·70	—	Neutral.
,, ,, No. 2	11·48	7·92	·62	22·79	51·95	2·44	2·48	—	Slightly acid.
Bananina	9·50	4·10	·40	84·00		—	—	2·07	Banana flour.
Benger's Food	11·29	10·43	1·10	9·90	66·32	—	—	·96	—
Blair's Wheat Food ..	9·85	7·16	1·56	13·69	64·80	1·75	1·71	—	Neutral.
Chapman's Whole Wheat Flour	8·40	9·40	2·00	79·30		—	—	·90	Neutral.
Chapman's Malted Food	8·54	10·93	1·79	2·10	76·84	—	—	1·40	—
Carnrick's Soluble Food	5·17	16·69	5·53	28·11	41·50	—	—	3·00	—
Cereal Milk	9·33	11·08	1·01	20·00	58·42	4·60	15·40	—	Slightly acid.
Cheltine Infants' Food ..	7·20	16·20	3·92	71·00		—	—	1·83	Much unchanged starch.
,, Maltose Food ..	4·60	5·30	·27	87·60	—	—	—	2·25	Fully malted.
Coombs's Malted Food ..	7·90	12·10	2·80	76·80		—	—	·40	Much unchanged starch.

TABLE III.—INFANTS' AND INVALIDS' FOODS—PERCENTAGES—*Continued.*

	Water.	Protein.	Fat.	Carbohydrate.				Ash.	Remarks.
				Soluble.	Starch.	Glucose.	Cane-Sugar.		
Cremalto	22·26	6·40	20·26	44·67		—	—	1·79	Cream and malt.
Diastased Farina.. ..	8·60	7·60	1·30	71·70		—	—	1·10	Malted flour.
Falona	7·00	8·40	3·50	79·90		—	—	1·20	Cereal and bean flour.
Fairchild's Peptogenic Milk Powder	5·54	1·19	·05	92·00	—	—	—	1·22	—
Frame Food	7·62	13·69	·44	22·33	54·96	—	—	·96	—
Franco-Swiss Food ..	4·43	13·00	3·70	46·09	30·86	—	—	1·40	Much cane-sugar.
Gerber's Milk Food ..	6·78	9·56	2·21	44·76	38·48	6·06	30·50	—	Slightly acid.
Gluten Flour (Farwell's)	12·67	10·39	·84	7·23	68·36	2·23	1·42	—	Of doubtful value.
Hawley's Liebig Food ..	6·60	5·38	·61	76·54	10·97	40·57	3·44	—	Slightly acid.
Hazard and Graham's Farina	9·12	8·48	·81	6·35	69·68	2·19	2·49	—	Neutral.
Horlick's Malted Milk ..	3·06	16·35	8·78	67·95	—	49·15	—	3·86	—
Ditto prepared for use	92·40	1·15	·60	5·38	—	—	—	·29	See below.
Horlick's Malted Food ..	9·70	10·43	·34	76·83	2·20	—	—	—	Diastased Farina.
Hygiama (Theinhardt's)	4·75	21·22	10·05	49·10	11·33	—	—	3·55	—
I. and I. Food	5·50	10·30	2·30	80·50		—	—	1·40	Mainly starch.
Imperial Granum ..	5·49	10·51	1·01	3·56	78·93	trace	trace	—	Neutral.
Infantina (Theinhardt's)	5·03	16·17	5·00	53·61	16·72	—	—	3·47	—
John Bull Food, No. 1 ..	3·95	21·10	11·87	54·29*	—	—	—	5·32	*Lactose, 27·0; maltose, 21·3.
,, ,, No. 2 ..	1·68	11·06	·68	37·67*	43·30	1·32	—	1·70	*Lactose, 7·1; maltose, 23·3.

K. and M. Food	27·95	nil	—	71·50	nil	36·75	—	·55	Neutral.
Kufeke's Infant Food ..	5·03	13·24	1·69	23·71	50·96	—	—	2·23	—
Lahmann's Vegetable Milk	24·40	7·50	24·60	41·80		—	—	1·50	Made of nuts.
Loeflund's Cream Emulsion	24·32	8·23	15·32	49·43	—	—	—	2·60	Malted wheat and milk.
Malted Food	2·36	16·07	11·80	65·89	—	—	—	3·88	Ditto.
Manhu Infant Food ..	8·80	8·70	5·60	75·90		—	—	1·00	Much starch, dried milk, and cereals.
Mellin's Food	3·70	9·08	·17	83·51	—	—	—	3·67	See below.
Moseley's Food	14·00	11·59	1·28	4·54	67·64	—	—	·99	—
Neave's Food	5·03	13·20	1·70	4·71	74·27	—	—	1·09	—
Nestlé's Milk Food ..	4·75	8·23	1·91	44·88	40·16	6·02	32·93	·08	Slightly alkaline.
Nichols' Food of Health	11·90	7·70	1·70	76·90		—	—	1·70	Mainly starch.
Nutroa Food	6·80	15·90	10·30	66·00		—	—	1·00	Cereal, pea, and nut.
Opmus	10·90	9·10	1·00	—	78·60	—	—	·42	Wheat flour.
Ovaltine	3·30	12·01	7·99	76·70	2·57	—	—	3·44	—
Phosphatine Fallières ..	5·85	2·35	1·92	56·68	31·98	—	—	1·22	—
Ridge's Food	9·23	9·24	·63	5·19	77·96	2·40	2·20	1·74	Neutral.
Robinson's Barley ..	10·10	5·13	·97	4·11	77·76	3·08	·90	—	,,
Savory and Moore's Food	8·34	9·63	·40	44·83	36·46	20·41	9·08	1·60	,,
Scott's Oat Flour ..	5·80	9·70	5·00	—	78·00	—	—	1·30	Fine oat flour.
Triticumina Food ..	8·60	12·50	2·20	75·70		—	—	1·00	Mainly starch.
Victor Baby Food ..	7·49	8·78	1·62	20·54	63·45	·62	19·20	—	Slightly acid.
Virol	24·04	4·16	10·75	59·25	—	—	—	1·80	—
Wells and Richardson's Food	7·76	11·85	1·64	39·00	36·43	—	—	2·61	Partly malted, much cane-sugar.
Worth's Perfect Food ..	2·40	11·10	2·00	81·50		—	—	·50	—
Wheat flour	9·02	6·40	1·01	5·66	76·07	2·34	2·46	—	—
,, ,, baked ..	7·88	—	·41	14·29	67·60	—	—	—	—

used as breakfast foods. Noodles consist of strips of rolled dough baked and eaten with soup; vermicelli is eaten in soup, macaroni in soup or pudding and with savoury dishes. These wheat preparations are characterized by containing a large proportion of protein derived from the gluten in the cereal, a correspondingly high proportion of carbohydrate, but very little fat as compared with oat meal.

Infants' and Invalids' Foods.

The composition of a number of foods intended for infants and invalids is given in the table on pp. 444-445. A few notes on some of them may be useful. Those foods which contain much unchanged starch should not be given to infants under six months old.

Allenbury's No. 1 Food contains no starch. It consists of desiccated cow's milk from which some casein has been removed; vegetable albumin, sugar, and cream, have been added. The No. 2 food contains some malted flour, but no starch is present when properly prepared. The Malted Food is chiefly wheat flour and malt, and is intended for children over six months.

Benger's Food consists of wheat flour and pancreatic extract, the enzymes of which transform the starch into dextrin and dextrose, the added milk being also partly digested.

Horlick's Malted Milk consists of desiccated milk 50, wheat flour, 26·25, malt 23, parts; soda bicarbonate ¾ part. Starch should be transformed by the malt. The Malted Food of the same makers is almost completely transformed into soluble carbohydrates.

Carnrick's Soluble Food consists of dried milk 37·5, malted wheat 37·5, milk-sugar 25, parts. The diastase is destroyed by boiling the food; it should therefore be prepared at a temperature below 140° F., to secure proper transformation.

Nestlé's Food consists of equal parts of dried milk, baked flour, and cane-sugar; therefore much starch remains unchanged.

Mellin's Food is made of wheat flour, malt, and carbonate of potash; it is digested by Liebig's process until all starch is converted into dextrose and dextrin; it is then strained to remove husks, bran, etc., and evaporated to dryness in a vacuum-pan at 140° F.

Savory and Moore's Food is wheat flour and malt. When mixed into a paste with cold water or milk, and then one-third boiling milk or milk and water added to it, it attains a temperature suitable for the action of the diastase, which converts nearly all the starch into dextrin and maltose.

John Bull Foods consist of dried milk and malted cereals.

Diastased Farina is a malted cereal food. When carefully prepared, all the starch is transformed to dextrin and maltose.

Coombs's and other malted foods are similar. Some of them contain dried milk.

Nutroa Food is made of cereal and peanut flour, and has much unchanged starch, but is self-digesting.

Vegetable Milk is similar.

Ridge's, Neave's, and **Frame Foods** are baked flour in which some of the starch is dextrinized by heat.

Falona is wheat, oat, barley, and bean flour.

Theinhardt's Infantina consists of diastased cereals, dried milk, lactose, and cane-sugar.

Hygiama is similar, but more concentrated, and contains a little cocoa.

Entire-Wheat Flour is a valuable food for invalids and infants when it is carefully prepared and in combination with milk. There are various reasons for the removal of the bran, cerealin, and germ, from flour which is intended for making bread. The same reasons do not apply with equal cogency when the flour is not about to be made into bread. It is true that the oil in the germ may undergo oxidation and become rancid ; but this is obviated by keeping the flour in hermetically sealed tins. We may thus have a flour containing all the valuable proteins, with the organic and earthy phosphates natural to the grain. In the recent discussion on so-called "standard" bread, an outcry has been made for the inclusion of the germ ; and experiments have been made by which the observers claim to have proved the superiority of such flour for growing animals and children. Whether we agree with the conclusions drawn from those observations or not, we must acknowledge that the germ and cerealin are rich in proteins and amides. There are other reasons, moreover, for the inclusion of these substances in flour which is intended for the food of children. They contain enzymes of great value (see Flour and Wheat). When the cerealin is present in the flour, these enzymes act upon the starch and transform some portion of it into dextrin. A good example is **Chapman's Entire-Wheat Flour,** which in its natural state contains moisture 15·2, gluten 14·1, cerealin 1·91, and phosphates 1·61, per cent. An improvement in the whole-wheat meal is produced by roasting or baking it, a portion of the starch being transformed into dextrin by that means. Moreover, the cerealin is not wholly destroyed by heat, if the roasting is carefully carried out. Attfield found that the cerealin in the unbaked flour amounts to 1·92 per cent., and in the roasted flour 1·20 per cent., the cerealin remaining in a soluble form, and able to act upon the starch during the preparation of the food and in the stomach. Chapman's roasted entire-wheat flour contains moisture 10·8, gluten 15, cerealin 1·20, phosphates 1·65, per cent. The richness of entire-wheat flour in nitrogenous matters, enzymes, and phosphates, renders it a valuable food for children and invalids.

Semolina, Macaroni, and Vermicelli.

These preparations are the product of **Hard Wheat** (*Triticum durum ;* German, *Hartweizen ;* French, *Blé dur*). This species of wheat grows tall, has smooth broad leaves, with a hard cuticle. The corn has an exceptionally long beard ; the grains are hard, large, yellow to red in colour, and of a semi-translucent appearance.

This grain does not make such good bread as the softer kinds of wheat, but it is combined with soft wheats to give to the flour various properties in which it is deficient (*vide* Bread-making). It has to be moistened before it can be ground.

Semolina is the name applied to the large hard grains retained in the bolting machine after fine flour has passed through it in the operation of milling. It is of various degrees of fineness. It is a favourite food in France, and is used to some extent in England for making puddings. Owing to this demand for it, semolina is intentionally prepared from hard wheat, which is decorticated, crushed, and bolted, leaving the small, hard, pearl-like grains sold commercially. In order to obtain it in a granular condition the millstones are grooved so that the entire grain is not reduced to a powder. It is then sifted to remove the finer or starchy portion, and what remains consists of granules of a light amber or yellow colour, and rich in gluten. It is a good nitrogenous food, useful for making porridge, puddings, and for thickening soup. A kind of semolina is also made from rice, but it is deficient in protein.

Macaroni and Vermicelli are made from the same kind of wheat. They are usually made from the hard red wheat grown along the borders of the Black Sea, mingled with Italian wheat. It is ground and sifted to remove the starchy part and separate out the glutinous portion, which consists of light amber or yellow fragments. These are reduced to flour, made into a paste with boiling water, and thoroughly kneaded until a homogeneous glutinous dough is formed. The dough is placed in a vertical cylinder, the bottom of which is perforated with holes, and driven through it by hydraulic pressure to produce the long vermicular pieces. The hollow or tubular macaroni and solid vermicelli are made from the same dough, their form only being different. The tubular form of macaroni is due to an arrangement of the bottom of the cylinder. Each tube of macaroni has a vertical slit at the side as it passes through the plate, but this closes at once. It is now seldom made by hand. The vermicular pieces are cut about 3 feet long, and hung in the sunshine to dry for about two hours. They are afterwards removed to a damp cellar for twelve hours; here they again become pliable, and are then hung up to dry for several days, or are more quickly dried by exposure to a current of air for eight to twenty-four hours in a properly-constructed chamber. The time required for drying depends upon the moisture in the air. When finished, the pieces have a toughness which will resist considerable handling.

Although they chiefly consist of carbohydrates, these food materials are a valuable source of protein, especially when eaten with milk or cheese. During cooking they swell up and absorb three times their weight of water. They contain very little cellulose or fibre, and, according to Rubner,[1] are almost entirely absorbed in the alimentary canal. They are therefore especially useful for

[1] *Zeit. für Biol.*, 1879, xv. 165.

all cases where it is deemed advisable to leave as little residue as possible in the intestinal canal—*e.g.*, chronic enteric catarrh, stricture, or malignant disease. They may be taken in puddings with milk and sugar, or in soup, which is enriched and increased in value by their presence.

COMPOSITION OF MACARONI, VERMICELLI, AND SEMOLINA—PERCENTAGES.

Nutrients per Cent.	Water.	Protein.	Fat.	Carbo-hydrate.	Cellu-lose.	Ash.	Authority.
Macaroni, fine quality ..	13·0	11·10	·90	73·80	·40	·80	Church's "Foods," p. 81.
Macaroni, cheaper quality ..	10·0	13·50	2·30	70·80	1·40	2·00	
Macaroni ..	11·6	10·98	·45	76·05	·28	·64	Balland, *The Analyst*, 1898, 178.
	12·0	10·89	·65	75·70	·26	·50	
Vermicelli ..	10·9	11·74	·50	75·84	·38	·74	
	10·0	12·51	·80	75·51	·28	·90	
Pâtes d'Italie ..	10·4	12·51	·80	75·23	·30	·76	
Semolina ..	9·2	13·50	·85	75·45	·50	·50	
	9·2	10·42	·55	78·63	·45	·75	
	10·5	11·96	·60	75·79	·50	·65	
Rice semolina ..	10·8	7·34	·34	80·96	·40	·20	

Vegetable Protein Preparations.

Among the best-known examples of albuminous preparations derived from the vegetable kingdom are Aleuronat, Roborat, and Glidine.

Aleuronat is a vegetable protein food containing in the water-free substance 90 to 92 per cent. of nitrogenous matter, a small amount of starch and dextrin, fatty acids, and ash. It is a light brown powder, prepared from the nitrogenous residue obtained in the manufacture of "starch" from wheat. The residue is "gluten," which undergoes putrefaction on drying. But in the manufacture of Aleuronat the greater part of the adhering starch is dissolved, and the protein substance submitted to heat for a prolonged period. By this process, however, the lecithin is destroyed or reduced to fatty acids and glycerophosphoric acid. It is fairly well assimilated, the loss of nitrogen in the fæces being 5·7 per cent., as compared with 2·3 per cent. from meat in the same individual.

Roborat is practically pure vegetable "albumin," free from nuclein and starch, but containing the lecithin combined with albumin (*lecith-albumin*). It is made from grain (wheat, rice, maize). It is a white powder of extreme fineness, free from smell, and almost tasteless. It can be taken in soup, milk, cocoa, gruel, or made into cakes for the diabetic. It is assimilated better than Aleuronat, only 3·17 per cent. of the nitrogen reappearing in the fæces. It is also more valuable from its containing lecithin. The

makers claim that the water-free material consists of wheat albumin 96, wheat salts (including lecithin) 3, carbohydrates 1, per cent.

Glidine is also a vegetable protein food prepared from wheat, and is in the form of a fine white powder. The makers claim that the water-free substances contain—albumin 95·69, lecithin 0·87, carbohydrate 2·72, and ash 0·72, per cent. The lecithin is in combination with albumin, and is a *lecith-albumin* as it occurs in the grain. It should therefore not be cooked, but can be added to warm food. As much as 50 grammes daily can be taken without disturbing the nitrogenous balance. It is free from nuclein bases and extractives, and does not lead to the increase of uric acid.

LEEDS & WEST RIDING
MEDICO-CHIRURGICAL SOCIETY.

CHAPTER XVII

BAKING-POWDERS, AND OTHER METHODS OF AERATION

A CONSIDERABLE amount of baking-powder and other materials which have the capacity for aerating flour are in demand, and it is deemed advisable to include them here.

Baking-Powders are combinations of chemical substances intended to be used for the aeration of bread and other dietetic articles. They are not much used for making bread except on a small scale, and then only to a limited extent. But they are extensively used in the manufacture of "smalls," or cakes, pastries, and other dietetic articles, both domestically and commercially.

The object of aerating bread by any means is to separate the gluten into thin films, and maintain it in that condition until it is "set," or fixed by the application of heat. Originally all bread and cakes were aerated by a spontaneous leaven; later on by brewer's yeast, or barm made by the baker. The growth of knowledge, however, led to the discovery that the chief agent in the process of leavening bread or pastry is the gas generated during the activity of yeast, and that this gas could be generated in the dough by other means than the yeast fungus. It was found by mingling with the flour about to be made into dough two substances, which will ultimately combine and evolve carbonic acid, that the dough will be leavened. It was further found that there are certain advantages to be gained by this method of leavening. When bread is leavened by yeast, the process is attended by changes in the flour, especially by the destruction of sugar and soluble proteins; whereas such change and loss of valuable foodstuff does not occur when chemical aerators are used. On the other hand, this mode of aeration is applicable to mixtures containing a quantity of milk, sugar, and eggs, which are not readily leavened by yeast. It is also a better method of aerating very soft flours, because the latter do not very well stand the softening effect of yeast upon the gluten. When a soft flour is made into bread with yeast, the loaves are apt to be flat and raw-tasted; but such effects do not follow the use of chemical aerators. It is further argued in favour of chemical aerators that they replace some of the mineral substances removed from the flour with the

bran. This method of aeration is therefore appreciated by the baker who wishes to avoid the loss of valuable time spent in leavening his goods by yeast, especially when using soft flour, as in making some valuable dietetic articles, or in manufacturing biscuits, cakes, scones, and pastry, where the fermentative process is undesired.

Baking-powders usually consist of (1) alum and bicarbonate of soda ; (2) acid phosphate of lime and soda ; (3) acid tartrate of potassium (cream of tartar) and soda ; or (4) tartaric acid and soda. These ingredients are generally combined in a dry state with rice flour or some other inert substance, and a definite quantity is mixed with the materials to be used in making bread, pastry, etc. The moisture of the dough dissolves the chemicals, a reaction takes place, *a new substance is formed*, and carbonic acid gas is liberated and leavens the dough.

Examples of their composition are as follows :

1. *Delfonte's Baking-Powder.*—Tartaric acid 4 ounces, alum 8 ounces, bicarbonate of soda 12 ounces, carbonate of ammonia 3 ounces, farina 16 ounces.[1]

2. *The Horsford-Liebig Baking-Powder.*—Acid phosphate of calcium 550 parts, bicarbonate of soda 113 parts, chloride of potash 100 parts. Powder of this composition should generate 13 per cent. of carbonic acid gas.[2]

3. *Goodall's Baking-Powder* consists of bicarbonate of soda and tartaric acid in nearly equal parts, and rice flour 2 parts. Some makers of a similar powder use starch or milk-sugar.[3]

4. Macdonald substitutes acid sulphate of potash or soda for the tartaric acid or cream of tartar used in the powder of other makers. The proportions are—bicarbonate of soda 1 part, acid sulphate of potash or soda 1·5 parts, flour 1 or 2 parts.

5. Weitz employs phosphoric acid 5·1 parts, bicarbonate of soda 8·7 parts, flour 1,000 parts.

It was found by Mallet[4] that the amount of CO_2 generated by twenty-seven kinds of baking-powder of different makers varied from 36·91 to 99·37 cubic inches per ounce, with an average of 60 cubic inches. The variation was chiefly due, he found, to differences in the quality of bicarbonate of soda used, and to the greater or less care exercised in mixing the powders. A larger quantity of a "weak" than of a "strong" baking-powder is required to produce the leavening effect, and the excessive use of a "weak" powder leads to the formation of a large residue.

Examples of the composition and analysis of three kinds of baking-powder[5] are appended (see p. 453).

1 "Cooley's Encyclopædia," vol. i., p. 373.
2 "The Modern Baker and Confectioner."
3 Thorpe's "Dictionary of Applied Chemistry," vol. i., p. 263.
4 *Chemical News*, 1888, ii. 276.
5 Bulletin 13, part v., U.S. Department of Agriculture, Bureau of Chemistry.

		Per Cent.
Cream of tartar baking-powder, consisting of— Parts.		
Cream of tartar 50	Carbon dioxide (CO_2) ..	12·25
Sodium bicarbonate .. 25	*Available* CO_2 ..	11·13
Starch 25	Sodium oxide (Na_2O) ..	11·03
With small quantities of other substances	Potassium oxide (K_2O)	11·71
	Calcium oxide (CaO) ..	·19
	Tartaric acid ($C_4H_6O_6$)	35·14
	Sulphuric acid	·12
	Starch	18·43
	Water of combination ..	11·13
Acid phosphate baking-powder, consisting of—		
Acid calcium phosphate 37	Total CO_2	13·47
Sodium bicarbonate .. 26	*Available* CO_2 ..	12·86
Starch 27	Sodium oxide (Na_2O) ..	12·66
Water of association .. 10	Potassium oxide (K_2O)	·31
With small amounts of other substances	Calcium oxide (CaO) ..	10·27
	Phosphoric acid (P_2O_5)	21·83
	Starch	26·41
	Water, by difference ..	15·05
Alum baking-powder, consisting of—		
Ammonia alum (anhydrous) 15	Total CO_2	7·90
Sodium bicarbonate .. 21	*Available* CO_2 ..	6·41
Starch 45	Sodium oxide (Na_2O) ..	6·99
Water of crystallization, etc. 19	Calcium oxide (CaO) ..	·12
	Aluminium oxide (Al_2O_3)	3·65
	Ammonia (NH_3) ..	1·02
	Sulphuric acid (SO_3) ..	10·11
	Starch	45·41
	Water, by difference ..	24·80

yields on analysis—

The Residue.—The reaction of the most common baking-powders and other modes of aeration, and the residues formed, are as follows :

1. *Tartaric Acid and Soda.*—When substances are dissolved in water, some of the material becomes dissociated into ions, and when ions of an opposite character are formed new compounds are produced. In a solution of sodium bicarbonate a small portion of the alkali is split into anions and cations, the sodium being a monovalent cation, and the CO_3 a divalent anion. The solution, however, never contains more than a limited number of ions at a given moment, but as fast as they are removed fresh ions are formed. If now an acid solution is mingled with an alkaline solution—*e.g.*, tartaric acid and soda—the acid ions or anions combine with the metallic ions to form a new compound, thereby removing the ions from the solution. New ions are formed with lightning rapidity, and the union of the nascent radicals or ions is equally rapid. Dissociation and reunion continue with great rapidity until one or other reagent is exhausted, the anions and cations uniting to form a new salt. A solution of bicarbonate of sodium contains the cation Na and the anion CO_3. The latter combines with water, or H ions liberated from the acid, to form carbonic

acid, H_2CO_3, which speedily dissociates into water and carbon dioxide. A solution of tartaric acid contains the tartrion or anion of the acid. When the two solutions are brought together, the tartrion joins the natrion (sodium or metallic ion), and forms sodium tartrate ; or, put briefly, two sodium ions replace two hydrogen ions from the molecule of tartaric acid :

$$\underset{\text{Tartaric acid}}{C_4H_6O_6} + 2\underset{\substack{\text{Sodium}\\ \text{bicarbonate.}}}{NaHCO_3} = \underset{\text{Sodium tartrate.}}{Na_2C_4H_4O_6} + 2H_2O + 2CO_2.$$

2. *Cream of Tartar and Soda.*—When tartaric acid and soda are used in a baking-powder, the ionization is exceedingly rapid, and consequently the evolution of carbon dioxide is soon over. The formation of gas does not continue when the dough or pastry is in the oven, "in consequence of which the finished article lacks bulk" ("The Modern Baker"). For this reason tartaric acid is usually replaced by cream of tartar (potassium hydrogen tartrate). This salt is not so soluble as the free acid, consequently ionization is more difficult, the reaction is slower and longer in process, and continues while the dough or pastry is in the oven. The use of cream of tartar is therefore more favourable to the article being cooked, by causing the liberation of gas at the required moment. The cream of tartar, or potassium hydrogen tartrate, gives off hydrogen ions. Sodium bicarbonate being dissociated, the metallic ion Na replaces the hydrogen from the other molecule. We have thus formed Rochelle salts (potassium sodium tartrate), and when the dough is sufficiently moist it takes up water of crystallization. The residue from two teaspoonfuls of baking-powder is about 11 grammes, or 165 grains, of Rochelle salts. As in the former reaction, the H ions and CO_3 ions form H_2CO_3, which is at once decomposed into CO_2 and water. The reaction is as follows :

$$\underset{\substack{\text{Potassium hydrogen}\\ \text{tartrate.}}}{KHC_4H_4O_6} + \underset{\substack{\text{Sodium}\\ \text{bicarbonate.}}}{NaHCO_3} = \underset{\substack{\text{Potassium sodium}\\ \text{tartrate.}}}{KNaC_4H_4O_6} + H_2O + \underset{\substack{\text{Carbon}\\ \text{dioxide.}}}{CO_2}.$$

3. *Acid Phosphate and Soda.*—When acid phosphate of lime is the acid constituent of the baking-powder, and the alkali is sodium bicarbonate, the mixture results in the formation of sodium and calcium phosphates. Two teaspoonfuls of baking-powder leave a residue of 16 grammes, or 250 grains, of these phosphates in about equal proportions. The CO_2 liberated by the reaction acts in leavening the dough. Most of the well-known baking and cream powders are compounds of acid phosphate of lime, ammonia, or potash. One of the earliest known baking-powders was the Liebig-Horsford powder, whose constituents are given above. The following equations show the reactions between acid phosphates of lime and potash with bicarbonate of soda :

$$(a)\quad \underset{\substack{\text{Acid calcium}\\ \text{phosphate.}}}{CaH_4(PO_4)_2} + 2\underset{\substack{\text{Sodium}\\ \text{bicarbonate.}}}{NaHCO_3} = \underset{\substack{\text{Calcium hydro-}\\ \text{gen phosphate.}}}{CaHPO_4} + \underset{\substack{\text{Disodium}\\ \text{hydrogen}\\ \text{phosphate.}}}{Na_2HPO_4} + 2H_2O + \underset{\substack{\text{Carbon}\\ \text{dioxide.}}}{2CO_2}.$$

(*b*) $KH_2PO_4 + 2NaHCO_3 = Na_2KPO_4 + 2H_2O + 2CO_2$.
Acid potassium phosphate. — Disodium potassium phosphate.

4. *Acid Sulphates and Soda.*—When baking-powders are composed of acid sodium sulphate or acid potassium sulphate and sodium bicarbonate, the residue is sodium sulphate or potassium sodium sulphate, and the reactions are as follows :

(*a*) $NaHSO_4 + NaHCO_3 = Na_2SO_4 + H_2O + CO_2$.
Sodium hydrogen sulphate. — Sodium sulphate.

(*b*) $KHSO_4 + NaHCO_3 = KNaSO_4 + H_2O + CO_2$.
Potassium hydrogen sulphate. — Potassium sodium sulphate.

5. *Hydrochloric Acid and Soda.*—The process of aeration by hydrochloric acid and sodium bicarbonate consists in mixing the soda with the dry flour, and the acid with the water to be used in mixing the dough. They are used in such proportion that the acid is neutralized, perhaps with a little excess of soda. As the residue consists of sodium chloride, it is unnecessary to add much, if any, common salt to the flour. The dissociated ions unite, the monovalent cation sodium with the monovalent anion chlorine, and the two hydrogen cations with the divalent carbonate anion, the latter being again dissociated into CO_2 and water.

$$NaHCO_3 + HCl = NaCl + H_2O + CO_2.$$

An example is the following : Flour 6 pounds, water 3 pints, hydrochloric acid 3 drachms, sodium bicarbonate 3 drachms.

6. *Alum and Soda.*—Alum baking-powders consist of a sulphate of alumina and bicarbonate of soda, there being two residues—sodium sulphate and ammonium or potassium sulphate, according as the ammonia or potash alum is used. The residue left by two teaspoonfuls of such a baking-powder weighs 11 grammes, or 165 grains. The reaction is as follows :

(*a*) $K_2Al_2(SO_4)_4 + 6NaHCO_3 = Al_2(OH)_6 + 3Na_2SO_4 + K_2SO_4 + 6CO_2$.
Potash alum. — Sodium bicarbonate. — Aluminium trihydrate. — Sodium sulphate. — Potassium sulphate. — Carbon dioxide.

(*b*) $Al_2(NH_4)_2(SO_4)_4 + 6NaHCO_3 = Al_2(OH)_6 + 3Na_2SO_4 + (NH_4)_2SO_4 + 6CO_2$.
Ammonia-alum. — Ammonium sulphate.

7. *Carbonate of Soda as Aerator.*—When sodium bicarbonate is heated to a temperature of 100° C., it becomes dissociated into sodium carbonate and carbonic acid, and by a secondary reaction the carbonic acid dissociates into CO_2 and water, as follows :

(*a*) $2NaHCO_3 = Na_2CO_3 + H_2CO_3$ and (*b*) $H_2CO_3 = H_2O + CO_2$.
Sodium bicarbonate. — Sodium carbonate. — Carbonic acid.

The residue—sodium carbonate—gives a yellow colour, a strong alkaline reaction, and a characteristic taste, to the bread, cake, pastry, or biscuits. It is therefore seldom used alone. A similar

effect follows the use of baking-powders containing an excess of sodium bicarbonate.

8. *Soda and Milk.*—In domestic cooking, scones, cakes, biscuits, etc., are frequently mixed with bicarbonate of soda and milk, sour milk, or buttermilk. The result is much the same as when soda is used alone, except that the material is enriched by the constituents of milk. Sodium bicarbonate requires rather more than its own weight of lactic acid to neutralize it, whereas sour milk contains only 0·5 to 1 per cent.; it follows, therefore, that there is insufficient acid for the purpose. But a small quantity of CO_2 is evolved by this action, and still more arises by the decomposition of sodium bicarbonate by the effect of the heat employed in cooking. The following equation shows the reaction which occurs, one hydrogen ion being replaced by a metallic ion in the lactic acid molecule:

$$\underset{\text{Lactic acid.}}{C_3H_6O_3} + \underset{\text{Sodium bicarbonate.}}{NaHCO_3} = \underset{\text{Sodium lactate.}}{NaC_3H_5O_3} + H_2O + CO_2.$$

9. *Ammonia as Aerator.*—Ordinary "carbonate of ammonia" is also readily dissociated by heat into ammonia, carbon dioxide, and water, the ammonia volatilizing and leaving scarcely a trace behind. This decomposition has unwittingly been taken advantage of by bakers and biscuit-makers, who frequently use it to leaven their goods. Ordinary "carbonate of ammonia" is a mixture of carbamate and bicarbonate of ammonia. The decomposition is as follows:

$$(NH_4)_2.NH_2HCO_2CO_3 = 3NH_3 + H_2O = 2CO_2.$$

10. *Aeration by Ready-made Carbon Dioxide.*—Bread is often aerated by using "carbonated water" or aerated water instead of yeast. Special machinery is used. The method was introduced by Dr. Dauglish in 1856. The "carbonated water" is made by the ordinary method of preparing CO_2 by the action of sulphuric acid on chalk, and the water is impregnated with this gas under pressure. The dough is made in a closed apparatus; the atmospheric air is abstracted, and the flour mixed with the "carbonated water"; the machine kneads the dough, and turns it out to be caught in tins, which are at once transferred to the oven, where the heat causes an expansion of the gas and vesiculation of the loaf. Such bread is unfermented, and therefore no change in the constituents of flour takes place.

11. *Albumin as Aerator.*—When albumin of any kind—*e.g.*, egg-white, serum-albumin, gluten, etc.—is thoroughly "whipped," it forms a stiff froth which retains air in its vesicles. Advantage of this fact is taken by the baker or cook who uses eggs to leaven a substance about to be cooked. When the article which is mixed with whipped egg-white is put into the oven, the heat causes an expansion of the air introduced into the substance with it, and thereby leavens the material to some degree. The albumin is coagulated by the heat, and the vesicles consequently retain their form

after the substance becomes cold. Yolk of egg when well whipped will also stiffen and retain air, but not to the same extent as the white of egg, because it contains less albumin.[1] Egg substitutes do not act in the same manner; they consist chiefly of gelatin, which is softened by heat and dissolves in the presence of moisture.

12. *Aeration aided by Fat.*—Butter, lard, and other fats, have the effect of aerating and shortening small goods, according to their mode of use. The *shortening* effect is produced by thoroughly incorporating the fat with the flour, thereby isolating every particle and preventing agglutination; the result is **short pastry.** But the effect of *aeration* is produced by another mode of using fat when **puff pastry** is made: the dough being made is flattened out somewhat, and a layer of butter, lard, or other fat, spread over it; it is then rolled very thin, and by successively doubling it up and rolling into thin layers, which are spread with fat, the dough becomes laminated, and the laminæ are prevented by fat from adhering. When such pastry is put into the oven, the heat expands the moisture into vapour, which separates the laminæ, and the pastry becomes a mass of light, friable layers or flakes.[2]

The Salutariness of Baking-Powders.—The chief reasons for their use are that they are ready at all times, the great convenience in handling them, and their prompt action. But their salutariness is open to question. They introduce into the material a foreign substance, which cannot fail to have a physiological significance when consumed with the food. The residues are sodium carbonate, sodium chloride, sodium tartrate, potassium sodium tartrate (Rochelle salts), aluminium hydrates or hydroxides, sodium and potassium sulphates, potassium sodium phosphate, calcium phosphate, etc. Since sodium, potassium, and calcium salts are even and everywhere present in the human body, the presence of a small residue of carbonates of the alkali metals can scarcely be considered to be deleterious. But the impropriety of introducing unknown quantities of Rochelle salts, sulphates and phosphates of soda, potash, ammonia, or alumina, into the human system cannot be denied. Sodium tartrate, potassium sodium tartrate, as well as the potassium and sodium sulphates, are all purgatives. Some manufacturers claim that the phosphates of lime and soda which remain after using acid calcium phosphate and soda baking-powder merely replace some of the phosphates which have been removed from the wheat with the bran. But this is a fallacious argument, for the phosphates in the bran are an organic compound, while those from the baking-powder are ordinary inorganic compounds. The acid phosphate may be adulterated with calcium sulphate (*gypsum*), calcium phosphate, bone meal, etc. Cream of tartar may be contaminated by lead, and so on. When alum baking-powders are used, the residues consist of aluminium hydroxide and sulphates of potash and soda, the latter being more powerful purgatives than

[1] "The Modern Baker and Confectioner." [2] *Ibid.*

the tartrate salts. The use of alum in bread is prohibited by the Food and Drugs Act.

It is claimed, by those who advocate the use of alum baking-powders, that as soon as the mixture of alum and bicarbonate of soda is moistened the aluminium sulphate is decomposed, as shown above; that sodium sulphate is formed, together with potassium or ammonium sulphate; and that the alum assumes the form of aluminium hydroxide, a substance insoluble in water, inert, and therefore harmless in the alimentary canal. It has also been noticed that some of the alum is converted into aluminium phosphate by phosphoric acid or phosphates existing in the flour; but this substance is also insoluble and inert. It is further claimed that, at the temperature at which bread or pastry is baked, even the aluminium hydroxide is decomposed, water being driven off, and it is reduced to alumina, the highly insoluble aluminium oxide which is as harmless and inert as clay or other indifferent matter.

On the other hand it is claimed that aluminium hydroxide or trihydrate is injurious to the human organism, and that the heat of baking may not be sufficient to insure its reduction to alumina; therefore some portion of the hydroxide remains. This point was carefully examined by Professor Mallet of Virginia University.[1] As aluminium hydroxide and aluminium phosphate are heated they give off water, and thereby become less soluble in acids; and the anhydrous aluminium oxide is insoluble in dilute acids, or even in moderately strong acids. When, therefore, we consider the solubility of the residues of baking-powders, not in water, but in the gastric juice, it is necessary to know in what condition of hydration these substances are left. Now, the temperature of an oven for baking bread varies from 244° to 258° C. (472° to 496° F.), and it was found by Mallet that when a self-registering thermometer was used the temperature in the centre of the loaf varied from 93° to 100° C. (197° to 212° F.), according to the size and shape of the loaf, but never exceeded 100° C. He concluded, therefore, that the residues of baking-powders were never submitted to a higher temperature than 100° C. (212° F.), and that when the temperature only attained 93° C. the bread was not sufficiently baked. He next determined the condition of the residue of baking-powder after being dried at 100° C., and he found that at this temperature aluminium hydroxide or trihydrate, $Al_2(OH)_6$, gives off 39·1 per cent. of water, and becomes the monohydrate, $Al_2O_2(OH)_2$. In fact, a temperature of 300° C. (550° F.) is necessary for the complete reduction of the hydroxide or hydrate to oxide of alumina, Al_2O_3.

The aluminium trihydrate, $Al_2(HO)_6$, the dihydrate, $Al_2O(OH)_4$, and the monohydrate, $Al_2O_2(OH)_2$, are all soluble in acids, and all yield the same aluminium salts; therefore, when they are taken into the stomach, some of the aluminium unites with gastric juice, and, according to Mallet, some other portion of aluminium hydroxide or phosphate throws down the pepsin in an insoluble form.[2] It

[1] *Chemical News*, 1888, ii. 276.

[2] *Ibid.*

thereby interferes with normal digestion. Observations made on human beings, who previously had no symptoms of indigestion, showed that, although no pain was produced, the alum retarded digestion by coagulating and hardening the proteins of the food; that an inhibitory effect was exercised upon the pepsin, and the persons suffered from a sensation of oppression for two or three hours after taking food. It therefore cannot be said that the use of alum baking-powders is free from undesirable effects.

The general conclusion is that the use of baking-powders cannot be regarded as harmless; but they must be considered to be more or less objectionable, and should be avoided when the object aimed at is the production of wholesome bread.

CHAPTER XVIII

THE CEREALS—*Continued*

Rye.

THE grain of *Secale cereale* (German, *Roggen;* French, *Seigle*). There are five or six known species of *Secale*, which inhabit Western Temperate Asia and South-Eastern Europe. The original home of rye, according to De Candolle, is the region between the Austrian Alps and the north of the Caspian Sea. It thrives better in northern than in southern countries. Its cultivation is not very ancient, except, perhaps, in Russia and Thrace. The ancient Greeks did not know it. It has not been found in Egyptian monuments. There is no trace of it in the lake-dwellings of Switzerland or Savoy of the Age of Bronze. The first Latin author who mentions it in the Roman Empire is Pliny. The principal names for it are of North European origin. "History and philology show that the species probably had its origin in the countries north of the Danube, and that its cultivation is hardly earlier than the Christian era in the Roman Empire, but is perhaps more ancient in Russia and Tartary."[1] Rye, however, ranks next to wheat as a bread-maker, and was formerly grown for that purpose in England. On the Continent of Europe it is a very important foodstuff, and rye bread is largely consumed in Holland, Belgium, Germany, Austria, and Russia.

Rye Grain has a structure similar to that of wheat, being naked or free from husk when thrashed, but narrower and darker in colour. The *testa* closely resembles that of wheat, but the unicellular hair-cells are shorter. Its composition is given in the annexed table.

Rye Flour.—The composition depends upon the care exercised in milling and bolting; the finest flour is deficient in proteins when compared with wheat. The starch is similar to that of flour; the granules are slightly larger, and vary from 0·039 to 0·052 millimetre; the largest have a rayed hilum or a triangular fissure radiating from the hilum; the granules are also flatter and more circular than in wheat or barley. The carbohydrates include, besides 58 per cent. of starch, about 3·8 or 4·0 per cent. of sugar, and 6 or 7 per cent. of dextrin. The *fat* consists of oleic, palmitic, and stearic acids, and a little cholesterin.

The **Proteins** of rye grain average 11 per cent. of the flour, but

[1] De Candolle's "Origin of Cultivated Plants," p. 373.

COMPOSITION OF RYE—NUTRIENTS PER CENT.

	Water.	Protein.	Fat.	Carbo-hydrate.	Cellulose.	Ash.	Authority.
Grain : Mean composition	13·50	11·00	1·80	69·50	2·00	2·20	Tibbles.
	14·24	10·97	1·95	70·64	1·63	1·48	König.
						1·80	
European	15·00	11·50	1·80	67·90	2·00	1·80	Parkes.
	13·50	13·10	2·00	69·30	—	2·10	
American : Mean	8·70	11·30	1·90	74·50	1·50	2·10	Richardson.
Maximum	10·00	15·60	2·90	77·50	1·90	2·70	
Minimum	7·00	8·80	1·40	68·70	1·10	1·30	
Dried Rye	—	12·50	2·25	79·55	3·10	2·60	Payen.
Rye Flour : Fine	14·24	10·95	1·95	69·74	1·63	1·48	König.
		Water-free Substance.					
Fine white	11·25	7·43	·99	91·09	—	·49	Romberg.[1]
Intermediate	11·84	11·59	1·14	86·35	—	·92	
	11·26	17·28	2·13	78·70	—	1·89	
Dark, entire grain ..	11·40	16·84	2·13	78·81	—	2·22	

[1] *Archiv f. Hygiene*, 1897, xxviii. 244.

vary from 8 to 15 per cent. according to its quality. Assuming 12 per cent. as a mean, the proteins consist of 3·35 per cent. of soluble and 8·65 per cent. of insoluble proteins. The soluble protein compares very favourably with that of wheat flour. Rye is never so finely milled as wheat, and some of the soluble protein of the aleurone layer, removed in the case of wheat, is included in the flour. Gluten is obtained from rye flour with difficulty; when wet it is of a dirty grey colour, and softens more readily than that of wheat. It consists chiefly of mucedin and gluten-casein. There is a remarkable deficiency of gliadin in rye gluten as compared with that of wheat. In rye gluten the gliadin : glutenin :: 8 : 92; in wheat gluten the gliadin : glutenin :: 62 : 38. This difference is the chief reason for rye being so much inferior to wheat as a bread-maker. The soluble proteins of rye are much more abundant than in wheat; and the effect of the soluble upon the insoluble proteins renders rye bread close, damp, and of small volume, instead of being spongy and bulky as in wheaten bread. But these soluble proteins are an admirable yeast food; by means of their diastatic property they produce sugar, which is utilized by the yeast. This fact is taken advantage of by English and Continental bakers in making ordinary wheaten bread: 3 pounds of rye flour is used for each sack of wheat flour; it is made into a paste with water at a temperature of 165° F., and allowed to stand for three or four hours, and then mixed with the leaven in the dough. Thus aided, the yeast will produce double the amount of CO_2 to that produced in wheaten flour alone. Unfortunately, the *softening* effect of the rye proteins on the wheat proteins will make the dough "runny" and the bread flat if too much is used.[1]

Rye Bread is usually made from a "straight grade" of flour, although white, intermediate, and dark flours are produced and used for special qualities. The composition of rye bread is given in the section on Bread. The digestibility of the finer qualities of rye bread is about equal to that of wheaten bread. The coarser and cheaper kinds are made of flour which has not been so carefully milled and bolted. It is estimated that 20 per cent. of the protein in fine rye bread escapes digestion, and 43 per cent. in coarse rye bread; 1·5 to 14 per cent. of the carbohydrates escapes digestion, according to the quality of the flour. These rather exceed the losses from white bread, which are as follows: Protein unabsorbed varies from 20 per cent. in fine white bread to 30 per cent. in Graham or whole-meal bread, and the carbohydrate unabsorbed varies from 1·1 to 7·5 per cent., according to fineness of the wheat flour.

Oats.

Oats are the seeds of *Avena sativa* and other varieties of *Avena* (German, *Hafer;* French, *Avoine*). "All the varieties of oats are *cultivated,* and none have been discovered in a truly wild state;

1 "The Modern Baker and Confectioner," vol. ii., p. 233.

it is therefore very probable that they have all been derived from a single prehistoric form, a native of temperate Eastern Europe and Tartary.[1] It is certain that oats were first cultivated in the Northern Hemisphere, and, according to De Candolle, the vernacular names prove its existence in Europe to the north and west of the Alps and on the borders of Europe towards Tartary and the Caucasus. Oats have been found in tombs of the first century A.D., or a little earlier in Germany, and in the remains of Swiss lake-dwellings of the Bronze Age ; but none have been found in the lake-dwellings of Italy, which confirms the belief that they were not cultivated in Italy at the time of the Roman Republic. The Latins knew the species and called it *Avena*, but there is no proof that it was cultivated by them. The ancient Greeks knew oats very well, and called the species Βρόμος. The Egyptians and Hebrews did not cultivate oats. The earliest mention of them in China is in a work on the history of the period 618 to 907 A.D., where *Avena sativa* is referred to. The species has therefore been cultivated for more than 2,000 years, particularly in Europe to the north of Italy and Greece, and later on it became diffused in the southern countries of the Roman Empire. Oats grow readily by the roadside and on rubbish-heaps near to cultivated ground—in fact, more readily than any other cereal—and persist in such a way as to appear wild. This fact has led to semi-wild oats being found in such widely different places as Yorkshire, Algeria, China, Japan, and the environs of Paris, and to the assumption that really wild oats have been found in the island of Juan Fernandez and other places, which, however, has not been established. The half-wild or naturalized oats are more common in Austria from Dalmatia to Transylvania than elsewhere. *Avena strigosa* is a variety of common oats which also has never been found wild, but exists in a semi-wild condition in deserted fields in Europe. *Avena orientalis*, Eastern or Tartarian oats, is a variety of which the spikelets lean all to one side ; it has been cultivated in Europe for more than a century. Like the other forms, it has not been found in a wild condition, but the local names given to it in Germany, Hungary, and Turkey, indicate its introduction from the East in modern times.

There are numerous varieties of the common oats (*A. sativa*), known as red, white, long black or bearded, the naked, the potato oat (one of the best kinds), and others. The seed or grain is closely invested by the husk, consisting of the *paleæ* and pericarp, which is very adherent to it. It is necessary to submit the grain to heat in a kiln in order to divest it of this husk or hull. The *testa* consists of three envelopes : (*a*) an external coat consisting of long narrow cells, with evenly serrated margins, and carrying short spinous hairs ; (*b*) the middle coat, very indistinct ; (*c*) the inner coat, resembling that of wheat, but with larger cells. The *endosperm* is the portion used for oatmeal, and it consists largely of starch.

[1] De Candolle, *ibid.*, p. 376.

COMPOSITION OF OATS—NUTRIENTS PER CENT.

	Water.	Protein.	Fat.	Carbo-hydrates.	Fibre.	Ash.	Authority.
English oats, average of 500 analyses	12·91	10·55	5·32	58·51	9·61	3·10	Tibbles' mean.
European oats, average of 170 analyses	12·30	10·40	5·20	58·00	11·10	3·00	König.
,, ,, ,, ...	14·00	11·50	6·00	56·50	9·00	3·00	Johnston.
American oats, in husk :							
Mean of 100 analyses	6·90	14·30	8·10	67·10	1·40	2·20	Richardson.
Highest	11·10	19·40	11·20	71·90	2·10	2·90	
Lowest	4·70	9·10	6·50	62·80	·90	·90	
American oats : Unhulled	10·00	12·15	4·33	57·90	12·07	3·46	Wiley's "Foods," p. 234.
Hulled	6·93	14·10	8·14	67·09	1·38	2·15	
Miscellaneous oats : Minimum ..	9·80	7·10	2·80	56·60	7·00	1·50	Balland, *Compt. Rend.*, 1897, 125.
Maximum ..	17·00	14·30	6·83	64·30	12·20	6·90	
Dried oats	—	14·39	5·50	69·84	7·06	3·25	Payen.

The **Composition** of oats naturally varies according as it is in the husk or decorticated. When the corn is ground with the husk upon it, the meal contains more fibre and cellulose ; but when the husk is removed, the grain is drier, the resulting meal contains less fibre and cellulose, but all the other constituents are increased in proportion.

The *Carbohydrates* consist of starch, sugar, and dextrin. The starch consists of minute polygonal or angular granules which are faceted ; they exist in aggregates of two or four granules, which appear like round or elliptical bodies. The individual granules are very small, average 0·004 millimetre, or 10 microns, and they show no lines nor hilum. The dextrin averages 2·04, and sugar amounts to 1·5 or 2·0, per cent., according to Blyth. The amount of *fat* is greater than in wheat, but is similar to it. The *mineral* substances are valuable ; the ash has the following composition : Potash 37·48, soda 2·40, lime 3·00, magnesia 7·80, ferric oxide 0·69, phosphoric acid 20·80, sulphuric acid 1·80, chlorine 0·22, and silica 25·9, per cent.

The Proteins.—The proportion of nitrogenous material is fairly high, but its constitution is such that it will not form gluten, for which reason oatmeal is a poor bread-making material. The proteins are determined by the factor N × 5·7, as in wheat and rye. They consist chiefly of **avenin**, also called oat-myosin, oat-legumin, or oat-casein, and a very little oat-gliadin. Wiley[1] gives the proportion as follows : Proteins of oats—soluble in alcohol 1·25, soluble in salt solution 1·5, soluble in alkali solution 8·5, total 11·25, per cent. Avenin, or oat-myosin, can be obtained by washing oatmeal upon a fine sieve and allowing the milky liquid to deposit its starch ; the liquid is then decanted, heated to 200° F., and acidulated by acetic acid, when the protein will be precipitated as a white flocculent mass. It is similar to the legumin of peas, but contains more sulphur (see Legumes).

Oatmeal.—The best oatmeal is made from decorticated oats (**groats**), the bran having been carefully removed without the removal of the germ. The grain requires to be carefully prepared. Even the finest oatmeal sometimes contains portions of the " beard," husk, or other parts of the bran, which are apt to irritate the gastric and intestinal mucosa, thereby causing catarrh of these viscera. In some persons the coarse particles produce diarrhœa, and in others they form hard fæcal accumulations or concretions, which in turn irritate the mucous membrane. Oatmeal, even the finest, requires thorough cooking in order to soften the cellulose. Moreover it is a valuable food, both as flesh-former and energy-producer. Parkes compared it with other foods thus : One ounce of potato yields 33, of egg 68, bread 88, cooked meat 106, pea flour 119, **oatmeal 130**, cheese 150, and butter 339, foot-tons of energy when completely oxidized. Atwater found the fuel value of 1 ounce of potato was 24, egg 45, bread 75, cooked meat 82, pea flour 103,

[1] " Foods," p. 224.

oatmeal 116, cheese 134, and butter 225, calories. E. Smith compared cereals in the following way:

	Nitrogen.	Carbon.
	Grains.	Grains.
Oatmeal, one pound contains	140	2,768
Wheat flour, ,, ...	120	2,656
Barley meal, ,, ...	93	2,500
Rye meal, ,, ...	88	2,660

These estimates all show that oatmeal is a superior food.

Bread made from oatmeal by the aid of fermentation is soft in texture and very wholesome; oat-cakes are usually unfermented. The stomach requires some discipline before it can digest them with ease and comfort.

Oatmeal and other oat preparations are nutritive and stimulating foods. When combined with milk they form a typical and almost ideal food, which is very suitable for persons doing mental work. They have a laxative effect, and, when taken as a breakfast food, are of service to persons who suffer from habitual constipation. Oatmeal is apt to disagree with some dyspeptics, causing them pyrosis and acidity. Those accustomed to it may also become dyspeptic, and may find relief from their sufferings by a temporary cessation of its use. The intestinal concretions which sometimes occur in consumers of oatmeal consist of phosphate of lime and the stiff hairs from the end of the oat grain, agglutinated together by mucus or animal matter. They were formerly much more common than at the present day, their formation being obviated by decorticating and properly cleaning the oats before they are ground.

Barley.

Barley is the grain of *Hordeum* (German, *Gerste;* French, *Orge*). Barley, like oats, is closely invested with the husk, consisting of the *paleæ*, which is everywhere adherent to it, for which reason it is classed by some authorities with the spelts. There are three varieties of this species of grass: *Hordeum distichon*, which bears two rows of flowers and seeds; *H. vulgare*, bearing four rows; the Escourgeon (*H. vulgare hybernicum*) is a variety of the latter grown in France; and *H. hexastichon*, bearing six rows of flowers and seeds. The only kind which has been found wild is the two-rowed barley, *H. distichon*, the simplest and least productive variety. It is probable that the four- and six-rowed barleys were derived from it by natural or artificial selection. *H. distichon* has been found wild in Western Asia, Arabia, about the ruins of Persepolis, near the Caspian Sea, to the south of the Caucasus, and in Turcomania.

Barley is among the most ancient of cultivated plants. It was cultivated by the Semitic and Turanian peoples, but it has not

COMPOSITION OF OATMEAL AND OTHER PREPARATIONS OF OATS—NUTRIENTS PER CENT.

	Water.	Protein.	Fat.	Carbo-hydrate.	Cellulose.	Ash.	Authority.
Oatmeal—Fine : Minimum ..	8·20	12·90	8·00	54·00	—	1·70	Dyer, *The Analyst*, 1901, 152.
Maximum ..	9·50	18·10	10·23	65·60	—	4·00	
Coarse : Minimum ..	7·90	13·00	8·70	64·50	—	1·70	
Maximum ..	9·10	15·40	10·32	65·20	—	1·90	
Crushed oats : Minimum ..	8·10	12·60	7·50	65·20	—	1·60	
Maximum ..	8·90	15·10	9·30	67·00	—	1·90	
Oatmeal, average	7·66	15·48	7·46	67·71	1·29	1·25	Wiley's "Foods."
	12·92	11·73	6·04	55·43	10·83	3·05	Blyth's "Foods."
Irish, average	9·26	16·18	8·00	57·23	6·90	2·00	Johnston.
Scotch, average	8·70	12·70	7·50	62·00	7·60	1·50	
	7·30	16·10	7·20	67·50	·90	1·90	
Boiled	84·50	2·80	·50	11·50	—	·70	Atwater, Bulletin 28.
Gruel	91·60	1·20	·40	6·30	—	·50	
Water	96·00	·70	·10	2·90	—	·30	
Rolled oats	7·70	16·70	7·30	66·20	1·30	2·10	
Scotch oatmeal	5·00	14·60	10·10	65·10	3·10	2·10	
Irish oatmeal	5·00	13·40	8·80	68·40	1·70	2·00	
Scott's Oat Flour	5·80	10·00	5·00	7·79		1·70	
Montgommery's Oat Flour ..	6·30	11·00	6·80	74·20		1·70	Hutchison, "Food and Dietetics," p. 214.
Quaker Oats	7·80	14·70	6·20	69·80		1·50	
Carter's Oats	3·10	12·80	6·20	76·00		1·80	
"H.O."	9·00	13·80	8·30	67·20		1·70	
Robinson's Groats (decorticated oats)	10·40	11·30	6·50	70·40		1·70	

been found in Egyptian monuments. It is mentioned in the Old Testament, the writings of Berosus, Moses of Chorene, Pausanias, Theophrastus, and Marcus Polo. It was cultivated in Switzerland by the lake-dwellers before they possessed metals. The common four-rowed barley is certainly less ancient than the two-rowed. However, it is mentioned by Theophrastus, and therefore it has been cultivated for more than 2,000 years; but it has not been found in Egyptian monuments or remains of lake-dwellings. On the other hand, the six-rowed barley, called **bere** or **bigg**, is not only mentioned by Greek authors, but has been found in the earliest Egyptian monuments, and in remains of the lake-dwellings of the Stone Age in Switzerland, and those of the Age of Bronze in Italy and Savoy. It is therefore more ancient than the four-rowed or common barley. There are other varieties of cultivated barley—*e.g.*, the **fan-shaped** barley (*H. zeocriton*), which appears to be a recent form derived from *H. distichon* by cultivation; as also does that variety in which the grain is bare at maturity (*H. distichon nudum*), which in France is called "coffee barley" and "Peruvian barley."

Barley was formerly extensively used as a bread-maker by the peasants or serfs of England in early times, a moderately good bread being made by combining it with a small proportion of rye or wheat. This was the common foodstuff of the peasantry down to the reign of Charles I., while as recent as the middle of the eighteenth century it was usual for the labourers of the South of England to be paid their wages in meal or grain, usually barley. At that time barley bread was commonly consumed in Wales, Westmorland, Cumberland, and part of Scotland, where wheaten bread was a luxury eaten only upon special occasions, except by the wealthy. Writing in 1858, Robert Hogg, in his "Vegetable Kingdom," says barley "is a common article of food among the poor population of several countries of Europe, particularly in the mountainous districts of Switzerland, Sweden, and Scotland." But the superior qualities of wheat as a bread-maker, together with the more abundant supply of that cereal from colonial and foreign sources, have led to a successive decline of the use of barley for this purpose. In Northern Europe it is still used more or less for bread-making; and if ever the supply of wheat in England falls below the demand for it, it is possible that barley bread, made from properly cleaned, decorticated, and milled grain, would again come into use.

Barley is now grown chiefly for the manufacture of malt liquors and spirits, or for feeding cattle and horses. English and Irish barleys are better than Scotch. The variety most commonly grown in England for malting is the two-rowed barley (*H. distichon*), but the six-rowed barley (*H. hexastichon*) is largely grown in Scotland for the same purpose. The latter is known by the names of **bere** and **bigg**; it is an inferior kind of barley, containing three times as much fibre as the ordinary kind of grain; otherwise the composition is similar.

THE COMPOSITION OF BARLEY—NUTRIENTS PER CENT.

	Water.	Protein.	Fat.	Carbo-hydrate.	Cellulose.	Ash.	Authority.
Barley, 450 analyses : Minimum ..	4·50	7·40	1·20	56·90	2·50	1·50	
Maximum	16·00	14·90	3·50	76·90	12·00	4·40	
Average ..	12·30	10·05	2·23	68·78	5·15	2·57	
European	13·50	11·10	2·20	65·00	5·30	2·70	König.
	14·05	10·58	2·05	63·66	7·09	2·57	Warrington.
English	16·00	9·50	2·50	63·20	6·30	2·50	Johnston.
Saxon	15·00	8·40	1·60	66·80	4·60	3·60	Maercker.
Canadian	8·00	9·80	2·70	73·20	3·50	2·80	Richardson.
American : Minimum	4·50	8·80	2·10	69·40	2·60	1·50	
Maximum	9·20	14·90	3·50	76·80	4·70	4·40	
	6·50	11·30	2·70	72·80	3·80	2·90	
Average	11·31	10·61	2·09	69·47	4·07	2·44	Church.
	12·30	10·10	1·90	69·50	3·80	2·40	Bulletin 45.
Pearl or decorticated barley ..	11·50	8·50	1·10	77·80	·30	1·10	Atwater.
European	12·70	7·40	1·20	76·70	·80	1·20	König.
American	6·30	11·80	2·70	75·40	1·60	2·20	Richardson.
Dried barley	—	12·96	2·76	76·43	4·75	3·10	Payen.
	12·00	13·20	2·60	56·90	11·50	2·80	Lawes and Gilbert.
	11·90	10·50	2·20	72·80	6·50	2·60	Atwater.
Barley meal	10·81	12·76	2·90	63·59	6·30	3·60	Addyman.
	11·30	12·70	2·00	71·00	—	3·00	Parkes.
	11·90	10·00	2·20	72·50	1·80	2·60	Hutchison.
Barley flour	14·30	11·25	1·75	72·00	—	1·00	Kenwood.
Robinson's Patent Barley ..	10·10	5·13	·95	81·87	—	1·93	Leeds.
Granulated barley	10·90	7·50	·90	79·80	·70	·90	Atwater.
Barley bread	12·39	5·90	·90	74·90	5·93	—	Blyth.
Barley malt (pale)	—	13·90	1·65	65·38	11·57	2·60	Valentine.
Barley water	99·29	·03	·02	·44	—	·03	Blyth.

A grain of barley has practically the same structure as that of wheat—viz., the "hull" or skin, the endosperm, and germ. The husk, however, is adherent, and consists of the *paleæ*, beneath which is the pericarp or testa. The **testa** is similar to that of wheat; the cells of the external layer, or epidermis, however, are smaller than those of wheat, more uniform in size, their outline is serrated instead of beaded, and some of them bear short thick hairs. The aleurone layer consists of four rows of cells, instead of one as in wheat and rye. These characters serve to distinguish barley flour from the flour of other cereals, when aided by an examination of the starch grains. The granules of starch are similar in shape to those of wheat, but there are more of the intermediate size than in wheat, instead of being either large or small. The size of the largest granules is about 0·26 millimetre; in these the striæ are slightly visible, but not in the smaller ones. The carbohydrate includes sugar and dextrin, which are put down as amounting to 10 per cent. in water-free barley, by Payen, equivalent to about 8·7 per cent. in ordinary ripened barley; but this is too much according to most authorities—indeed, 4 or 5 per cent. is nearer the mark. Blyth says the sugar averages 3·9 per cent., and Johnston gives sugar 1·5, dextrin 1·25, per cent. Smith found 4·9 per cent. of sugar in barley meal. Very little is known about the fat in barley.

The Proteins.—The amount of protein is determined by the factor N × 6·0. The total protein is less than in wheat, rye, and oats. Barley always contains less gluten than wheat; only small quantities can be obtained by washing the dough. Proust found only an average of 3 per cent.; but Fleurent gives the amount of insoluble protein as 13·8 per cent., equivalent to a mixture containing gliadin 15·60 to glutenin 84·40 per cent. Barley grown on light chalk or dry gravelly land contains less gluten than that grown on heavy loam or clay land, but it is more suitable for the purposes of the brewer.

Analysts formerly named the proteins of wheat gluten-casein, gluten-fibrin, mucedin, and albumin, following the example of Ritthausen; the gluten-casein being nearly insoluble in water and dilute acids, but readily soluble in dilute alkaline solution; mucedin being also only slightly soluble in water, but soluble in alcohol, dilute acids, and alkalies. The protein of barley insoluble in salt solution, like glutenin of wheat, is probably a combination of mucedin, casein, and fibrin. In more recent years, however, the proteins of barley have been reinvestigated, and Osborne found the total proteins to be as follows:

(*a*) Insoluble proteins—		
Hordein, insoluble in salt solution	..	4·00 per cent.
Protein, another insoluble in salt	..	4·50 ,,
(*b*) Soluble proteins—		
Edestin (a globulin) and proteose	..	1·95 ,,
Leucosine, an albumin	..	·30 ,,
Total	..	10·75 ,,

Petit has also extracted a nuclein from barley, but it differs from the nucleins of Kossel, according to Bunge and Liebermann, in not containing sulphur.[1] There is no gliadin, but the hordein resembles it, and is sometimes called by that name; it consists of C 52·75, H 6·84, N 17·72, O 22·48, S 1·21, per cent. (Osborne). The other insoluble protein corresponds to the glutenin of wheat. These proteins are not sufficiently adhesive to make good bread; but barley flour answers very well for this purpose when mixed with wheat or rye flours, and the proportion of protein can be increased by adding bean or pea flour to the combination. The mineral substances in barley grain average 2·57, in the meal 2·8, in decorticated or pearl barley 1·2, per cent.

COMPOSITION OF THE ASH.

	Per Cent.[2]	Per Cent.[3]
Potash, K_2O	21·38	21·35
Soda, Na_2O	4·00	2·25
Magnesia, MgO	9·10	8·66
Lime, CaO	2·40	2·74
Ferric oxide, Fe_2O_3	·15	·91
Phosphoric acid, P_2O_5	33·17	35·19
Sulphuric acid, SO_3	2·10	1·72
Silica, SiO_3	27·50	26·10
Chlorine, Cl	·30	·88

Pearl Barley (*H. decorticatum*) consists practically of the endosperm, the hull and the testa having been removed by decorticating and polishing the grain. Scotch barley is about the same as pearl barley, but not quite so much of the external covering is removed. They require to be boiled for two hours at the least in order to permit of their easy digestion.

Malt.—The reader is referred to the chapter on Malt Liquors for an account of malt and the changes produced in the grain by malting.

Malt Extract is an excellent dietetic preparation. It is obtained by the maceration of powdered malt in water for five or six hours; the expressed liquid being afterwards evaporated at a temperature of about 115° F., but not exceeding 125° F.; otherwise the diastase will be destroyed.

COMPOSITION OF EXTRACT OF MALT.[4]

Proteins	6·39 per cent.
Maltose	45·00 ,,
Invert sugar	14·49 ,,
Cane-sugar	3·40 ,,
Dextrin	7·20 ,,
Ash	1·70 ,,
Water	21·76 ,,

[1] *Compt. Rend.*, 1893, cxvi. 18.
[2] Johnston's "Agricultural Chemistry," p. 272.
[3] Wolff, Thorpe's "Dictionary of Applied Chemistry," vol. iii., p. 143.
[4] Chapman, *The Analyst*, 1901, 231.

It is thus seen that malt extract contains 65 to 70 per cent. of assimilable carbohydrates, which Korn[1] gives as having the following variation: Maltose 41·43 to 60·43, dextrose 0·47 to 6·24, cane-sugar 0·33 to 3·60, dextrin 11·70 to 22·70, per cent. The proteins, according to Osborne and Campbell,[2] consist of maltoglobulin or bynedestin; leucosine, an albumin, identical with that found in wheat, rye, and barley, and intimately associated with the diastase; bynine, a proteose which forms 1·25 per cent. of malt; and two other proteoses or protoproteoses. Malt extract is therefore a highly concentrated carbohydrate food containing a fair proportion of proteins. In addition it contains enough diastase to convert several times its own weight of starch from almost any farina into maltose, ready for assimilation. These characters make it a carbohydrate food of great value in wasting diseases. As an aid to the digestion of farinaceous foods, it may be taken by many people whose power of digesting the starches has been enfeebled. It is best taken before a meal in a little warm gruel or milk; if it is taken after a meal, two hours should be allowed to pass—that is to say, it should not be taken until gastric digestion has passed its height, and the acid gastric juice has become exhausted or the hydrochloric acid fixed; the diastase will then assist in the final stages of digestion. Malt extract has a further use in dietetics, especially in the feeding of infants. Cow's milk normally forms large curds in the early stage of digestion, and the curds formed in some states of the body are unusually hard and firm. If, however, one or two teaspoonfuls of extract of malt be added to ½ pint of milk, freshly boiled and cooled down to 110° or 115° F., stirred in and allowed to stand for ten minutes, the casein will be so affected that the coagula formed in the stomach after its consumption will be light, flocculent, and easily digested. Such milk can be given to adults who vomit cow's milk in large hard curds, or suffer from discomfort after drinking it. It may also be used as the basis of infants' food, being diluted with water, and some cream added to it, to bring it up to the standard strength of human milk.

Barley Water is a useful demulcent and slightly nutritive fluid, which has many uses in sick-room dietary and infant feeding. It possesses to a slight extent the property of preventing milk from coagulating in hard large curds referred to above. It is made by washing 2 ounces of pearl barley well with cold water, rejecting the washings, and afterwards boiling it with a pint of water for twenty minutes in a covered vessel. For infants' foods it is strained and used plain. For sick-room uses it is usually flavoured with sugar and lemon-juice, or lemon-peel is boiled with it. The longer the barley is cooked, the more dextrin is extracted, and such barley water is considered even better for mingling with milk for infants, as the dextrin prevents the clotting of the milk in the infant's stomach.

[1] *Berl. der Deutsch Pharm.-ges.*, vi. 349.
[2] *Jour. Amer. Chem. Soc.*, xviii. 542.

Rice.

Rice is the grain of *Oryza sativa* (German, *Reis ;* French, *Riz*). It is indigenous in India and Southern China ; there are several species, five of which are considered by the Chinese to be indigenous in their country. It has been found growing wild in various parts of India, and historical evidence as well as botanical probability tend to show that it existed there before the art of cultivation. De Candolle considers it probably existed before all cultivation in Southern Asia from China to Bengal. It is a very ancient food material, being one of the five seeds sown in the annual ceremony instituted by Chin-Nong, 2800 B.C. In British India its cultivation dates at the least from the Aryan invasion, for it is frequently mentioned in Sanskrit writings. The Greeks became acquainted with it through Alexander's expedition, and its cultivation was established from this time (400 B.C.) in the Valley of the Euphrates, and from the beginning of the Christian era in the hot and irrigated districts of Syria, whence it spread into Egypt. The Arabs introduced it into Spain ; it was first cultivated in Italy, near Pisa, in A.D. 1468, and more recently in Louisiana, U.S.A.

Rice is chiefly grown in India, China, Burmah, Siam, Ceylon, the West Indies, and tropical America. It grows in damp or swampy regions where the soil is under water during part of the year, or where it can be flooded by irrigation. It is harvested in the same manner as wheat, being thrashed and winnowed. The grain, however, is still covered by a yellow or reddish integument, consisting of the *paleæ*, and is commonly called " rough rice " in America, and " paddy " or *padi* in Asia. Consequently the grain has to be decorticated or hulled before it is consumed ; only hulled or pearled rice enters the British markets. It is mostly imported from the East Indies and Indo-China, a large amount coming direct from Bengal and Burmah.

There are more than a hundred varieties of rice, forty of which are cultivated in Siam alone. Some varieties resemble each other very closely ; others present characteristics of size, shape colour, and flavour, which are very distinct. Possibly some of these characteristics have been evolved by the conditions under which the cereal has been cultivated for centuries—*e.g.*, glutinous rice, red rice, and the small round-grained rice. Glutinous rice is quite different from the ordinary rice. It cannot be eaten in large quantities with impunity by those unused to it ; it is injurious to their health and constitution. But it is eaten by many people as a luxury, and considered a delicacy. Red rice is also peculiar ; when ripe the ears of the cereal are black, but when hulled and boiled the grains are of a reddish colour and have a peculiar fragrance.[1]

The composition of rice and its product varies, the same as that of other cereals and vegetables, with the soil on which it is grown, the variety of the plant, and other conditions. It forms a staple

[1] A. C. Carter, " The Kingdom of Siam," p. 23.

COMPOSITION OF RICE—NUTRIENTS PER CENT.

	Water.	Protein.	Fat.	Starch.	Sugar and Gum.	Cellulose.	Ash.	Authority.
Rice : In Husk	9·60	5·90	1·80	72·70		5·80	4·20	König.
Hulled	12·58	6·73	1·88	74·66		1·53	·82	
Polished	12·52	7·52	·84	78·80		·48	·64	
In husk	10·50	6·80	1·60	68·10		9·00	4·00	Bulletin 45, U.S. Department of Agriculture.
Hulled	12·00	7·20	2·00	76·80		1·00	1·00	
Polished	12·40	6·90	·40	79·40		·40	·50	
East Indian rice	12·80	7·30	·60	78·30		·40	·60	Church.
	12·10	8·95	·42	76·25	·86	·32	1·10	
	13·20	8·79	·71	73·90	1·20	·40	1·60	
	13·23	6·87	·35	77·40	·95	·36	·80	
Patna	9·80	7·22	·09	80·00	1·81	·18	·90	Thorpe's "Dictionary of Applied Chemistry," vol. iii., p. 378.
Russian	10·70	7·94	·40	75·80	1·21	·44	1·78	
Persian	10·80	11·21	·75	73·20	1·45	·81	1·45	
Egyptian	11·84	6·70	—	73·30	—	—	1·16	
Japanese : (*a*) Mountain	—	8·75	2·58	85·53		1·90	1·18	Kellner.
(*b*) Marsh : Ordinary	12·60	7·00	2·29	84·76		4·50	1·37	
Glutinous	—	5·87	3·44	83·89		5·20	1·61	
Ordinary	12·80	6·10	2·00	73·90		4·00	1·20	Kinch.
Piedmont	—	3·60	·25	84·05		4·80	—	Braconnet.
American, polished	12·40	7·40	·40	79·20		·20	·40	Jenkins.
Parched rice	—	7·55	·80	89·65		1·10	·90	Payen.
Boiled rice	52·70	5·00	·10	41·90		—	·30	Hutchison.
	72·50	2·80	·10	24·40		—	·20	Atwater.
Rice pudding	63·00	4·30	8·80	22·10		·20	—	Tibbles.
Rice custard	59·40	4·00	4·60	31·40		—	·60	Atwater.
Rice flour	10·80	7·20	·10	78·80	1·6	·20	·90	Lawes and Gilbert.
Rice meal	10·30	13·00	9·31	53·97		6·12	7·20	Addyman.
Rice semolina	10·80	7·34	·30	86·88		·40	·20	Balland.
Ground rice	12·00	5·00	·50	82·00		—	·50	Kenwood.
Flaked rice (rizina)	9·50	7·90	·40	81·90		·20	·30	Atwater.

food of the inhabitants of China, Japan, Siam, Burmah, parts of India, and the Indian Archipelago. It is, in fact, the "staff of life" for about one-half of the human race. But although it affords sustenance for millions of people in the tropics, the composition shows that it is not equally suitable for the denizens of temperate climates. The fat is very small in amount, being less than in other cereals. The "gluten," according to Payen, averages only 7 per cent., which contrasts with the 22 per cent. in wheat, 14 per cent. in oats, and 12 per cent. in maize, which were found by the same authority.

The carbohydrates consist chiefly of starch, the sugar and dextrin only amounting to about 1·25 per cent., about 0·4 per cent. being sugar. The starch is the main portion of the endosperm, which is surrounded by the **testa.** The testa, or pericarp, of rice has an external coat consisting of long narrow cells and fine siliceous particles collected together in ridges, which cross and recross each other at right angles. The "hair cells" are numerous, and the "hairs" long and spinous. The middle and inner coats consist of elongated narrow cells, which are flattened and variously arranged. This condition necessitates that the grain should be hulled or decorticated, and, at any rate in Europe, only polished rice is used. The starch consists of granules which are closely packed together in angular masses in the cells of the endosperm ; they are exceedingly minute, from 0·0050 to 0·0076 millimetre (4 to 6 microns) in diameter, faceted, show no striæ, but have a distinct hilum in the centre, visible under a high power.

The proteins exist only in a small proportion in rice when compared with the amount in wheat and oats. The amount was estimated by Parkes as averaging only 5·0 per cent., but the foregoing table shows that it varies from 5·0 to 11·0 and averages about 7·0, per cent. The factor for determining the amount of proteins in rice is $N \times 5{\cdot}7$, which is the same as for wheat, rye, and oats. Their character is such as to render rice flour unsuitable for bread-making, the proportion of gliadin to glutenin being 14·3 : 85·7, according to Fleurent.[1] Although rice itself is not a good bread-maker, it may in times of scarcity be combined with wheat to make bread, and, being consumed in other forms, would lessen the demand for bread.

The mineral substances are chiefly phosphates of potash and magnesia. The ash consists of potash 23·7, soda 4·0, magnesia 12·1, lime 3·15, phosphoric acid 55·0, sulphuric acid 0·05, silica 2·0, with ferric oxide 1·23, per cent.

Rice as a Food.—It is poor in protein and fat, but rich in carbohydrates and minerals. Its poverty in nitrogen makes it a badly balanced food when consumed alone, the starch being out of proportion to the other principles. It is consumed enormously by the inhabitants of Eastern countries, and is suitable for their temperament and climate. It should not be overlooked, however,

[1] *Compt. Rend.*, 1901.

that the same people consume the soy bean and its preparations, especially soy cheese and sauce, which largely compensate for the deficiency of protein. The deficiency of rice in stimulating properties, infinitely less than those of oats and oatmeal, accounts to some extent for the indolence and apathy of many Orientals, and it is a significant fact that the advance of the Japanese as a nation is contemporaneous with the larger consumption of flesh foods. When taken alone, rice is not sufficiently stimulating, especially to the inhabitants of temperate regions, and particularly to those who live in Northern climates. When, however, it is taken in combination with other foods—that is, as one of several courses rather than the entire repast—it is a valuable addition to our food. It has the advantage of possessing an easily-digested starch granule, and for this reason is a useful food in disordered states of the alimentary canal. In the case of persons suffering from diarrhœa or dysentery, it agrees better than any other kind of solid food. It has no laxative effect, such as is exerted by some of the other cereals, but is often regarded as constipating, while as a matter of fact it is simply neutral. Perhaps it is best eaten in the form of rice pudding, combined with the fat and proteins of eggs and milk. This is a valuable and nutritious food, easy of digestion, and of great value in every form of illness and invalidism where carbohydrates are allowable. When cooked alone, rice is better steamed than boiled, as by this method the granules become fully swollen without loss of protein and soluble materials. If it is boiled, a portion of the already small quantity of protein and saline matter is lost. Although rice alone does not admit of being made into bread, it is much used in Paris in forming the very white bread which is so much in request.

Beri-beri.—The frequent association of beri-beri with the consumption of rice has led to the belief that the disease arises from this article of food. The matter has been keenly debated, and no satisfactory conclusion has been drawn. The consumption of unpolished rice is said by some men to be the cause of the disease; others have asserted that it is due to polished rice. A substance called *arsin* has been isolated, which is credited with being the actual cause of the disease; but even this has not been definitely proved. It is possible that the disease is due to an absence from the decorticated grain of some substance which is essential for nutrition, and upon this point work has been done and is still being undertaken by Fraser and Stanton.[1] At the end of every grain of polished rice there is a minute depression, which contained the germ or embryo plant. After the *padi* or rice grain has been hulled, and most of the husk removed by winnowing, the grain is passed into a polishing apparatus, where it is deprived of the pericarp, subpericarp, and the germ. The subpericarpal layers are yellow, so that rice which is not highly polished is of that colour. But rice sent to the European markets is usually rendered white by the

[1] "The Etiology of Beri-beri."

removal of the subpericarpal layer, and the subsequent facing or glazing of the grain with talc. The polishings, or those materials which have been removed, therefore, should afford some information to the investigator. We already know that all cereals contain enzymes and amino-acids in the aleurone layer (part of the subpericarpal substance) and the germ, and the writer believes these bodies to be of great importance in promoting the growth and nutrition of the consumer. When the grain is hulled it is deprived of these substances. Whether the polishings contain any definite substance other than the enzymes and amino-acids, whose removal leads to the poor state of nutrition which obtains in beri-beri, or any poison which causes that disease, remains to be seen.

Curry consists of boiled rice combined with cayenne pepper and various other spices, which render the food heating and stimulating (see Curry-Powder).

Ground Rice consists of the grain reduced to various degrees of fineness, and is much used for making puddings, cakes, etc., with eggs, butter, and milk.

Rice Semolina is very much coarser than ground rice.

Flaked Rice consists of the grains prepared in the same way as "rolled oats," whereby some of the starch is dextrinized. The grain is steamed until the starch granules are ruptured, and afterwards pressed flat and dried between hot rollers.

Roasted or "Torrified" Rice.—The cereal is subjected to heat in a revolving cylinder until the starch grains burst and some of the starch is dextrinized. The rice is by this means largely increased in size.

Rice from various regions shows different characteristics, which are specially noticeable when the grain is boiled. Some kinds of Indian grain remain distinct after cooking, do not become mucilaginous or adhere together, and are the best for making curry. Other grains, like those of Carolina, break up during boiling, and form a soft and mucilaginous food ; these are better for puddings. The varieties imported chiefly into England are—

1. *Carolina Rice,* consisting of large roundish grains of good colour and sweet taste, which swell up and become pulpy, and somewhat glutinous, during cooking. This kind is considered by far the best rice, the puddings made from it being creamy and palatable.

2. *Java Rice* ranks next to it, and has similar characteristics ; it is highly esteemed.

3. *Patna Rice* is also highly esteemed. It consists of long slender grains, which are narrow-pointed and very white. When boiled the grains remain firm and distinct, never glutinous like Carolina rice. This kind is therefore the best for making curries, for boiled rice, and for rice flour.

4. *Rangoon Rice* is of less value than either of the others. Three classes of Indian rice are sold under this name : (1) Table rice, (2) Ballam, (3) Moonghy ; the latter is very inferior.

Rice Starch.—Rice is largely used for making starch. The flour is treated with an alkaline solution, such as caustic soda, to dissolve out the nitrogenous matters. The starch is then allowed to deposit, being subsequently washed and dried. The starch granules are remarkable for their smallness of size, being irregular-shaped or angular (see Starch).

Maize—Indian Corn.

Indian corn is the grain or seed of maize, *Zea maidis* (German, *Mais ;* French, *Mais*). Maize is a true grass, native of America, but grown for ages in the Asiatic islands under the Equator, whence its cultivation has spread over immense regions in Europe, Asia, Africa, and America. The proofs of its American origin have been disputed, but remain unshaken, although it has not been found growing wild there. Its cultivation in that country is very ancient. The Peruvians and Mexicans cultivated it in the early days. There is a tradition that Nahualt, chief of the Nahuas, who preceded the Incas and Toltecs, taught its cultivation. De Candolle thinks maize probably first existed in the high lands of Chili and Mexico or New Granada.[1] Maize was unknown in Europe at the time of the Roman Empire, and is said to have been brought from the East in the Middle Ages, at which time its cultivation became widespread. But the total silence of authors on the subject of maize before the discovery of America is against the idea of its Oriental origin. We refer the reader to the discussion of the matter in De Candolle's " Origin of Cultivated Plants." The conclusion there arrived at is that maize is not a native of the Old World, but became rapidly diffused after the discovery of America ; that if it had a prior existence in Asia or Africa it would have been much earlier cultivated there, and played a part in agriculture for thousands of years. When the new continent was discovered, maize was one of the staples of cultivation from the Valley of La Plata to the United States. It was found in the burial-grounds of the natives of North America who preceded those of our day, also in the tombs of the Incas and the catacombs of Peru, just as wheat, barley, and millet, are found in the Egyptian monuments and remains of lake-dwellings in Europe. The civilization of the Peruvians under the Incas, and of the Toltecs and Aztecs in Mexico, is not so ancient as that of the Chinese, Chaldeans, or Egyptians, and dates at most from the beginning of the Christian era. But the cultivation of maize is far more ancient than the civilization of the natives or their monuments, judging from the species of the cereal, the numerous varieties which have arisen, and their dispersal into remote regions. Darwin[2] found ears of Indian corn *embedded with sea-shells in land at a height of* 85 *feet above sea-level*, a proof not merely of the antiquity of the American Indians, but of the cultivation of maize. " The antiquity of the Indo-human race here, judging by the 85 feet rise of land, since the relics [including the maize—

1 " The Origin of Cultivated Plants," pp. 390-392.
2 " The Voyage of a Naturalist," p. 353.

COMPOSITION OF MAIZE, OR INDIAN CORN, AND ITS PREPARATIONS—NUTRIENTS PER CENT.

	Water.	Protein.	Fat.	Carbo-hydrate.	Cellulose.	Ash.	Authority.
Maize from all parts of the world, mean of 871 analyses	10·99	10·27	4·87	69·87	2·22	1·33	Tibbles.
American corn: Minimum ..	9·58	8·58	2·95	68·97	1·00	1·19	Bulletin 50, Div. Chem., U.S. Department of Agriculture.
Maximum ..	13·32	11·55	5·06	75·07	2·00	1·55	
Average ..	10·93	9·88	4·17	71·95	1·71	1·36	
Mean of 200 analyses	10·04	10·39	5·20	70·69	2·09	1·55	
Northern States	9·98	10·64	5·11	71·32	1·54	1·41	
Southern States..	8·96	10·95	4·94	72·06	1·72	1·37	
Middle West	12·33	10·89	4·97	68·16	2·22	1·43	
Far West	9·50	10·43	5·30	70·75	2·47	1·55	
Pacific Slope	9·78	8·14	6·40	72·13	2·07	1·48	
European corn: Minimum ..	10·43	9·80	4·02	68·02	1·57	1·26	
Maximum ..	12·60	11·55	4·85	71·85	2·20	1·80	
Average ..	11·71	10·72	4·51	69·65	1·87	1·54	
Italian corn	10·26	3·84	2·88	67·72	2·88	1·95	König.
South-East Europe	14·53	9·42	4·13	69·37	2·34	1·39	
South-West Europe	12·47	8·84	5·80	65·79	4·16	2·06	
Miscellaneous	13·35	9·45	4·29	69·33	2·29	1·29	
White maize	13·30	9·56	4·84	67·04	1·72	1·72	Zegga and Maistovoric.[1]
Yellow maize	12·60	10·11	4·23	72·14	1·43	1·40	
Sugar or sweet corn	8·70	11·43	7·79	62·76	2·86	1·81	König.
	8·40	11·48	8·57	66·72	2·82	1·97	Richardson.
Popcorn: Raw	10·08	11·20	5·20	71·40	—	1·40	Bulletin 28.
Popped	4·30	10·70	5·00	78·70	—	1·30	
Maize meal, corn-flour: "Becta," or best	12·66	6·94	1·21	78·67	·63	·52	Bulletin 50, Div. Chem., U.S. Department of Agriculture.
"Topeka"	12·05	8·50	1·76	76·86	1·17	·83	
"Decatus"	13·01	5·94	1·02	79·56	·80	·47	
Average	12·57	7·13	1·33	78·36	·87	·61	
Maize meal: Hominy	11·97	8·20	·60	78·90	—	·40	Bulletin 28.
Cerealine..	10·60	9·50	1·00	78·60	—	·30	
Corn-starch "Maizena"	14·30	·50	—	84·90	—	·30	Klemperer.
Corn-bread "Johnny" cake ..	38·00	8·50	2·70	47·30	—	3·50	Bulletin 28.
Hominy, cooked	—	2·20	·20	17·80	—	—	

[1] *Chem. Zeit.*, 1899, xxiii, 544.

Author] were embedded, is the more remarkable, as on the coast of Patagonia, where the land stood the same number of feet lower, the Macrauchenia was a living beast."[1]

Although maize is a staple food in America and Africa, it is far less commonly used in Europe. During the Irish potato famine it was largely imported and made into bread by the aid of baking-powder. It is now used to a considerable extent in Italy. Bread made from Indian corn is a popular diet in the Southern States of America, where it is the chief bread food, and in all parts of the country maize forms a portion of the food of the people. Maize meal or corn meal is also used for making the cakes called "Johnny" or "Journey" cakes, corn-mush (hasty-pudding), hominy, and other forms of food. The grain is also used for the manufacture of starch, corn-flour, glucose, whisky, and alcohol.

The structure of the grain is similar to that of wheat and other cereals, but the *testa* has only two coats, the external one consisting of elongated flattened cells, irregular in size and shape, resembling those of the middle coat in wheat. The grains vary in size according to their source, 100 European grains varying from 18 to 46, and averaging 28, grammes; American grains varying from 10 to 48, and averaging 38, grammes per 100.

The amount of water is greater in European than in American corn, and, according to König, the greater abundance exists in the grain of South-Eastern Europe.

The *Carbohydrates* consist chiefly of starch in the form of irregular grains, which are polygonal and faceted, similar to those of oats, generally with a stellate hilum and faintly-marked concentric striæ; their size averages 0·02 millimetre, or 13 μ, with a variation of 10 to 25 μ in diameter. These granules do not adhere together or form aggregates, as they do in oats and some other cereals; on the other hand, the starch feels gritty owing to the polyhedric character of the granules. The carbohydrate also includes about 1 per cent. of sugar and 0·75 per cent. of dextrin.

The Fat.—The amount of oil in maize is large as compared with that in other cereals. It consists of oleic, palmitic, and stearic acids. It is chiefly contained in the germ, which is removed when the grain is milled. But the amount of fat in corn meal is fairly large, and the meal is liable to degenerate when kept, owing to rancidity of the oil.

The Proteins.—The percentage of nitrogen in maize proteins is 16·05, equivalent to the factor 6·23; therefore the proteins of maize = N × 6·23. According to Osborne,[2] 100 grammes of maize or corn meal contain 8·59 grammes of protein—thus:

Zeins: soluble in alcohol 5, insoluble 3·14 ..	8·14
Globulins	·39
Albumins	·06
	8·59

[1] Darwin, *loc. cit.*

[2] *Jour. Amer. Chem. Soc.*, xix. 525.

The zeins consist of maize-fibrin soluble in alcohol, and conglutin, or a similar vegetable casein, insoluble in alcohol. The globulins include maize-globulin, maize-myosin, and maize-vitellin, the latter being identical with edestin in wheat. The albumins are too small in amount to name them.

The mineral substances amount to 1·53 per cent., about a quarter of which is soluble phosphate of potash and magnesia, with some soda, lime, and iron. According to Johnston, the ash has the following composition : K_2O, 37·95 ; Na_2O, 3·00 ; MgO, 7·50 ; CaO, 3·40 ; Fe_2O_3, 0·40 ; P_2O_5, 44·80 ; SO_3, 1·50 ; SiO_2, 1·45 ; Cl, a trace—per cent.

Maize or Corn Meal.—The meal is white or yellow according as it is derived from white or yellow maize. White corn makes flour as white as the flour of wheat when prepared by modern methods of grinding. Yellow corn yields a flour of rich yellow colour, highly prized because it imparts a rich yellow colour to bread made from it. Their nutritive value is about the same, although a slight difference in their composition is shown in the analyses of Zegga and Maistovoric.

The method of grinding maize between stones, afterwards bolting it, is still prevalent in parts of America. Such meal, having only the coarse bran removed, has nearly the same composition as the entire kernel. It is required to be used while it is fresh, on account of its hygroscopic character and high proportion of oil ; it is very liable to become mouldy and rancid. These faults are preventible by the modern method of grinding, which is as follows : The corn is passed through a machine which cracks the grain and loosens the germ ; the hull and the germ are then removed by bolting cloths and currents of air. The corn is afterwards ground between heated corrugated iron rollers and again bolted. The product is a granular meal consisting of 65 to 70 per cent. of the entire grain ; but it has lost the germ, some protein, minerals, and 75 per cent. of the fat. It is therefore of lower nutritive value than entire corn meal, but possesses the advantages of freedom from bran and rancidity in almost the same degree as wheat flour. The inhabitants of the Southern States do not care very much for granular corn meal, but prefer the soft meal prepared in the old way by stone-grinding.

Corn Bread can be made from white or yellow meal. It is popular in the Southern States of America, but is not so much consumed in the Northern or Western States, where the corn is extensively grown. In Europe corn bread is seldom heard of, and it is even considered that maize is unfit to make bread. The fact that Indian-corn bread has been used in America for centuries ought to remove that prejudice. It is highly nutritious. Its use in times of peace and war, and the analyses of many chemists, show that it amply suffices to take the place of wheaten bread. The most palatable bread, however, is made from stone-ground meal, which is coarse and simply bolted to remove the larger particles of bran, mixed with a little salt and water, and baked into hard unleavened cakes

called " Johnny cakes." Maize is deficient in agglutinating power, and the " gluten " which is formed by mixing the meal with water is not the same as that of wheat but, according to Fleurent, is equivalent to gliadin : glutenin :: 47·5 : 52·5. The meal is not easily leavened by either yeast or baking-powder. In the Northern States " Johnny cake " is made of corn meal, milk, eggs, and baking-powder, and is therefore different from the former. A similar cake fermented with yeast is called " pone " in Italy and " hoe-cake " in the United States. Corn meal is also consumed in the form of a " hasty-pudding," called " corn-mush " in America and " polenta " in Italy.

The high value of corn meal ought to be impressed upon European philanthropists. It is cheap, easily digested, and well assimilated. When the digestibility of wheat and Indian corn are compared, we find that every part of the corn, except the crude fibre, is digested better than wheat, as shown in the following comparison :[1]

THE DIGESTIBILITY OF WHEAT AND MAIZE COMPARED.

Absorbed, per cent.	Cracked Wheat.	Cracked Corn.
Total dry matter	82	90
Proteins	80	90
Fat (ether extract)	70	78
Carbohydrate (nitrogen-free extract)	83	94
Crude fibre	60	48

The entire evidence of physiologists and chemists shows, from the point of view of composition and digestibility, that maize is fully equivalent to wheat as a human foodstuff. There is, however, the element of palatability. On this point there is the widest difference of opinion. American writers laud it as being an extremely palatable food, and state that many people prefer it to wheat. On the other hand, European writers are either silent or condemn it as unfit for the food of man. Undoubtedly, custom enters largely into our likes and dislikes, but other nations than the American might find in maize and its products a food which is not only palatable and nutritious, but one of the best means of providing nutriment for the poor when in need of a cheap form of nutriment or an economical source of sustenance. It is, in fact, so used by the natives of Africa and many Oriental countries.

Although the proportion of protein in corn meal is not more than two-thirds that in wheat flour, the coefficient of digestibility is higher, and therefore makes up to some extent for that deficiency. In respect of fat, the products of Indian corn take precedence of all other cereals except decorticated oats ; they contain twice as much fat as wheat or barley, three times as much as rye, and two-thirds

[1] Bulletin 36, U.S. Department of Agriculture.

as much as hulled oats. The amount of *digestible* starch, dextrin, sugar, and cellulose, is higher than in oats, about the same as in wheat, but slightly less than in rye and barley. The minerals are slightly deficient, but as the other cereal foods yield more mineral matter than the body requires, the slight comparative deficiency really does not matter.

There are, however, several other maize preparations in the market which are little more than starch, because most of the protein and fat have been removed. **Maizena**, or corn-flour, as it is called in England, is an example ; in the United States it is more properly called " corn-starch." Corn-flour is, in fact, the purified starch of maize, some of the protein and most of the fat being removed by treatment with alkalies. Nevertheless it sometimes contains more protein than sago, tapioca, or arrowroot. Its composition is as follows : Water 11·5 to 14, protein 2 to 6, starch 81 to 87, per cent.

Popcorn.—This variety of maize, *Zea everta*, bears a small hard-grained corn which is roasted and eaten as a luxury (see table of composition). On the application of heat the starch grains become considerably enlarged, and the interior of the corn transformed into a soft material which is considered a delicacy. The *testa* is a tough and firm envelope ; during roasting there is a great expansion of the moisture within, and when the pressure reaches a high degree the grain explodes, whence the name " popcorn," and leaves a cavity within it.

Mealies, or Green Indian Corn.—The special variety of maize known as " sweet " or " sugar " corn, *Zea saccharata*, is eaten in the green or immature state after boiling or roasting, and is considered a delicacy. The composition of the **green corn**, according, to Wiley, is as follows : Water 73·0, protein 5·0, starch 13·5, sugars 6·0, fat 0·6, fibre 1·2, ash 0·7, per cent. The sugar disappears rapidly after severing the head from the stem of the plant ; it is therefore necessary that " mealies " should be cooked quite fresh. Canned corn is frequently adulterated by saccharin to increase the sweet flavour.

Millet.

Millet consists of the seeds of *Panicum setaria* and allied genera grown largely in Africa, India, China, Japan, and Korea, where it is made into bread. It is also grown in Southern and Eastern Europe and America. The seed is small, not much larger than a pin's head. Indian millet, or durra, is a species of sorghum ; the seeds are larger than the former. It is grown largely in warm countries, especially in Africa, India, and other parts of Asia. The term " millet " is used in this section to embrace both classes. The millets are important as a source of food for man ; it is estimated that they feed one-third the inhabitants of the earth. India alone annually sows 35,000,000 to 40,000,000 acres of land with these seeds to produce human food. Japan also uses 35,000,000 bushels of the seeds each year for human food. The inhabitants of Korea,

China, and other countries, also consume enormous quantities of millet. It is the commonest grain food of Africa, being largely consumed by the Arabs and other native races.[1]

The millets belong to the genera *Chætochloa* (formerly *Setaria*) and *Panicum*, and are divided into three classes—viz., the foxtail, barnyard, and broom-corn millets. Durra, or Indian millet, is *Sorghum vulgare* and its varieties.

1. **Foxtail Millet** (*Chætochloa italica*) and its variety *germanica* is probably the most important species. It includes the common millet of America, Golden Wonder millet, Italian, German, Hungarian, Japanese, and Korean millets. Its cultivation is prehistoric. Seeds of this species have been found in abundance in the remains of lake-dwellings of the Stone Age in Switzerland. There is also evidence that it formed one of the chief foods in China 2700 B.C. De Candolle says the sum of historical, philological, and botanical data leads him to the conclusion that the species existed before all cultivation in China, Japan, and the Indian Archipelago, and that its cultivation spread westward through Russia and Austria until it arrived among the lake-dwellers of the Stone Age in Switzerland. It is still extensively used for human food in Japan, Korea, China, the East Indies, and Transcaucasia. Professor Church says[2] that in India it is usually prepared by boiling or parching, and is eaten alone or mixed with milk and sugar to form the dish known as *sir* among the natives.

2. **Barnyard Millet** includes the following and other varieties: *Panicum crus-galli*, the common barnyard millet, and *bharti* of India; *Panicum colonum*, the *shama* millet of Asia; and *Panicum frumentaceum*, the *sanwa* millet. The common barnyard millet is grown in various parts of the world; but the seeds are especially used by the poor people of India, to whom they are known as *bharti*. In other regions the crop is commonly grown as fodder for animals. Shama millet, also called **jungle rice,** is commonly cultivated for human food in India. It is used in some places to a considerable extent by labourers as a usual article of diet; it is made into *khir* by being boiled with milk.[3] The grain alone is a poor food. Sanwa millet is also much used in India, being parched or boiled like rice, and eaten with milk and sugar.

3. **Broom-corn Millet.**—This term is applied in the United States to *Panicum miliaceum*, the common millet of Europe. This grain is so ancient that all the early records speak of it as "cultivated," and there is no authentic instance of it having been found in a wild state. It was extensively used in Europe as a human food in former times. Its cultivation is prehistoric in Egypt, the South of Europe, and Asia. It was well known to the ancient Greeks and Romans; the Swiss lake-dwellers made great use of it, as also did those of Italy. The Latin authors mention it as one of the foods of the inhabitants of Gaul and other countries; but, as no

[1] Farmers' Bulletin 101, U.S. Department of Agriculture.
[2] "Food Grains of India," p. 55.
[3] Church, *ibid.*, p. 50.

specimens have been found there among the relics, it is uncertain whether they intended *Panicum* or *Sorghum*. De Candolle considers it probably arose in Egypt and Arabia, and that it became naturalized in other countries as the result of frequent cultivation from the time of the ancient Egyptians. It is now grown extensively from Southern to Central Europe, the Mediterranean regions, especially Northern Africa, also in India, China, and Japan. There are numerous species, but three distinct types are recognized—white, yellow, and red. There are also intermediate varieties; thus, the red may be dark brown, the yellow variety greenish, and the white may be gray, or the seed may be striped with a dark colour upon a light ground. The seeds are still further named according to their source and peculiarities—*e.g.*, French white, Chinese white, French red, Japanese red, Chinese, Californian, Manitoba, Turkish, hog millet, etc. The broom-corn millets are better adapted for human food than barnyard or foxtail millets.

4. **Indian Millet, Sorghum, Durra or Dourra.**—The seeds of *Sorghum vulgare* (also called *Holcus sorghum* and *Andropogon sorghum*) and its varieties. It has been cultivated for more than 4,000 years, and is now grown in Egypt, Arabia, Abyssinia, Syria, the East Indies, China, and other parts of Asia. It is the commonest food grain of Africa, much used by the inhabitants of the northern part of that continent. It is the largest of the small cereal grains.

De Candolle considers *Sorghum vulgare* had its origin in tropical Africa, in support of which theory Schmidt says the species abounds in the island of San Antonio, in the Cape Verde Islands, and in rocky places of Africa. Linnæus believed it had an Indian origin, but Roxburgh asserts he never found any other than the cultivated variety in India, and says the same of the *Bicolor*, *Saccharatum*, and other varieties; furthermore, the absence of a Sanskrit name for the plant or grain renders an Indian origin very doubtful. A Chinese origin has also been claimed, but the ancient authors of China do not mention it. It has not been found wild in Egypt, but the ancient Egyptians cultivated it, and it was impossible for them to have received it from China while it remained unknown in the intermediate countries. "It is easier to understand that it is indigenous in tropical Africa, was introduced into Egypt in prehistoric times, afterwards into India, and finally into China, where its cultivation does not appear to be ancient, for the first work which mentions it belongs to the fourth century of our era." [1]

Sweet Sorghum.—The grain of *Sorghum saccharatum*, *Holcus saccharatus*, or *Andropogon saccharatus*. Sweet sorghum, or sugar-grass, is a taller species than the common sorghum, and is cultivated for fodder or for the sugar obtained from it; the Chinese use it chiefly for the production of alcohol. It is cultivated in India, China, Indo-China; also in Egypt and Arabia, but to a less extent than dourra. The date of its first cultivation is unknown. It was not

[1] De Candolle, *loc. cit.*, p. 382.

known in ancient India, China, Greece, or Rome, as it is not mentioned in their writings. De Candolle says we must seek its origin in Africa, where it is extensively cultivated. "The spread of its cultivation from the interior of Africa to Egypt after the time of the Pharaohs, thence to Arabia, the Indian Archipelago, India, and finally China at the beginning of our era, tallies with historical data, and is not difficult to admit. The inverse hypothesis of a transmission from east to west presents a number of objections."[1]

Other varieties of sorghum cultivated in Asia and Africa are *S. cernuus*, with drooping panicles; *S. bicolor*, which resembles sweet sorghum in height; *S. niger* and *S. rubescens*—all of which appear to be products of cultivation.

The composition of the millets is equal to that of many larger cereal grains. The starch grains are similar to those of wheat, but smaller; they average 0·010 millimetre. The proteins do not include the whole nitrogen of the grain; they are represented by the factor $N \times 5{\cdot}7$, which is the same as that for wheat, and not by the ordinary factor, $N \times 6{\cdot}25$, for most vegetables. Millet is used for making bread, which, however, is not so good as wheaten bread, but is very nutritious. It makes excellent puddings, and is largely used in combination with milk by the native races of the countries where it is chiefly cultivated. The seeds are also roasted or "parched." As a source of nitrogen it occupies a position intermediate between rice and wheat. Church says: "It is generally regarded as nutritious and digestible, but in some places it is considered to be rather heating." Millet boiled and mixed with milk and sugar is called *sir* in India, and shama millet boiled in milk is called *khir*. Such preparations are rich in nitrogen and fat, as well as starch and sugar; eaten in this way they form a better balanced and therefore more complete food than wheat or rice, and they are fairly digestible.

Buckwheat.

Buckwheat consists of the seeds of *Fagopyrum esculentum* or *Polygonum fagopyrum;* N.O., Polygonaceæ. It is not a cereal, but as its use is similar it is included in this section for convenience. There are eight species of buckwheat, or *Fagopyrum*, all natives of temperate Asia. Buckwheat is a native of Manchuria and Central Siberia. Its cultivation is not ancient, for the Chinese author who first mentions it lived in the tenth or eleventh century of the Christian era. It does not appear to have been known to the Sanskrit-speaking Orientals nor to the western Aryans. It was certainly unknown to the ancient Greeks and Romans. The species came into Europe through Tartary and Russia in the Middle Ages. Its cultivation in Germany is first mentioned in 1436, but in the sixteenth century it became diffused through Belgium into France and Italy. The German name *Buchweitzen*, corrupted into the English buckwheat, arises from the similarity

[1] De Candolle, *loc. cit.*

COMPOSITION OF MILLETS—NUTRIENTS PER CENT.

	Water.	Protein	Fat.	Carbo-hydrate.	Cellulose.	Ash.	Authority.
Millet, average of 300 collected analyses ..	12·0	12·6	4·6	62·2	5·8	2·8	Tibbles.
Minimum	10·0	8·9	2·2	56·0*	3·0	1·4	Balland.[1]
Maximum	13·0	15·0	7·3	66·0*	10·0	6·0	*Starch and sugar.
(*a*) Foxtail Millet (*Chætochloa vel Setaria italica*)	12·8	11·0	3·8	61·2	7·8	3·4	Farmers' Bulletin 101, U.S. Department of Agriculture.
Without husk	10·2	10·8	2·9	73·4	1·5	1·2	
Golden Wonder	9·3	13·8	4·5	60·5	9·2	2·0	
(*b*) Barnyard Millet, shama millet (*Panicum colonum*)	10·3	12·3	5·7	60·9	7·7	3·1	
Without husk	12·0	9·6	·6	74·3	1·5	2·0	Church.[2]
Sanwa millet (*Panicum frumentaceum*) ..	12·0	8·4	3·0	72·5	2·2	1·9	
(*c*) Broom-Corn Millet, common millet (*Panicum miliaceum*)	13·2	10·2	3·8	56·9	12·8	3·1	König chiefly.
Without husk	11·6	12·4	4·7	65·6	3·3	2·4	
Hog millet: *Panicum miliare*	10·2	9·1	3·6	69·0	4·6	3·5	Church.[2]
Paspalum scrobiculatum	11·7	7·0	2·1	77·2	·7	1·3	
Penisetum typhoideum	11·3	10·4	3·3	71·5	1·5	2·3	
Eleusine corocaria	12·5	5·9	·8	74·6	3·6	2·6	
Hulled	13·2	7·3	1·5	73·2	2·5	2·3	
(*d*) Dourra, sorghum: *Sorghum vulgare* ..	12·5	9·3	2·0	72·3	2·2	1·7	Various.
Sorghum tartare	11·1	9·5	4·2	71·7	1·7	1·8	

[1] *Compt. Rend.*, 1898, 125.

[2] "Food Grains of India," p. 55.

of the seed in shape to a beechnut, whence also the Latin *Fagopyrum* and the Italian *Faggina*. The French name, *Blé sarrasin* (Saracen wheat), was adopted on its introduction into that country, probably from the colour of the seeds. It is an important product of cultivation in countries where the soil is poor—*e.g.*, Brittany. **Tartary Buckwheat** (*Fagopyrum tartaricum*) is less sensitive to cold than the former, but yields a smaller seed. It is cultivated chiefly in Tartary, but sometimes in other parts of Asia, and even in Europe. De Candolle considers this variety to have been known to the Aryan races. The notch-seeded buckwheat (*F. emarginatum*) is grown in the highlands of North-Eastern India and China.

Buckwheat is now cultivated largely in Russia and Central Asia, and to a less extent in Austria, Germany, France, Holland, and the United States.

Composition of Buckwheat—Nutrients per Cent.

	Water.	Protein.	Fat.	Carbo-hydrate.	Cellu-lose.	Ash.	Authority.
Seeds: Minimum	13·0	9·4	1·9	58·90	8·6	1·50	Balland.[1]
Maximum	15·2	11·4	2·8	63·35	10·5	2·46	
Average	14·5	11·3	2·7	61·56	7·8	2·15	Tibbles.
	13·4	15·2	3·4	63·60	2·1	2·30	Wiley.[2]
	13·0	10·2	2·2	61·20	11·1	2·20	Bulletin 45, U.S. Department of Agriculture.
Flour: Average	14·0	7·2	·9	77·40	—	·50	Tibbles.
	13·9	6·4	1·2	77·90	—	·60	Atwater.
	14·0	7·9	·5	79·50	—	·40	Hutchison.[3]

The foregoing table shows that buckwheat is a highly nutritious food. The seeds are enclosed in a shell or husk which is hard and indigestible, and requires to be removed from the meal or flour by bolting. The endosperm consists largely of starch in the form of angular or polyhedric granules, similar to those of rice, oats, and maize, from which they are indistinguishable. They vary in size from 10 to 15 microns, have a well-defined nucleus, but no concentric striæ are apparent, and they tend to form aggregates as in oats. When mixed with water the proteins have a certain amount of adhesiveness, which permits buckwheat flour to be made into bread and cakes. Cakes are made by leavening the dough with yeast or baking-powder. The former method is slow, and requires some time for the yeast to leaven it; the latter is rapid, and the cakes can be baked immediately after mixing the dough. The cakes are baked on a hot iron plate, and turned like pancakes or pyclets. Buckwheat cakes are eaten in most countries where the seeds are cultivated. In France, where the seeds are also called *blé noir*,

[1] *Compt. Rend.*, 1897, 125. [2] "Foods and their Adulteration."
[3] "Food and Dietetics."

the bread made from them is called "black bread." It is fairly palatable and nutritious, but not so nourishing or delicious as wheaten bread. In Brittany, Holland, etc., the meal is eaten as a porridge. Buckwheat was at one period a staple food of the peasantry in England. The flour is adulterated with rye, wheat, maize, and other cereals, which may be detected by a microscopic examination of the starch grains and fragments of the testa.

Kiery.

Kiery consists of the seeds of *Amarantus frumentaceus*, an annual plant cultivated in the Indian Peninsula for its small farinaceous seeds, which form a principal food of the natives in some localities. Various other species are cultivated as vegetables.

Quinoa.

Quinoa, or "petty rice," consists of the seeds of *Chenopodium quinoa;* N.O. Chenopodiaceæ. These seeds form one of the staple foods of New Granada, Chili, and Peru, where the cultivation has been carried on for many centuries before the Spanish conquest. There are two species—quinoa with coloured leaves, and quinoa with green leaves and white seeds. Both are of American origin, and are believed to be very ancient.

Composition of Quinoa—Nutrients per Cent (Voelcker).

	Dry Seeds.	Flour.
Nitrogenous matters ..	22·86	19
Starch	58·60	60
Fat	5·74	5
Cellulose	9·54	—
Water	—	16

The less-coloured seeds are the most farinaceous, and probably derived from the other by cultivation. They are eaten in soup, and the flour is made into cakes, which are unleavened. The starch granules are alleged to be the smallest known. The protein reaches a high proportion, and the fat a moderate one. The ash is said to contain more iron than that of any other vegetable. The leaves of the plant are eaten as a green vegetable, like spinach.

CHAPTER XIX

ROOTS AND VEGETABLES

THE following is a list of the cultivated plants commonly used for food, according to Professor Bailey's "Principles of Vegetable Gardening":

CLASS I.—ANNUAL VEGETABLES.

SUBCLASS I.—GROWN FOR THE SUBTERRANEAN PARTS.

1. ROOT CROPS: Beet, *Beta vulgaris.*
   Carrot, *Daucus carota.*
   Parsnip, *Pastinaca sativa.*
   Radish, *Raphanus sativus.*
   Salsify, *Tragopogon porrifolius.*
   Scorzonera, *Scorzonera hispanica.*
   Turnips and swedes, *Brassica* species.
   Horse-radish, *Cochlearia armoracia.*
2. TUBER CROPS: Potato, *Solanum tuberosum.*
   Sweet-potato, *Ipomœa batatas.*
3. BULB CROPS: Onion, *Allium cepa, A. fistulorum.*
   Leek, *A. porrum.*
   Garlic, *A. sativum.*
   Shallot, *A. ascalonicum.*
   Chives, *A. schœnoprasum.*

SUBCLASS II.—GROWN FOR THE FOLIAGE.

4. COLE CROPS: Kale and borecole, *Brassica oleracea.*
   Brussels-sprouts, *B. oleracea* var.
   Cabbage, *B. oleracea* var.
   Cauliflower and broccoli, *B. oleracea* var.
   Kohlrabi, *B. oleracea* var.
5. POT-HERBS, used for "greens":
   Spinach, *Spinacia oleracea.*
   Chard and beet, *Beta vulgaris.*
   Orach, *Atriplex hortensis.*
   Purslane *Portulaca oleracea.*
   Dandelion, *Taraxacum officinale.*
   Mustard, *Brassica* species.
6. SALAD CROPS: Lettuce, *Lactuca sativa.*
   Endive, *Cichorium endivia.*
   Celery, *Apium graveolens.*
   Parsley, *Carum petroselinum.*
   Cress, *Lepidium sativum.*
   Upland or winter cress, *Barbarea vulgaris.*
   Watercress, *Nasturtium officinale.*

SUBCLASS III.—GROWN FOR FRUIT OR SEEDS.

7. PULSE CROPS: Beans *Phaseolus, Dolichos, Vicia.*
Pea, *Pisum sativum.*

8. SOLANACEOUS CROPS:
Tomato, *Lycopersicum esculentum.*
Egg-plant, *Solanum melongena.*
Red-pepper, *Capsicum annum.*
Husk tomato, *Physalis.*

9. CUCURBITOUS CROPS:
Cucumber, *Cucumis sativa.*
Melon, *C. melo.*
Gherkin, *C. anguria.*
Water-melon, *Citrullus vulgaris.*
Luffa, *Luffa ægyptiaca* or *acutangula.*
Wax gourd, or zit-kwa, *Benincasa cerifera.*
Pumpkin and squash, *Cucurbita.*

10. SWEET-CORN, etc.:
Sweet-corn, *Zea mayis.*
Okra, *Hibiscus esculentus.*
Martynia, *Martynia proboscidea.*

11. CONDIMENTAL AND SWEET HERBS.

12. MUSHROOMS, etc.

CLASS II.—PERENNIALS.

Asparagus.
Rhubarb.
Dock.
Sorrel.
Artichoke.
Jerusalem artichoke.
Seakale.

Roots and Tubers.

The causes which favour or obstruct the growth of vegetables account chiefly for the distribution of edible roots and tubers over the surface of the globe, and explain why certain regions have been occupied for thousands of years by husbandmen, while other areas are still occupied by nomadic tribes.

The sweet-potato was widely diffused before the historic period. But the climate of South America was particularly favourable to the potato, sweet-potato, and manioc, whence cultivation began at an early period in that region; while in the North of America, of Europe, and of Asia, where the climate was unfavourable to cultivation, agriculture began much later, and the people lived by fishing and hunting, and eked out their existence by the addition of indigenous vegetables, such as cabbage. It is a curious fact that most roots and tubers which have an especial food value, excepting yams, should have arisen, or at any rate have been earliest cultivated, on the American continent.

Roots and tubers are storehouses of carbohydrate for the future use of the plant, or for the development of young plants which spring from them. The carbohydrate consists chiefly of starch in some genera, but in others sugar predominates. Fat is practically absent. The amount of nitrogenous substances is small in proportion, and of this only a small part consists of protein, the greater proportion being in the form of amides and other extractives.

The act of cooking deprives many roots and tubers of a con-

siderable portion of their nutritive properties. But poor as such foods are in protein, fat, and sometimes carbohydrate also, the roots and tubers have a value which cannot be replaced by cereal foods. This is due to the presence of mineral ingredients, and especially salts of potash. The action of potatoes and fresh vegetables in the prevention or treatment of scurvy and other diseased states of the system, where their value is undoubted, is not well understood. Something is due to the mineral ingredients, but much more is due to the **freshness** of the tubers and vegetables, for it has been observed that dried tubers and vegetables have not the same effect in preventing or curing scurvy and allied diseases. It is probable that this difference arises from the state of the mineral and saline constituents. These salts are absorbed by plants chiefly in the form of **ions.** They circulate through the tissues of the plant as ions, and it is the ions which keep the globulins in solution. But the salts are only ionizable in dilute solutions. If, therefore, the proportion of salts to the water is increased, as by evaporating or drying the vegetable or tuber, not only does the plant lose its vigour and freshness, but the mineral and saline substances pass out of the condition of ions, and become more or less stable salts. The greater value of fresh tubers, vegetables, and fruit, over dried substances, is, in the estimation of the author, entirely due to the difference in the number of ions and their electric charge. It may be argued that ionization of the salts would be induced by soaking them in water. Even if this be granted, the ions would probably be different from the original ions in the juice, and consequently the re-formed juice will not be the same as that of the fresh plant. It is an actual fact that the juice expressed from a fresh plant is different from that obtained by infusion of the dried plant.

Potatoes.

The **Potato** is the tuber of *Solanum tuberosum*, N.O. Solanaceæ. It is a native of South America and of the Chonos Archipelago.

De Candolle[1] says it grows wild in Chili in a form which is still seen in our cultivated plants; and it is doubtful whether its natural home extends to Mexico, Peru, and New Granada. It became early cultivated, and was diffused, before the discovery of America, from Chili to New Granada. It was introduced in the latter part of the sixteenth century into Virginia and Carolina. It was brought to Europe between 1580 and 1585, first by the Spaniards, and afterwards by the English, at the time of Raleigh's voyages to Virginia. Other authorities say they were brought to England by Sir John Hawkins, in 1565, from Santa Fé, in Mexico.

It is proved beyond doubt that the cultivation of the potato was practised in the regions extending from Chili to New Granada before the discovery of America, with every appearance of ancient usage. The species could scarcely have been introduced into Virginia or Carolina before Raleigh's time, unless the ancient Mexicans had possessed it, and its cultivation had been diffused among the aborigines to the north of Mexico. But Roulin finds no sign of the potato in the United States before the arrival of the Europeans. It seems most likely that the English colonists received the tubers from Spanish or

[1] "Origin of Cultivated Plants."

other travellers, traders, or adventurers, after the discovery of America. Many vessels since the conquest of Peru and Chili (1535 to 1585) would have carried tubers; and the Spaniards had introduced the plant into Europe before 1585. As regards Europe, its cultivation began after its introduction, and gradually spread all over the Continent by 1592; but it is said they were not known in Flanders until 1620. Their first culture in Ireland is referred to Sir Walter Raleigh, who had large estates there; and their cultivation was largely encouraged by Thomas Wentworth during his governorship (1640-1643). The tubers soon became of immense importance to the Irish people, and a failure of the crop in their country has led to disastrous consequences, such as the famine of 1846. In England the tubers did not win favour so rapidly, for Bradley wrote in 1719 that they were of "less note than horse-radish, radish-scorzoners, beets, and skirrets."

The tuber is a staple food for millions of people, and, next to the cereals, is considered to be probably the most important material for the food of the human race. An acre of land planted with potatoes will feed twice as many people as an acre planted with wheat; in fact, there is scarcely any other vegetable product, excepting the banana (*q.v.*), which is capable of feeding so many people from a given area of land.

The tubers consist of the flesh or body of the potato and the peel. The peel consists of the epidermis, or outer layer, which forms 2·5 per cent., and an inner or fibro-vascular layer, forming 8·5 per cent. of the tuber. The epidermis contains a small proportion of **solanin,** a poisonous alkaloid. Young tubers contain more than ripe ones. The alkaloid is removed with the peel, or destroyed by heat when the tubers are cooked in their skins. The fibro-vascular layer contains pigment, which becomes green when the tubers are exposed to light, and gives rise to an unpleasant taste. The body or flesh consists of solids and juice. The solids are chiefly starch, sugar, a little protein, fibre, and salts. The juice contains proteins and salts, and has an acid reaction from the presence of organic acids.

The **nitrogenous matters** in the composition of potatoes range from 0·4 to 2·8 per cent., but rarely exceed 2·25 per cent. They consist of albumin, globulin, tuberin (a peculiar protein), peptone, asparagin, xanthin, leucin, tyrosin, and other amino-acids, and salts. It is therefore not all protein-nitrogen; in fact, according to Kellner, only 49 per cent. of the nitrogen is in the form of protein, and 51 per cent. is non-protein nitrogen; and the non-protein nitrogenous bodies include an average of 0·3 per cent. of asparagin,[1] besides the other amides mentioned. This fact is of importance, and unless it is duly appreciated the student is likely to over-estimate the flesh-forming value of potatoes. The flesh-forming nitrogen or proteins only average 2·05 per cent. of the entire tuber, as determined from an examination of the reports of thirty analysts and thousands of analyses; but, as a matter of fact, the proportion of protein in the flesh or body of the potato is only 1·5 per cent. of the substance, while the peel contains 1·7 per cent. There is therefore a little loss of protein caused through peeling the potatoes; but as the peel consists largely of fibro-cellulose, and is not very

[1] Schultze.

THE COMPOSITION OF POTATOES, ACCORDING TO STANDARD AUTHORITIES.

NUTRIENTS PER CENT.

	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Ash.	Authority.
Average composition	75·66	2·05	·16	19·94	1·02	1·08	Tibbles' collection.
Number of authorities ..	(33)	(30)	(30)	(63)	(31)	(31)	
Reports of standard authorities :							
Minimum	66·00	1·40	·16	15·00	·55	·97	Balland.[1]
Maximum	80·00	2·80	·40	29·00	·75	1·60	
Potatoes as purchased : Average	62·60	1·80	·10	14·70	—	·80	
Edible part : Minimum ..	67·80	1·10	—	13·50	·20	·50	Atwater,[2] 136 analyses.
Maximum ..	84·00	3·00	·20	27·40	·90	1·90	
	78·30	2·20	·10	18·40	·40	1·00	
	81·30	2·20	·10	15·70	—	·90	Bulletin 43, U.S. Department of Agriculture.
	75·50	2·06	·75	18·55	2·12	·90	Johnston.[3]
	75·48	1·95	·15	20·69	·98	1·09	König.
	75·00	2·10	·20	20·70	1·10	·90	Wolff.
	76·00	2·10	·20	19·70	·80	1·20	Lintner.
Average ..	75·00	1·20	·30	20·00	1·00	1·00	Church.
	75·00	?	·08	19·87	·77	1·00	Frazier.
	71·00	2·12	·11	19·06	1·65	1·60	Saillaire.
	76·97	2·09	?	18·85	—	—	Maine Experimental Station.
	79·40	2·28	·06	15·95	·36	1·20	Vermont Experimental Station.
	74·40	1·70	·10	21·20	1·50	1·10	Payen.
	75·00	2·10	·20	21·88	—	·70	Frémy.

Varieties : American Early Rose	77·38	1·58	·65	19·59	1·92	·80	Johnston.[4]
American Goodrich	77·08	1·69	·60	17·87	2·00	·76	
Belgians	72·03	2·11	·75	21·84	2·36	·93	
Champions	72·50	2·28	·73	21·63	1·84	1·02	
Red-skin "Flour-balls" ..	76·11	1·90	·68	18·44	2·06	·81	
Regents	79·87	1·52	·52	15·68	1·76	·67	
White Rock	77·42	1·62	·63	17·67	1·82	·84	
White Elephant	76·97	2·09	?	18·85	—	—	Maine Experimental Station.
Dried or evaporated potatoes ..	7·10	8·50	·40	8·90	—	3·10	Atwater.
Cooked potatoes :							
Boiled in skins	73·80	1·20	·10	19·10	·60	·90	
,, without skins ..	75·50	2·50	·10	20·90	·60	1·00	
,, mashed and creamed	75·10	2·60	3·00	17·80	—	1·50	
"Chips," fried in fat ..	2·20	6·80	39·80	46·70	—	4·50	

[1] *Compt. Rend.*, 1897, 125. [2] Bulletin 28, U.S. Department of Agriculture.
[3] "Agricultural Chemistry," p. 429. [4] *Ibid.*

THE COMPOSITION OF THE PARTS OF A POTATO—PERCENTAGES.[1]

Parts of a Potato.	Proportion of the Whole.	Water.	Nitrogen.		Fat.	Carbohydrate.	Ash.
			Protein.	Total.			
Peel : 1. Outer skin	2½	80·1	·25	·43	·8	14·6	1·8
2. Fibro-vascular layer ..	8½	83·2	·24	·36	·1	13·3	1·1
Flesh, or body	89	81·1	·18	·32	·1	16·0	·8
Entire potato	100	81·3	·19	·32	·1	15·7	·9

[1] Bulletin 43, U.S. Department of Agriculture.

digestible, it is better removed for most people. Most of the nitrogenous matters are in the juice, which contains 85 per cent. of the total quantity, and the solid matter only contains 15 per cent. of the total nitrogen. The more juice the tubers contain, the greater the proportion of nitrogen, as a rule. Young potatoes have the most juice, and as a rule contain more protein and less starch. Old potatoes contain less than the average amount of protein, and more starch.

The **Fat** varies from 0·1 to 0·75 per cent. Eichorn found an average of 0·73 per cent., half of which was in the peel.

Carbohydrates.—The total amount varies from 13.5 to 29 per cent. of the entire tuber. It consists chiefly of starch and sugar. The amount of fermentable sugar varies from 0·56 to 3·3 per cent., with an average of 1·5 per cent., obtained from reports of fourteen authorities. When potatoes are used in the manufacture of alcohol, the choice of tubers depends upon the amount of sugar, as well as the convertibility of the starch into this carbohydrate.

The starch varies in amount from 13 to 25 per cent., with an average of 18·7 per cent., from the reports of thirty-nine authorities. It is prepared as British arrowroot, and is one of the chief sources of commercial starch and glucose. The quantity present in different varieties of the tubers is a matter of importance in their choice as a source of nutriment and for manufacturing purposes. The following examples are given by Wiley :[1]

STARCH IN POTATOES.

Red variety	22·7 per cent.
Shaw's variety	20·5 ,,
Kernour's variety	17·9 ,,
Beauvais variety	17·7 ,,
White Elephant	16·0 ,,
British Red	16·0 ,,
Giant Blue	15·9 ,,

The starch granules are large, 40 to 110 μ in diameter, medium ones being 40 to 65 μ, or 0.14 millimetre. They are pyriform, and have a characteristic appearance under the microscope ; they look like miniature oyster-shells. The hilum is circular or linear, and situated at the smaller end. From this point the well-marked concentric striæ begin.

The Salts.—The water in which potato pulp has been washed to obtain the starch contains albumin, tuberin, asparagin, and other amides, a bitter aromatic resin, citrates of lime and potash, phosphates of lime and potash, and free citric acid. According to Church, it contains extractives, solanin, and organic acids, 1·5 per cent. The mineral matter is 1 per cent. The salts of potassium predominate over the other inorganic materials, and potatoes form one of the chief sources of that substance in human foods. The *ash* has the following composition :[2]

1 "Foods and their Adulteration."
2 Johnston's "Agricultural Chemistry," p. 272.

THE ASH OF POTATOES.

Potash, K_2O	61·60 per cent.
Soda, Na_2O	1·00 ,,
Magnesia, MgO	5·00 ,,
Lime, CaO	2·40 ,,
Ferric oxide, Fe_2O_3	·85 ,,
Phosphoric acid, P_2O_5	17·67 ,,
Sulphuric acid, SO_3	6·25 ,,
Silica, SiO_3	1·00 ,,
Chlorine, Cl	2·23 ,,

According to Maercker,[1] the amount of ferric oxide averages 1·18 per cent. ; in other respects he finds the ash has a similar composition to the above.

Cooked Potatoes.—Their composition is shown in the foregoing table, in the form of potatoes boiled in their skins and without their skins, in the form of purée—*i.e.*, mashed and mixed with cream—and as ' chips," or sliced potatoes fried in fat. It is obvious that there must be some loss of nutriment during cooking, part of the soluble materials passing into the water ; but this loss is greater when the potatoes are peeled before boiling them than when they are cooked in their skins. The difference is well shown in the following table :[2]

LOSS OF MATERIAL IN BOILING POTATOES—PERCENTAGES.

	Total Dry Matter.	Nitrogen.			Carbo-hydrate.	Minerals.
		Protein.	Non-Protein.	Total.		
Skins removed :						
Water cold at beginning of test	3·7	4·3	12·9	8·3	2·5	17·0
Water hot at beginning of test	4·0	3·3	17·9	10·0	2·8	17·4
Average loss	3·9	3·8	15·4	9·0	2·7	17·2
Skins not removed :						
Water cold at beginning of test	·3	·6	·6	·6	·2	1·9
Water hot at beginning of test	·3	·4	1·7	1·0	·1	1·2
Average loss	·3	·5	1·1	·8	·2	1·6

We learn from these tests that the least loss of foodstuff occurs when the potatoes are boiled in their " jackets," and whether

[1] " Handbuch der Spirit-fabrikation," p. 99.
[2] Bulletin 43, p. 30, U.S. Department of Agriculture.

peeled or not the loss is least when they are put into a pan of cold water and gradually boiled. The tests support the experience of housewives, with whom the custom prevails of putting them on the fire in cold water and gradually raising the temperature. The changes due to cooking potatoes in the ordinary way, therefore, involve the loss of 4·3 per cent. of the protein, 13 per cent. of the non-protein nitrogen, 2·5 per cent. of carbohydrates, sugar, dextrin, and gum, and 17 per cent. of the salts. The changes in the starch are not so marked as those produced in cereal starches by boiling. This arises from the fact that the starch granules are very closely packed in cellular spaces formed by fibro-cellulose, which, aided by the pressure of the granules against one another, offers sufficient resistance to prevent the rupture of the starch granules. The latter, therefore, while becoming swollen and fissured, remain intact, the granulose or gelatinous interior of the granule remaining still enclosed. This does not indicate that each starch granule is surrounded by a thick cellulose covering. On the contrary, it is believed that they are surrounded by a very thin layer of cellulose, in consequence of which they are readily affected by enzymes such as diastase. It should here be noted that Effront[1] found that the non-protein nitrogenous substances in potatoes have a considerable stimulating effect upon enzymic action. Upon adding 0·05 gramme of asparagin to a solution of starch containing diastase, a yield of 61·2 per cent. of maltose was obtained in the same time as only 8·63 per cent. of maltose in a check experiment without asparagin ; therefore the activity of the diastase was increased nearly eight times by the presence of only 0·05 gramme of asparagin. We may conclude from this observation that the consumption of potatoes influences beneficially the digestion of their own starch and that of other amylaceous substances consumed at the same meal. Kellner says[2] that the presence of asparagin in the food plays an important part in preventing the destruction of proteins in the intestines, and consequently that it promotes the absorption of both carbohydrates and proteins into the blood.

The *heat value* of potatoes was determined in the bomb-calorimeter by Atwater, who found they yielded the following number of calories per pound : Raw potatoes 385, potatoes peeled and boiled 440, potatoes mashed and creamed 505, " chips," or potatoes fried in fat, 2,675, calories per pound. The growth of potatoes as a source of food, starch, and alcohol, is now an enormous industry. Great search is made by experts to find the variety which will yield the greatest amount of starch or sugar for their particular branch of industry. Usually the search is for the greatest amount of fermentable carbohydrate. As regards their economic value, Boussingault found that a given piece of land yields the following proportion of materials :[3]

[1] " Les Ferments Solubles."
[2] Maly's *Jahr-Berichte*, 1898, 721.
[3] *Cf.* Hutchison's " Diet and Dietetics," p. 233.

Nutrient.	Wheat.	Rye.	Peas.	Potatoes.
Protein	510	440	560	950
Starch	1,590	1,196	580	6,840
Ash	90	62	60	323

Potatoes are, however, not suitable for the entire food of man ; the nitrogen-carbon ratio is incorrect. According to Atwater, 7 pounds of boiled potato, yielding 440 calories per pound, would yield 3,080 calories, or sufficient energy-producing material for a man doing ordinary work, and would contain 80 grammes of protein. Rubner also estimated that 6½ pounds of boiled potato would yield 3,000 calories. The bulk is very great. Moreover, the protein is below the standard of Voit (118 grammes), which constitutes the average of many dietaries. But it is adequate to maintain the nitrogen balance in equilibrium, according to Chittenden and other investigators, who consider the average consumption of protein to be excessive. Accepting Atwater's estimate that boiled potatoes contain an average of 2·5 per cent. of protein, a person must contain 9 pounds daily in order to obtain 100 grammes of protein. But this amount would contain 840 grammes of carbohydrate, or four times as much as is necessary for a person doing light work, and twice as much as would be required for heavy labour. The mere bulk would be too much for most people, and it would, if consumed, entail an unnecessary burden upon the digestive organs, tending to produce a dilatation of the same, and would probably lead to an enlargement of the abdomen, or "pot-belly"—a condition which is not uncommon among the Irish.

The manufacture of starch from potatoes is considered under the head of Arrowroot and Starch. When used in the manufacture of alcohol, the tubers are reduced to a pulp, the starch is separated and hydrolized by means of diastase or mineral acids, such as sulphuric or hydrochloric acid. The sugars produced (dextrose or maltose and lævulose) are fermented by yeast, and the product is distilled. The spirit obtained by distillation of the fermented liquor from potatoes has an odour of raspberries or violets.

Potatoes are subject to various diseases, due to fungi, which considerably influence the productiveness of the tubers in some seasons. "Potato blight" is due to the potato fungus, *Phytophthora infestans* (N.O. Peronosporeæ), which is one of the scourges most dreaded by those dependent upon the tubers as a supply of food. It appears in brown patches upon the leaves, the long hyphæ penetrating the epidermis. The "leaf-curl" is due to another fungus, *Macrosporium solani*. Another organism is the *Bacillus mesentericus*, which frequently occurs upon the tubers, especially around the "eyes," and causes the trouble called "ropiness" when potatoes are used in bread.

The **Swamp-Potato** (*Solanum commersoni*) of South America differs from *S. tuberosum* in being a small tuber which by cultivation has grown to near the size of the ordinary potato. It never needs replanting, but grows by tubers thrown out in all directions. The flavour is somewhat bitter, but it resists disease better than *S. tuberosum*, and its flavour may be improved by cultivation.

Sweet-Potatoes.

The tubers of *Batatas edulis* or *Convolvulus batatas*, N.O. Convolvulaceæ. They are grown largely in South and North America, the West Indies, Spain, Portugal, and in all tropical countries, with the same assiduity as the potato is cultivated in Europe.

It is not known when these tubers were first introduced into Europe, but it was certainly before the arrival of *S. tuberosum*. They were largely imported from Spain and Portugal in the reign of Queen Elizabeth. It was these tubers which were meant by Shakespeare when, in "The Merry Wives of Windsor," he makes Falstaff exclaim : "Let the sky rain potatoes and hail hissing comfits."

The plant is a native of the Malay Archipelago, where it formerly grew wild in the woods. But the place of its origin is unsettled. De Candolle[1] finds powerful arguments for an American origin, where fifteen species are found. Humboldt says it was amongst the offerings of Columbus to Queen Isabella, of the productions of the New World. There are other arguments in favour of an Asiatic origin. Bretschneider has proved that it was known in China at the beginning of the Christian era. But whether it was a native of the New or Old World, it is difficult to explain its transportation from America to China, or *vice versa*, at the beginning of our era, or from Asia or Australia at a time sufficiently remote for its cultivation to be early diffused from Southern America to Chili and Brazil, unless we assume a prehistoric communication between Asia and America, which is not inapplicable to the case.

Composition of Sweet-Potatoes—Percentages.

	Water.	Protein.	Fat.	Carbohydrate.	Fibre.	Ash.	Authority.
Raw, edible portion							
Minimum	45·8	0·40	·2	17·10	·60	·70	
Maximum	79·0	3·70	1·4	49·10	4·60	2·00	Atwater,[2] 95 analyses.
Average	69·0	1·80	·7	27·40	1·30	1·10	
Raw, as purchased ..	55·2	1·40	·6	21·90	—	·90	Refuse, 20·0.
	69·0	2·08	1·0	29·78	2·60	1·15	Wiley.
	67·5	1·50	·3	26·25	·45	2·60	Payen.
Average	72·9	1·60	·5	22·50	1·80	·70	Hutchison.
	73·1	?	?	23·60	—	—	Henry.
	75·0	1·50	·4	19·80	1·80	1·50	Church.
Cooked, with cream or milk ready for table	51·9	3·50	2·1	42·10	—	·90	Atwater.

Sweet-potatoes are highly prized as an article of food in China, the East and West Indies, America, and hot climates generally. In the regions where they are grown most abundantly they provide a large proportion of the food of the natives. In North America 50,000,000 bushels are grown annually, and they are a favourite

[1] "Origin of Cultivated Plants," p. 54.
[2] Bulletin 28, U.S. Department of Agriculture.

article of food, used more generally, perhaps, than any other vegetable, excepting the ordinary potato. Their cultivation is somewhat different from that of *Solanum tuberosum*, the plants being frequently forced by artificial heat, and afterwards transplanted to the soil in which they come to maturity and produce tubers. The tubers are starchy and sweet, spindle-shaped, and tapered like a parsnip. They are highly nutritious, being mealy when cooked, and are considered a delicacy by many people. They are eaten roasted or boiled. Eaten like an ordinary potato, they are wholesome, but possess slightly laxative properties. Owing to their sweet taste, they do not form such an appropriate accompaniment to meat as ordinary potatoes ; but the varieties most esteemed for the table by those who eat them freely are those which contain the largest proportion of sugar.

The amount of *protein* and *fat* is small, except when mixed with cream or milk for the table. The *carbohydrates* consist of 13 to 18 per cent. of starch in granules, which average 0·045 millimetre in diameter. The sugar varies from 4 to 10 per cent., and is nearly all cane-sugar or sucrose ; but of twenty-six samples analyzed in the United States Government Laboratories, Atwater found an average of only 2·5 per cent. of cane-sugar, and 3·4 per cent. of invert sugar. Church found only 1·7 per cent. of sugar, with 2·2 per cent. of dextrin and gum, and 0·9 per cent. of pectose. The total fermentable matter varies from 23 to 30 per cent. They yield a corresponding proportion of alcohol, and are much used for the production of spirit in the Azores.

Chinese sweet-potatoes are the product of *Ipomœa batatas* or *Ipomœa mammosa*, belonging to the same natural order. They grow wild near Amboyna, and are much cultivated in China, Cochin-China, and in the Western States of America. These roots have nearly the same food value as *Batatas edulis*, and present no superiority over them in point of nutrition. They are, however, preferred by the Chinese residents of various countries. There are two varieties—roots with rounded ends, and roots with pointed ends. Their composition is as follows :

CHINESE SWEET-POTATOES—PERCENTAGES.[1]

	Rounded Roots.	Pointed Roots.
Water	73·44	77·47
Protein	·78	·73
Fat	·25	·22
Starch	11·65	9·67
Cane-sugar	1·71	4·02
Reducing-sugar ..	4·07	3·19
Fibre	1·02	·93
Ash	·85	1·00

[1] Bulletin 68, U.S. Department of Agriculture : " Chinese Vegetable Food Materials."

Yams.

Yams consist of several varieties of *Dioscorea sativa*, genus Dioscorea, N.O. Dioscoreaceæ, cultivated extensively in China, the East and West Indies, the Malay Archipelago, Africa, America, and nearly all tropical countries. They are natives of the Old World, especially of Eastern and Southern Asia. There are about 200 species scattered over all the tropical and subtropical countries. They usually have rhizomes—*i.e.*, underground stems or branches—which become larger and more or less fleshy when the exposed part of the plant is near its period of decay.

In Ceylon, *D. sativa*, *D. alata*, and *D. purpurea*, are cultivated in gardens. The Chinese yam is *D. batatas*. It is cultivated extensively by the natives, in addition to *D. sativa*, which is similar to it, and *D. alata*. In Japan there is a subvariety, *D. japonica*, which is referred by authorities to *D. sativa*, and is cultivated in addition to the other varieties. In the Pacific Isles, the yam most commonly cultivated is *D. alata*. In French Guiana, the species chiefly cultivated is *D. triloba*, called the "Indian yam," which is also common in Brazil and the West Indies. In America, *D. sativa* and *D. alata* are grown. Less numerous varieties are found growing in Africa and America than in Asia. The ancient Egyptians cultivated no yams, and none of importance are cultivated there to-day.

The part eaten is the rhizome, sometimes called a "tuber," which varies in weight from 1 pound to 30 pounds, and may be 3 feet long. Boiled, roasted, or reduced to a powder for making bread and puddings, they are consumed to a considerable extent. They are palatable, wholesome, and nutritious food. Their composition resembles that of the sweet-potato, but they are not so sweet. They become mealy when boiled, and their carbohydrate is chiefly starch.

Composition of Yams—Percentages.

	D. Sativa.[1]	*D. Batatas.*[2]
Water	79·50	79·3
Protein	2·25	2·5
Fat	·61	—
Carbohydrate	16·10	16·0
Fibre	·84	1·1
Ash	·70	1·1

In many countries yams occupy the same position that is filled by the common potato in Europe. They are devoid of the sweetness of sweet-potatoes, are available all the year round, and they keep better when removed from the ground. At the period of the potato famine an attempt was made to introduce them into England and Ireland, but with little success.

There are other so-called "yams" grown in China and the West Indies. These are not true yams, or *Dioscorea*, but belong to the natural order of Leguminosæ. Such are the yam-beans, *Pachyrhizus tuberosum* and *angulatus*.

[1] Average of several authorities. [2] Frémy.

The former has a root which is large and round ; the latter is turnip-shaped. The root of these plants, according to Fawcett,[1] is formed of simple cord-like fibres several feet in length, which bear in their course a succession of tubers. They are grown in China, the West Indies, Africa, and other places, and are eaten like potatoes. Their composition is shown by the analysis of roots grown in British Guiana.[2]

Composition of Leguminous Roots—Percentages.

	P. Tuberosum.	*P. Angulatus.*
Water	85·70	82·25
Protein	1·04	1·05
Fat	·51	·30
Starch	2·03	8·46
Cane-sugar	—	1·29
Reducing-sugar ..	1·38	·36
Gum and pectose ..	2·79	1·62
Cellulose and fibre ..	5·10	2·80
Ash	1·37	1·84

The composition of the tubers of *Apios tuberosa*, of the same natural order, is, according to Payen : Water 57·8, nitrogenous matters 4·5, starch, sugar, and pectose, 33·55, fibre 0·8, and salts 2·25, per cent. They are sometimes eaten in Europe, being obtainable in German markets. These tubers are evidently not so nutritious as the true yams ; but it is stated by Harrison and Jenman that 75 per cent. of the fibro-cellulose is digestible.

Taro.

Taro consists of the roots of a large number of species of the genus *Colocasia*, N.O. Aroidaceæ, which have been from time immemorial an important foodstuff for the natives of various countries. They are at the present period one of the most commonly cultivated roots in the tropics, being cultivated in China, Japan, Southern India, Australia, the Pacific Islands, and Africa. The species most widely cultivated are *Colocasia antiquorum* (also called *Caladium* or *Arum esculentum*) and the varieties *C. indica*, and *C. odorata*, a native of India, Ceylon, the Malay and Fiji Islands ; *C. macrorhiza*, or Apé, a native of Ceylon, Otaheite, and other Southern islands. *Arum maculatum*, a native of Portland Island, used in the same way, is the source of Portland arrowroot. The species are found wild in Polynesia, the Malay Archipelago, and India. Their cultivation is ancient. Chinese books mention them 100 B.C. ; Pliny speaks of the *Arum ægyptium*, by which he means *C. antiquorum*. The European botanists gained their knowledge of *C. antiquorum* from Egypt, but the earliest European navigators found it cultivated from Japan to New Zealand.

The roots are tuberous, somewhat between a yam and a sweet-potato in appearance, and in Japan they are eaten like a potato.

[1] "Economic Products of Jamaica," 1897, p. 37.

[2] Harrison and Jenman : Report of Agricultural Work, Botanic Gardens, British Guiana, 1891-92, p. 71.

They contain a large amount of starch in the form of small granules, and some cane-sugar. The protein is of an albuminoid nature. Their composition is shown in the following table :

COLOCASIA ANTIQUORUM, OR CALADIUM (ARUM) ESCULENTUM—PERCENTAGES.

	Blasdale.[1]		Kellner.[2]	Nagai and Murai.[3]
	Large Roots.	Small Roots.		
Water ..	74·20	65·71	80·65	85·20
Protein, total	1·70	1·89	2·09	—
Albuminoids	1·67	1·62	1·39	—
Amides ..	·04	·27	·70	—
Fat	·27	·16	·17	·08
Starch ..	17·95	25·32	6·52	10·40
Sugar	1·15	1·86	large amount	·12
Fibre	·98	·66	·70	—
Ash	1·31	1·10	·85	·99

These roots are of similar nutritive value to that of potato and yam. They are a good substitute for those tubers, but present no advantage over them. They are, however, much appreciated by European residents of the tropics, who soon acquire a liking for them. They are boiled and eaten like potatoes.

Poi is the fecula obtained from taro in a similar manner to arrowroot, or simply by washing the roots and grinding them to a meal. It is of a pink or lavender colour. It is made into a porridge by slowly adding the fecula or meal to hot water, and stirring it until it has the consistency of paste. It is eaten with salt or sugar. The meal is also eaten like corn or oatmeal. The fecula is reputed to be suitable for persons with gastric ailments, such as ulcer, dyspepsia, acidity, and carcinoma. It is useful in enteric and other fevers, in convalescence from many illnesses, and for feeding children. It does not appear to present any advantages over other farinaceous foods.

Water-Chestnut.

The tubers or corms of *Eleocharis tuberosa* and *Scirpus tuberosus* are widely used in China and Japan. The former grow wild in watery places, and are not specially planted. They are sweet, juicy, and resemble a chestnut in their flavour, by having a brown skin and white interior. The latter are cultivated in rice-lands, and are very similar. *E. tuberosa* was analyzed by Blasdale,[4] and found to contain—Water 77·29, protein 1·53 (including albuminoid 1·16, amides 0·37), fat 0·15, starch 7·34, cane-sugar 6·35, reducing-sugar 1·94, fibre 0·94, ash 1·19, per cent. The striking feature is the high proportion of sugars, which gives them a sweet taste and makes them of value as a raw food. The protein consists chiefly of soluble albumin. The ash contains manganese.

[1] Bulletin 68, U.S. Department of Agriculture.
[2] *Land.-Vers.-Stat.*, 1884, xxx. 42. [3] König's "Chemie."
[4] Bulletin 68, U.S. Department of Agriculture.

Jerusalem Artichokes.

Jerusalem artichokes are the tubers of *Helianthus tuberosus*, N.O. Compositæ. They are indigenous to Canada and the Upper Mississippi Valley, and were cultivated by the American Indians. They were brought to Europe from North America in 1616. The English name, "Jerusalem artichoke," is a corruption of the Italian *girasole*, sunflower, combined with an allusion to the artichoke flavour of the tuber. They are boiled in water or milk, and eaten with white sauce, pepper, and salt; and also cooked in meat pies, stews, and various highly seasoned dishes, in which the condiments counteract the griping tendency of the tuber. They are wholesome, nourishing, and fattening, but are apt to produce griping and flatulence. They are not consumed to a large extent in England. They possess a sweetish taste from containing a large amount of sugar, but they are less agreeable to the palate than potatoes, and do not become mealy on boiling. The latter is due to their containing *no starch*. There are no granules to swell up and absorb moisture, or to break up the tissue into a loose friable mass. They therefore remain in a moist and watery condition after cooking, and are less digestible than potatoes.

Although the tubers contain no starch, they possess a considerable amount of sugar, estimated by Payen and Fevry to be 14·7 per cent. This, however, is soluble, and lost to a considerable extent by boiling, except when they are boiled in milk or the liquid in which they are cooked is used for making sauce. According to Tanret, the sugar is much smaller than that stated above. They, however, contain 2 per cent. of inulin, which is less soluble, and isomeric with starch. The chief carbohydrates, according to Tanret,[1] consist of two reducing substances — helianthin and synanthin. These are more soluble than inulin, and appear to have been calculated as sugar owing to their reducing property. The tubers also contain gummy substances (inulin 1·9 per cent., pectose bodies 1·3 per cent.), which cause them to be mucilaginous when boiled. Von Noorden is of opinion that artichokes are better borne by diabetics than other carbodydrates, and should certainly be allowed in mild cases of that disease.

Dahlias.

Attempts have been made to introduce the tubers of this elegant flowering plant as an esculent. They belong to N.O. Compositæ, and consist of many varieties derived from *D. variabilis* and *D. coccinea*. But the flavour of the tubers is not very acceptable to Europeans. They are rich in carbohydrate material, especially *inulin*, and, containing little or no starch, are recommended as food for diabetics.

[1] Watts, "Dict. Chem.," art. "Artichokes."

Beetroot.

The roots of *Beta vulgaris*, N.O. Chenopodiaceæ and its varieties. The common or red beet, *B. vulgaris*, var. *romana ;* white beet, *B. alba ;* sugar-beet, *B. altissima ;* and the mangold-wurtzel, *B. maritima*, are those most used for food. All the cultivated varieties of beet are derived from *B. vulgaris*, which is a native of the Old World. It grows wild in sandy soil, especially near the sea, in the Canary Isles, all along the coasts of the Mediterranean Sea, the Caspian Sea, in Persia, Babylon, and probably as far as Western India. It was cultivated by the Greeks, Romans, and Arabs from the third or fourth century before the Christian era. Aristotle, Pliny, and Theophrastus, name distinct varieties of the root, but their number has been increased in modern times. It was grown in Great Britain in the twelfth century. It is one of the plants most easily improved by cultivation and selection.

The root of *B. vulgaris* varies in colour from a light red or yellow to a deep or blackish red. It is extensively grown as a food for man and beast. The boiled roots are an appropriate accompaniment of roast meat ; they are also eaten cold, cut in slices, in salads and pickles. In either way they are equally nutritive. They are readily digested by most people, but pickled beet is apt to cause dyspepsia. Many years ago Lyon Playfair recommended beets to be used in making brown bread, by rasping the roots and mingling the meal so produced with an equal quantity of flour. Sugar-beet is largely grown in France, Belgium, Germany, America, and other countries, for the manufacture of sugar. The large midrib of the leaves, when boiled, forms an excellent vegetable (for their *composition*, see Greens). The mangold-wurtzel, which is closely allied to the sugar-beet, is chiefly of importance as a valuable and nutritive fodder for cattle ; but it also yields sugar, and is used for that purpose, as well as for the manufacture of alcohol.

Beetroot is chiefly of value for its carbohydrates, consisting of sugar, starch, and mucilage, and alkaline salts. The sugar, chiefly cane-sugar, ranges from 5 to 18 per cent., and averages 10 per cent. Starch and pectose were found by Payen to equal 4·5 per cent., the pectose according to other authorities being 2·4 per cent. A good deal of the sugar is lost by boiling, so that the cooked root only contains 5 or 6 per cent. of carbohydrate, including about 3 per cent. of sugar. The protein at best is only small in amount, the total nitrogen averaging about 2 per cent. of the roots ; but only 35 per cent. is present as protein, 29 per cent. as amides, and 36 per cent. in the form of ammonia and nitrates. The cellulose varies from 1·5 to 2 per cent. When softened by acetic acid, as in pickles, it is very easily digested.

Parsnips.

The parsnip is the root of *Pastinaca oleracea*, N.O. Umbelliferæ, found wild in meadows in Britain and all over Europe in chalky soil or upon dry banks. It was a common occupant of Roman

COMPOSITION OF JERUSALEM ARTICHOKES—PERCENTAGES.

	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Ash.	Authority.
Raw tubers: Average proportion	79·7	2·4	·20	16·1	1·1	1·00	Mean of all available analyses.
	80·0	2·0	·30	15·6	1·3	1·10	Johnston.
	76·0	3·1	·20	16·6	1·5	1·30	Mean of Payen, Poinsot, and Fevry.
	79·5	2·6	·20	16·7	·8	1·00	
Minimum	77·5	2·2	·10	15·3	·8	·90	Atwater.
Maximum	81·5	2·9	·20	18·3	·8	1·10	
Cooked tubers	91·6	1·8	·08	4·6	·9	·61	Hutchison.

COMPOSITION OF BEETROOTS—PERCENTAGES.

	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Ash.	Authority.
Common beet—Raw: Average proportion	84·9	1·45	·15	10·50	1·50	1·5	Mean of all authorities.
Minimum	70·0	·50	·10	4·00	—	·7	
Maximum	93·0	3·00	·20	18·00	—	2·0	
As purchased	70·0	1·30	·10	7·70	—	·9	Atwater, Bulletin 28, U.S. Department of Agriculture.
Edible part: Minimum ..	79·5	·90	·10	3·80	·60	·7	
Maximum ..	94·1	3·00	·20	16·30	1·70	2·0	
Average ..	87·5	1·60	·10	9·70	·90	1·1	
Cooked	88·6	2·30	·10	7·40	—	1·6	
	91·7	1·37	·10	5·13	·70	1·0	Mean of all analyses.
Sugar-beet, average	83·5	1·30	·12	12·80	1·24	1·0	Johnston's "Agricultural Chemistry," p. 429.
Mangold-wurtzel, average ..	88·0	1·40	·20	9·50	1·10	7·9	

gardens, and has probably been cultivated for rather less than 2,000 years, being mentioned by Dioscorides, but not by Theophrastus. It figures in ancient frescoes at Pompeii, etc. The root is fleshy, sweet, mucilaginous, and moderately nutritive. In times of scarcity it has been used for making bread. An excellent wine, resembling malmsey or madeira in flavour, is made from the roots, and the fermented liquor yields an excellent spirit. According to Goff, there are only three varieties.

The amount of nitrogenous substance is small, varying from 1 to 2·5 per cent., and, according to Johnston, consists chiefly of vegetable casein, or legumin. The fat averages 0·62 per cent. The carbohydrates are the most important constituents. They consist of 5 to 7 per cent. of starch in exceedingly small granules, which average 0·007 millimetre in diameter. The sugars vary from 3 to 6·8 per cent., gummy substances 5 or 6 per cent., and fibro-cellulose 1·5 to 2 per cent. Their heat value averages 300 calories per pound. Cooked parsnips lose a considerable proportion of nutriment. They only retain 0·5 per cent. of protein, and 5 or 6 per cent. of starch, sugar, gum, and cellulose. Their caloric value, therefore, is small. Nevertheless they are more valuable than turnips, are free from any substance which is likely to generate flatus, easily digested by most people, and even those whose digestion is rather feeble. They are used as an accompaniment of salted fish and roast or boiled meat. The ash was found by Atwater to consist of CaO 6, K_2O 42·2, MgO 3·1, P_2O_5 12·8, Na_2O 0·4, and Fe_2O_5 0·3, per cent.

Carrots.

The roots of *Daucus carota*, N.O. Umbelliferæ, found in its wild state all over Great Britain, Europe, and Western Asia. It is said that the cultivated carrot was introduced into England by the Flemish refugees who settled at Sandwich in the reign of Elizabeth. It apparently became very popular, for we also read that in the next reign the ladies wore carrot-leaves in their hats in the place of feathers. It has, however, been in cultivation for more than 2,000 years in Europe and Western Asia.

The root of the wild plant is white, slender, hard, or fibrous, and has an acrid taste and pungent, aromatic odour. By cultivation it has been transformed into a thick, fleshy, succulent root, of red, yellow, or pale straw colour, with a sweet, mucilaginous, and agreeable taste. There are twenty-eight varieties. Their composition and nutritive value are about the same as those of parsnips.

As usual in roots, the content of protein is very small. It varies from 0·5 to 2 per cent., a little more than half of which is albumin and gluten. The fat ranges up to 0·7 per cent. as a maximum ; it includes a small amount of oil. The amount of starch is as a rule small, but it has been estimated as reaching 8·4 per cent. The sugars, according to Attfield, are dextrose, lævulose, and mannite. According to Atwater, they consist of cane-sugar 3·6 per cent., and fruit-sugar (dextrose and lævulose) 3 per cent. The amount

COMPOSITION OF PARSNIPS—PERCENTAGES.

	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Ash.	Authority.
Raw roots: Average proportion	76·80	1·62	·62	12·50	1·70	1·10	Mean of all analyses.
	80·34	1·35	·66	16·09	·53	1·03	Wiley.
	85·00	1·36	·34	10·90	1·40	1·00	Johnston.
	80·01	1·40	1·00	14·10	2·00	1·30	Hutchison.
	82·00	1·10	·50	15·10	—	1·00	Letheby.
As purchased	66·40*	1·30	·40	10·80	—	1·10	*Refuse, 20 per cent.
Edible portion: Minimum ..	79·50	1·40	·20	8·50	—	·70	Atwater, Bulletin 28, U.S. Department of Agriculture.
Maximum	89·20	1·90	·80	16·70	—	1·90	
Average ..	83·00	1·60	·50	13·50	2·50	1·40	
Cooked roots	92·30	·22	·29	1·46	·72	·12	Hutchison.

COMPOSITION OF CARROTS—PERCENTAGES.

	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Ash.	Authority.
Raw carrots: Mean proportion	84·00	1·11	·30	9·50	1·50	1·00	All available reports.
As purchased: Average ..	85·00	1·00	·20	10·10	—	1·00	Attfield.
	88·32	1·04	·21	9·07	·95	·71	König.
	87·50	1·20	·20	8·97	1·10	1·03	Johnston.
	83·00	1·30	·20	14·50		1·00	Letheby.
	70·60	·90	·20	7·40	—*	·90	*Refuse, 20 per cent.
Edible portion: Average ..	88·20	1·10	·40	9·30	1·10	1·00	
Minimum ..	83·10	·70	—	6·50	·60	·60	Atwater, Bulletin 28.
Maximum ..	91·10	2·00	·70	13·80	2·30	1·60	
Evaporated	3·50	7·70	3·60	80·30	—	4·90	
Cooked ..	93·40	·53	·17	3·39	1·80	·32	Hutchison.

of fermentable substance is of such proportion that 1 ton of carrots will yield 12 gallons of alcohol. The fibre or fibro-cellulose varies in young roots from 0·6 to 2·5 per cent., but it may far exceed this amount. When the roots are allowed to remain a long time in the ground, they become fibrous, woody, and uneatable. The roots contain an average of 2·59 per cent. of pectin, besides gum and carrotin.

Carrotin is a ruby-red crystalline substance of neutral reaction, without taste and smell. It occurs also in tomatoes. Carrot-juice will coagulate on being heated ; 1,000 parts of juice yield 629 parts of solid matter, including albumin and pectin 429, carrotin 34, fat 10, salts 6, parts. Pectin can be precipitated from this juice, as it can from many other vegetable and fruit juices, by alcohol. This precipitate, on being washed with weak alcohol, dries into a semitransparent substance similar to isinglass. When immersed in 100 times its weight of water, it swells up and forms a homogeneous mass which gelatinizes. When acted upon by a fixed alkali or alkaline earthy base, it is transformed into *pectic acid* (see Pectose Bodies). The **salts** in carrots are malates, earthy phosphates, and chlorides of the alkalies. Their composition is as follows :

Ash of Carrots.	König.	Atwater.	Johnston.
Potash	35·21	53·7	41·46
Soda	22·07	1·4	17·60
Lime	11·42	7·3	8·86
Magnesia	4·73	2·8	5·36
Iron oxide	1·03	·8	·32
Phosphoric acid	12·16	9·8	12·68
Sulphuric acid	6·72	?	6·93
Silica	2·47	?	2·00
Chlorine	5·19	?	4·79

Carrots resemble parsnips in composition, but they are richer in sugar and poorer in starch. They contain only 0·5 per cent. of protein, and about 6 or 7 per cent. of sugar, with 2 or 3 per cent. of digestible pectose, starch, gum, and cellulose, the heat value of the raw edible portion being 210 calories per pound (Atwater).

Cooked carrots lose a considerable portion of their nutriment, especially the soluble protein and carbohydrate, of which they retain little more than 4 per cent. Even this is not all digested, according to Rubner, who found that 20·7 per cent. of cooked carrots escape digestion, including 39 per cent. of the nitrogen, 18·2 per cent. of the carbohydrate, and 33·8 per cent. of the minerals, which escape absorption.

Turnips.

The innumerable varieties and subvarieties of turnips, known as "white" and "yellow" turnips, "swedes," "kohlrabi," etc., belong to one of the four species of Linnæus : *Brassica napus*,

COMPOSITION OF TURNIPS—PERCENTAGES.

	Water.	Protein.	Fat.	Sugar.	Starch, Gum, etc.	Fibre.	Ash.	Authority.
Average of all varieties ..	87·90	·90	·20	3·50	4·70	1·20	1·60	Fifty reports.
White turnips : Average ..	91·24	·96	·16	4·08	1·90	·91	·75	König.
	92·00	1·08	·15	3·00	2·21	·96	·60	Johnston.
	91·00	1·20	—	2·10	5·10		·60	Payen.
	62·70	·90	·10	5·70		*	·60	*Refuse, 30 per cent.
Edible portion : Minimum	70·10	·70	·10	2·80		·80	·50	Atwater, Bulletin 28.
Maximum	95·70	3·90	·40	23·80		3·20	2·10	
Average	89·60	1·30	·20	8·10		1·30	·80	
Aberdeen yellow turnips ..	90·50	1·40	·20	3·90	1·90	1·00	1·00	Johnston.
Swede-turnips	89·50	1·45	·20	4·60	2·50	1·10	·64	
As purchased	62·20	·90	·10	6·00		*	·80	*Refuse, 30 per cent.
Edible portion : Minimum	87·10	·90	·10	6·20		1·10	·70	Atwater.
Maximum	91·80	2·00	·30	10·30		1·40	1·40	
Average	88·90	1·30	·20	8·50		1·20	1·10	
Kohlrabi, edible : Minimum	90·90	1·70	·10	5·40		1·10	1·30	
Maximum	91·30	2·30	·10	5·60		1·40	1·30	
Average	91·10	2·00	·10	5·50		1·30	1·30	

B. oleracea, B. rapa, B. campestris. The varieties commonly grown in Great Britain and America are—*Rapa depressa,* turnips white and yellow ; *Ruta baga,* Swedish turnip ; *Brassica caulo-rapa,* kohl-rabi, or turnip-cabbage. Goff makes forty-one varieties altogether. They are natives of temperate Europe and Western Siberia. Their cultivation was diffused throughout Europe before, and in Asia after, the Ayran invasion.

Turnips consist of a sweet juicy, mucilaginous substance, which is much appreciated as a vegetable when the roots are young, firm, and of a delicate texture ; but they should be rejected when they become soft, spongy, or fibrous. They are best eaten when boiled and mashed or made into a purée ; but they are also used in soups and stews. They are apt to give rise to flatulence, and sometimes to dyspepsia.

The solids are 12·1 per cent., consisting of 3·5 to 5 per cent. of sugars in white or yellow turnips, and 6 or 7 per cent. in swedes, chiefly fermentable ; 4·7 per cent. of gum and pectose, mostly the latter, and a very little protein and fat. The protein is chiefly albumin, and the non-protein nitrogen in the form of amides. **They contain no starch.** An extended analysis of swede turnips is given :[1]

Composition of Swede Turnips.

Juice = 97·466 per cent., containing—		
Water	90·020 per cent.	
Pectose		
Amides, etc.		
Soluble albuminoids	·167	,,
Cane-sugar	·817	,,
Glucose	6·030	,,
Soluble ash	·432	,,
Solids = 2·534 per cent., including—		
Insoluble ash	·205	,,
Insoluble albuminoids	·216	,,
Fibre	2·113	,,
	100·000	

Skirret.

Two roots are known by this name : (1) *Sisum sisarum,* N.O. Umbelliferæ ; and (2) *Scorzonera hispanica,* N.O. Compositæ. They are grown in Europe, America, Asia as far as China, Japan, Burmah, Siam, Cochin-China, etc., for their edible roots, which when boiled resemble a parsnip. They are boiled, and eaten with white sauce ; or half boiled and then fried, and eaten with pepper and other condiments.

Sisum sisarum has several roots, which diverge from the stem in the form of carrots. It is a native of Northern Persia and Southern Siberia. De Candolle considers it came into Russia from Siberia, and thence into Germany, and probably into England and France in the sixteenth century. It was known to the Romans

[1] Addyman's " Agricultural Analysis," p. 113.

(Pliny), but not to the Greeks before the Middle Ages. It is grown for its root, which contains a considerable amount of cane-sugar, the roots being sweet after boiling, and a fine white sugar can be obtained from them. They are much esteemed for this property by some people, who consider them the finest, whitest, and pleasantest root grown ; others dislike them because of their sweetness.

Scorzonera hispanica, sometimes called "black salsify," has a long black root. It is wild in Europe from Spain to the South of France and Germany, and is eaten cooked in the same way as the former. Another member of the family, *S. deliciosa*, which has a sweet, sugary root, is used in Palermo for making sherbets, and is preserved in sugar, to be eaten as a sweetmeat like angelica.

Salsafy or Salsify.

The roots of *Tragopogon porrifolius*, N.O. Compositæ, cultivated in gardens, are small, and are eaten like carrots. They were cultivated a century or two ago more than at the present time, but were little improved by cultivation. They grow wild in the South of Europe and Algeria. The *composition* of the cooked roots[1] is as follows : Water 87·2, protein 1·2, fat 0·08, carbohydrates 9·0, cellulose 2·0, salts 0·3, per cent. The uncooked root contains 1·3 per cent. of protein, 0·4 per cent. of fat, and 10·8 per cent. of carbohydrates, including starch and sugar. When tender, the roots are considered a delicacy, similar to asparagus, and are eaten with white sauce and lemon-juice. They have a flavour of oysters, which has gained for salsify the names of "oyster-plant" and "vegetable oyster." They can be stored like carrots and potatoes. The leaves are eaten as a salad. Spanish salsify, *Scolymus hispanica*, is closely allied to the cardoon and green artichoke. The root is much like that of salsify, but when cooked it has a flavour between a parsnip and salsify. The leaves are blanched, and eaten like cardoons or celery.

Other Edible Roots.

The tuberous roots of *Oxalis crenata*, N.O. Oxalideæ, are cultivated, eaten, and much esteemed, in Peru. They have a mealy consistency, like potatoes, and were introduced into Europe as a substitute for them. But no advantage accrued to the grower which he did not derive from potatoes, whence is attributed the failure of the experiment. The tubers are yellow, farinaceous, and pleasantly acid. *O. deppei* of Mexico has parsnip-shaped roots, which are less acid than the former. *O. tuberosa*, or **oca** of Bolivia, has smaller tubers, about 1 inch in diameter, which are mealy like potatoes when cooked, and have an acidity which they lose by exposure to the air for about ten days. The natives also expose some of them, in woollen bags, to the sunshine for several months. During this exposure they lose their acidity and become saccharine, and develop a consistency and sweetness which resembles that of dried figs ; they are then called *cani*. The *Ullucus tuberosus*, which is cultivated in Bolivia and Peru, has tubers which are eaten like potatoes. An attempt has been made to introduce them into France. The *Arracacha esculenta*, a native of South America, is boiled and eaten in Venezuela, Ecuador, New Granada, and other places in South America, as much as potatoes and yams. When boiled, it has a flavour

[1] Hutchison's "Diet and Dietetics," p. 239.

between a potato and a parsnip. De Candolle says it bears comparison with the potato, being quite as agreeable, and yielding a lighter fecula. Attempts to introduce it into Europe have failed through the dampness of the climate. In England we have the tuberous vetch, *Orobus tuberosus*, a native, whose tubers have been used in times of scarcity. There are also the *Apios tuberosa*, eaten here and in Germany; the *Bunium bulbocastanum* and *B. flexuosum* (N.O. Umbelliferæ), which grow in England and other parts of Europe. The exterior of these tubers is chestnut brown to black; the interior is white, aromatic, sweet, and mucilaginous. They are roasted and eaten like chestnuts; or boiled and eaten like potatoes, or in soup.

Arrowhead Tubers.

The tubers of various species of arrowhead, or *Sagittaria*, N.O. Alismaceæ, are common articles of food in some countries—*e.g.*, *Sagittaria arifolia* and *latifolia*, or wappato, used by American Indians; also *S. sinensis* and *S. sagittifolia* by the Asiatics, who cutivate them in India, China, etc. The Chinese in the Western States of America import the latter from Canton. The tubers are small, the interior yellow, farinaceous, and of the consistence of a potato. Their percentage of composition is as follows:[1]

	S. Latifolia.	*S. Sinensis.*	*S. Sagittifolia.*
Water	66·88	61·51	66·86
Protein	4·44	7·00	7·05
Albuminoids	3·98	4·71	5·76
Amides	·46	2·29	1·29
Fat	·76	·24	·55
Starch	19·70	22·90	22·93
Cane-sugar	2·49	2·26	
Pentosanes	—	·32	—
Fibre	·98	·72	1·18
Ash	2·04	1·69	1·43

The high percentage of protein proves their superiority over potatoes, sweet potatoes, and yams. Starch is the most important carbohydrate, although cane-sugar is present. The proteins are casein, soluble and insoluble albumin; and the non-protein substances are asparagin, leucin, etc. The tubers are largely consumed by the Chinese, Japanese, East Indians, Calmucks, and other Asiatics. The roots of the water-plantain (*Alisma plumbago*) also contain much starch, sugar, and some protein, and are eaten by Calmucks and other Far Eastern tribes.

Lily-Bulbs.

The bulbs and flowers of many species of *Lilium*, N.O. Liliaceæ. have long been used as articles of food by the Chinese, Japanese, and other Asiatic races. They are, however, a delicacy rather than

[1] "Chinese Vegetable Food Materials," Bulletin 68, U.S. Department of Agriculture.

a standard article of food. The bulbs are boiled, or slightly roasted, eaten with sugar, and are considered desirable food for invalids and convalescents.

Composition of Lily Bulbs—Percentages.[1]

	Dried Bulbs: *L. Japonicum.*	Fresh Bulbs.		
		L. Japonicum.	*L. Tigrinum.*	Species called "Yuri."
Water	10·16	66·72	71·46	69·63
Protein	5·57	2·33	4·51	3·40
Albuminoids	5·00	1·55	—	—
Amides	·57	·83	—	—
Fat	·37	·59	·24	·11
Starch	62·65	17·74	21·60	19·10
Cane-sugar	2·84	4·16		
Fibre	16·40	·75	1·04	1·42
Ash	2·68	1·24	1·15	1·35
Undetermined	14·09	6·42	—	—

The amount of protein is small, but greater than in potatoes. The chief carbohydrate is starch, but cane-sugar is present. Nagai and Murai, whose analysis of "yuri" is given above, found in the fresh bulb 0·62 per cent. of glucose, 1·92 of dextrin, and 2·44 of dextrose. The analysis of *L. tigrinum* is by Kellner, that of *L. japonicum* by Blasdale, who found an abundance of mucilaginous or pectose-like substance, which is included in the amount of undetermined substances. *L. japonicum* is nourishing and wholesome, and considered of great value to people with pulmonary complaints. Many other lily-bulbs are also eaten. *L. candidum* (white lily), a native of Syria and Asia Minor, is eaten by many people. It contains a good deal of mucilaginous material, and has an acrid taste. The latter it lost by drying the bulbs. They are roasted or boiled, and become viscid, pulpy, sweet, and sugary. *L. kamtschatense*, *L. martagon*, *L. pomponium*, etc., are eaten in Siberia. Their composition is similar to those given above.

The roots of certain **Water-lilies** (*Nupharidæ*) are eaten in various countries. The thick, fleshy stock-root of white water-lily (*Nymphæa alba*) was much used by the ancient Egyptians, and is still used by the Swedes. The roots are composed almost entirely of starch, sugar, and mucilage. They possess a slightly acrid narcotic principle, which is removed by washing the roots. The lotus of the ancient Egyptians is *N. lotus*, which was held sacred by them. Its roots form still one of the most common articles of food. They are gathered, dried, and boiled, and eaten as we eat potatoes, which they resemble in their farinaceous character. It is not the same plant as the lotus of the Hindoos.

[1] Bulletin 68, U.S. Department of Agriculture.

The Lotus.

The **Lotus** of Asia belongs to the water-beans ; varieties of *Nelumbium*, N.O. Nelumbiaceæ. It has been used from time immemorial as a food material by the Hindoos, by whom the plant is venerated, just as the lotus of Northern Africa (*Nymphæa lotus*) was venerated by the ancient Egyptians. The lotus still occupies an important place as a food in Japan, China, Indo-China, and other Asiatic countries. It is also used for the toilet and in medicine. For the sake of convenience the roots and seeds are both mentioned here. The **roots** of several varieties of Nelumbium, but particularly those of *N. speciosum* and *N. nucifera*, are eaten. These roots consist of yellowish nodular stocks, with firm, reddish, but fleshy interior. They contain an abundance of starch in the form of oval or elliptical granules which are distinctly striated. The fresh roots contain mucilage. The amount of nitrogenous material is small, little more than half of it being albuminoid. The dried roots contain about 2 per cent. of asparagin. They are boiled, and eaten like potatoes ; pickled in salt and vinegar, to be eaten with rice ; or dried and powdered, to be made into soup. A kind of arrowroot (*Chinese arrowroot*) is prepared from them, and is one of the most valuable products of the root. The roots of *N. luteum* in North America are boiled and eaten like new potatoes, which they are said to resemble.

Composition of Lotus (Roots and Seeds)—Nutrients per Cent.

	Roots.		Seeds.[3]	
	N. Speciosum.[1]	*N. Nucifera.*[2]	Large Sort.	Small Sort.
Water	84·60	85·80	8·72	9·40
Protein	1·57	1·09	16·64	17·73
Albuminoids	·91	·73	15·47	17·64
Amides	·66	·36	1·17	·09
Fat	·19	·20	2·44	2·96
Starch	7·71		51·64	40·63
Cane-sugar	·33	11·14	4·09	9·55
Reducing-sugar	2·18		2·41	—
Fibre	·76	1·02	3·15	2·95
Ash	·76	·71	3·03	4·15

The **seeds** of *N. speciosum* are the Egyptian beans of Pythagoras, the *lotus* or *tamara* of the Hindoos, the *Lien-hoa* of the Chinese. They are eaten as we eat filberts or other nuts, but also used in soup in China and Japan ; while in Egypt they are roasted and

[1] Blasdale, Bulletin 68, U.S. Department of Agriculture.
[2] Kellner, *cf.* König, " Chemie der Mensch.," etc., p. 705.
[3] Blasdale, *ibid.*

ground to a meal, and made into bread or cake. They contain a considerable amount of white starch.

The seeds compare well with peas and beans, some of which they resemble in flavour, and are equally nutritious.

Sago.

Sago is the starchy substance obtained from the pith of various palms grown in the tropics. It is included in this section for the sake of convenience. The sago-palms belong to the genus *Sagus*, N.O. Palmaceæ. There are several species, the chief one being *Sagus farinifera*, common in the East Indies, Ceylon, and Malay Archipelago. Sago is also derived from members of the N.O. Cycadaceæ, indigenous to China, Japan, and the Molucca Islands, the chief sago-palm of these regions being the *Cycas revoluta ;* and others are *Metroxylon* or *Cycas rumphii et læve*, which grow in the forests of Siam, Andaman, Cochin-China, and Malabar. Less fruitful sources of sago, and more or less localized, are *C. pectinata* in Burmah and Eastern Bengal ; *C. circinalis* in Ceylon and Malabar ; and *C. media* in Australia. The seeds or nuts of several of these varieties yield the same fecula.

Composition of Pearl Sago.

Water	13·5 to 15·0 per cent.
Protein	·0 ,, ·4 ,,
Fat	·1 ,, ·4 ,,
Starch	84·0 ,, 88·0 ,,
Minerals	·1 ,, ·2 ,,

Preparation of Sago.—The starch or fecula is obtained by felling the tree, dividing it into lengths of 5 or 6 feet, and splitting them lengthwise. The pith is removed from these by scraping. It is then reduced to a pulp, mixed with cold water, and stirred about until all the starch falls off, when the liquid is strained through a sieve, which allows the fecula to pass through, but separates coarse particles. The fecula is allowed to settle, is collected, washed several times, and when dried constitutes *sago flour*, which undergoes further treatment. According to Mr. J. R. Jackson, of the Royal Kew Gardens, the process is as follows : The sago flour is mixed with water to a paste, and *granulated* by being passed through a sieve. It is then submitted to violent agitation for about a minute, and afterwards *roasted* for three minutes, and again sifted to remove " sticky " or adhesive grains. Those which pass through the sieve are allowed to remain undisturbed for twelve hours. Various changes are produced by roasting. Before being submitted to heat, the grains are white and mealy in appearance, but the heat transforms them into a nearly transparent and glutinous substance. They are, however, still soft, tough, and about their original size. Finally they are again roasted. They now diminish in size, become tough and hard, and are ready for packing as pearl sago. The pearls or grains of sago vary in size, and are divided into small,

medium, and bullet sago. They are hard in texture, but tough, semitranslucent in appearance, and vary from white to yellowish-brown or pink in colour. A tree when cut down yields about 500 pounds of sago. About 99 per cent. of our supply comes from the Straits Settlements by way of Singapore ; the rest comes from Bombay, Java, and the Philippine Islands.

The starch granules are large and irregular in shape. Their size is about 0·07 millimetre, commonly round or round at one end and elongated at the other. They possess a central hilum, which is linear or stellate, and have ill-defined concentric striæ. Sago is mainly used for puddings, which are made with milk, eggs, butter, and sugar. Such puddings are of similar nutritive value to rice pudding, and equally suitable for food. They are eminently digestible, and leave very little residue.

Tapioca, and Manioc or Cassava.

Tapioca is derived from the tuberous roots of various species of manioc or cassava, N.O. Euphorbiaceæ, natives of South America, but grown extensively in Africa, the West Indies, and other tropical and subtropical countries. Their cultivation and use is of great antiquity. De Candolle[1] says maniocs were cultivated by the natives of Brazil and Mexico before the arrival of the Europeans. In the West Indies the cultivation was common enough to inspire a belief that it was of certain antiquity. They are less widely diffused in Africa, especially in regions at a distance from the coast. The manioc was introduced into the Isle of Bourbon by Labourdonnais, and into Asia by others from Bourbon and America. De Candolle says their origin is undoubtedly American, for numerous varieties are cultivated in Brazil, Guiana, and the West Indies. This is not the case in Africa. The forty-two known species of manihot all grow wild in America ; not one grows wild in the Old World. But *Manihot utilissima* and *M. aipi* have not been found in a wild state anywhere. De Candolle, however, considers them to be of American origin, and if we do not accept their Brazilian origin, we must have recourse to one of two hypotheses : either they were derived from wild species modified by cultivation, or they exist only by the agency of man after the disappearance of their progenitors from wild vegetation.

The most important species of manioc or cassava are bitter cassava, *Manihot utilissima*, and sweet cassava, *M. aipi*, *M. carthaginensis*, and *Jatropha manihot*.

The roots of these shrubs swell into the form of tubers 10 or 12 inches long, 3 or 4 inches thick, and grow in clusters of three to eight in number. Like all other members of the N.O. Euphorbiaceæ, they contain a milky juice. All the tubers contain prussic acid, which in the bitter cassava is distributed uniformly throughout the tuber, and forms 0·023 per cent. of the entire substance.

[1] " Origin of Cultivated Plants," pp. 62, 63.

In sweet cassava the prussic acid is not uniformly distributed. The inner portion of the root contains about 0·006 per cent., while the peel or cortical portion, which is removed, contains only 0·0028 per cent.[1] All species of manioc or cassava root are, in their season, boiled in several waters, and then fried and eaten like potatoes, which they more or less resemble, by the natives of the regions in which they grow. The fresh sweet cassava root is also grated to a pulp, and made into puddings, fritters, and batter-cakes, for which recipes are given in Bulletin 44, Bureau of Chemistry, U.S. Department of Agriculture. **Manioc** or **cassava bread** is also largely consumed by the poor inhabitants of South America. The roots are reduced to *farinha*, of which there are two kinds. *Farinha secca* is made by grating the roots to a coarse pulp, soaking it in water for a few hours, draining it, and baking the residue over a fire. The material is then reduced to a coarse powder or meal resembling oatmeal, which is eaten without further preparation. *Farinha d'agua* is the substance chiefly sold as manioc. It is prepared thus: The roots are washed and scraped to remove the peel, and soaked in water until they are soft. They are afterwards reduced to a pulp ,which is again washed in water and allowed to settle. The water is then poured off, and the residue drained, pressed, roasted on an iron plate, cooled, broken into irregular fragments, and dried in the sun. Its composition and that of the roots is as follows:

Composition of Cassava Roots and Cassava Bread—Percentages.

	Water.	Protein.	Fat.	Starch and Sugar.	Fibre.	Ash.	Authority.
Bitter cassava (*Manihot utilissima*):							
Peeled root, fresh..	67·65	1·17	·40	23·10	1·50	·65	Payen.[2]
,, ,, dried..	—	3·62	1·24	71·39	4·63	2·01	
Sweet cassava (*Manihot aipi*):							
Peeled root, fresh..	80·72	·64	·17	30·89	·85	·63	Ewell and Wiley.[3]
,, ,, dried..	—	1·66	·44	80·06	4·30	3·28	
Manioc or cassava bread	10·50	9·10	·30	79·00	—	1·10	Atwater.[4]

The nitrogenous material in the fresh roots is very small, while that in cassava bread or manioc averages about 9 per cent., which is about the same as that in wheaten bread. The carbohydrate is almost all starch, but it includes about 2 per cent. of sugar and dextrin. The starch granules vary from 0·008 to 0·022 millimetre diameter (0·0003 to 0·001 inch long by 0·0003 to 0·0008 inch broad). They are mullet-shaped for the most part, although a few appear

[1] Carmody, *Lancet*, September, 1900.
[2] *Compt. Rend.*, 1857, 401.
[3] *Amer. Jour. Chem.*, xv. 4.
[4] Bulletin 28, U.S. Department of Agriculture.

to be circular from a different view of the granule. They possess a central hilum and ill-defined striæ. The fat is negligible in estimations of food value; the pulp, crude fecula, and ether extract, yield a volatile oil. The ash consists chiefly of phosphate and carbonate of potash.

Tapioca is prepared from the afore-mentioned roots in the following manner: The tubers are washed, scraped, reduced to a pulp, and pressed to remove the juice. The juice is boiled down until it forms a thick black fluid known as **cassareep** or cassaripe, which is used as a basis for various sauces. The pulp is mixed with water, whereby the poisonous principle of the cassava is removed, and the water is afterwards left undisturbed to deposit the fecula or starch, which is collected and dried in the sun. This fecula is made into tapioca by being heated upon a hot-plate. The heat causes the granules to burst their cellulose envelopes, and their gelatinous contents adhere together and form nodules, which may be kept small by constantly stirring the material during heating. "Pearl" and "pearl-seed" tapioca are made somewhat differently. After being dried in the sun, the fecula is reduced to a powder, which is made into paste with a little water, passed through a sieve to give it a granular form, and then roasted.

Tapioca is whiter than sago, and is preferred by many people. The best commercial varieties are those of Rio and Penang. An artificial tapioca, made from potato starch, and consisting of small spherical grains, is sometimes sold as pearl tapioca.

Composition of Tapioca—Nutrients per Cent.

	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.	Authority.
Genuine tapioca	12·8	—	·20	86·88	·40	Balland.
Potato tapioca	16·0	·45	·15	82·95	10·45	
Genuine tapioca :						
Average	11·4	·40	·10	88·00	·10	Atwater.
Minimum	10·3	·20	—	86·60	—	
Maximum	12·3	·60	·30	89·00	·30	
Tapioca pudding :						
Average	64·5	3·30	3·20	28·20	·80	
Minimum	52·0	2·80	2·30	21·90	·50	
Maximum	71·6	4·20	4·80	38·10	·90	
With apples	70·1	·30	·10	29·30	·20	

Tapioca has a heat value equal to 1,650 calories per pound, and average tapioca pudding equals 720 calories per pound, or with apples 575 calories. Tapioca is eminently digestible and suitable for persons having a delicate stomach. Being one of the root starches, it is more quickly digested than cereal starches, as shown by experiment.[1] Penzoldt,[2] however, found that 40 grammes of

[1] Grierson, *Year-Book of Pharmacy*, 1894, 354.
[2] *Cf.* Hutchison's "Food and Dietetics," p. 236.

tapioca, made into a thick gruel, did not entirely leave the stomach under two and three-quarter hours. But this amount very much exceeds the quantity which a person would receive in three or four tablespoonfuls of tapioca pudding, wherein the starch is combined with milk, sugar, and probably eggs. There are very few foods which are more easily or so completely absorbed as tapioca pudding.

Arrowroot.

Arrowroot is a name said to be derived from the Indian word *ara-ruta*, meaning mealy root. Arrowroot is the fecula obtained from the rhizomes of various plants of the genus *Maranta*, N.O. Marantaceæ, and from various roots or tubers of other natural orders. The most important sources are as follows :

1. **Maranta Arrowroot.**—There are thirty-six species of maranta, at least thirty of which are of American origin.

(1) *M. arundinacea*, the *true* arrowroot, is a native of tropical America, but is also cultivated in the West Indies, East Indies, Africa, Ceylon, etc. It is largely exported from Jamaica, St. Vincent, Bermuda, Mauritius, Natal, Cape Colony, and Australia.

(2) *M. allouyia* and *M. nobilis*, grown in and natives of the West Indies, and *M. ramosissima*, a native of the East Indies, also yield arrowroot.

2. **Canna Arrowroot,** or **Tous les Mois,** is obtained from *Canna edulis*, another member of N.O. Marantaceæ, a native of the West Indies.

3. **Cassava Starch,** or **Brazilian Arrowroot,** is the fecula obtained from *Manihot utilissima* (see Cassava and Tapioca).

4. **East Indian Arrowroot,** or **Curcuma Starch,** is obtained from *Curcuma angustifolia*, grown largely in East India.

5. **Tahiti Arrowroot** is obtained from *Tacca pinnatifida*.

6. **Portland Arrowroot** is the starch obtained from the tubers of *Arum maculatum*, grown largely in the island of Portland. It is now seldom met with alone, but the exported product may be used as an adulterant of other kinds.

7. **English Arrowroot** is the starch obtained from ordinary potatoes, *Solanum tuberosum*. It is used as an adulterant of the foregoing varieties, and may itself be adulterated by starch obtained from wheat, rice, or maize.

8. **Starchy Farina** is largely obtained from maize, rice, wheat, and from leguminous seeds. Although used as adulterants of genuine arrowroot, these are mostly sold as "corn-flour" or as "starch."

9. **Starchy Farina,** obtained from the roots of *Zamia integrifolia*, grown in the West Indies, Cuba, Hayti, etc. ; from the pith of the trunk of *Encephalatus caffer*, called "Kaffir bread" in South Africa ; and the seeds of *Macrozamia spiralis*, which grows in Australia, are all used by the natives of those countries.

Preparation of Arrowroot.—The maranta roots or rhizomes, which average ¾ inch thick and 10 inches long, are washed, peeled, washed

again, and reduced to a pulp by machinery. The pulp is collected in a sieve, and the starch washed out of the fibrous material by a continuous stream of water. The milky liquid obtained in this manner is strained through muslin into a tank, where the arrowroot settles to the bottom. The water is then run off, the fecula collected, washed, and again allowed to settle. Finally, when the water in which it is washed becomes quite clear, the deposit is taken out and dried upon trays having cloth bottoms, or in copper pans, meanwhile being covered with muslin to prevent contamination by dust, insects, etc., and finally submitted to a gentle heat. It is then packed in barrels lined with paper, and carefully protected from contamination by undesirable odours, which readily taint it, during transport.

Composition of Arrowroot—Nutrients per Cent.

	Water.	Protein.	Fat.	Starch.	Sugar, Gum, etc.	Fibre.	Ash.	Authority.
Bermuda arrowroot:								
Maranta roots ..	16·50	·80	—	82·5	—	·05	·20	Atwater.
Brazilian arrowroot:								
Manihot roots ..	15·87	—	·07	83·7	·18	·04	·14	Thorpe.[1]
Arrowroot starch ..	2·30	—	—	97·5	—	—	·20	Atwater.
Arrowroot biscuits	6·53	6·71	12·21	73·77		—	·88	Stutzer.[2]

Genuine arrowroot is that obtained from the roots of various species of *Maranta*. Bermuda arrowroot is the best, but is scarcely distinguishable from St. Vincent arrowroot, which is much cheaper. The starch consists of oval or pyriform granules averaging 0·14 millimetre (30 to 60 μ, rarely exceeding 75 μ) in size, with well-marked concentric striæ and a central hilum, which is linear or circular. As it may be adulterated with other starches, it should be observed that potato starch presents a similar appearance, but has a typical oyster-shell appearance, and a well-marked stellate hilum at the smaller end, from which the equally well-marked striæ begin. Maranta starch granules are a little smaller, and the hilum is at the larger end. Canna starch, or *tous les mois*, has oval or pyriform granules, which are larger than those of the maranta or potato ; in fact, they are the largest starch granules known, and average 0·175 millimetre. They have well-marked striæ, but the hilum is indicated by a slight cross or cleft at the end of the granule. They do not swell up on the addition of liquor potassæ, as in the case of potato starch. Brazilian arrowroot or cassava starch consists of flask-shaped or mullet-shaped granules, some of which are double or triple, and may appear circular from the view presented under the microscope.

[1] "Dictionary of Applied Chemistry," iii. 583.
[2] *Russ. Zeit. Pharm.*, xxi. 724.

The nutritive value of arrowroot is practically the same as starch, but it is starch of an eminently digestible kind, being derived from roots. The fat and protein are so small as to be negligible. Europeans seldom eat it alone, but usually combine it with milk or milk and sugar, which contribute flavour as well as protein and fat to the combination. But the natives of regions where the derivative roots are grown subsist very largely upon the fecula derived from them and upon fruit.

Arrowroot is a valuable farinaceous food for infants and invalids *under specific conditions.* When combined with milk and egg-white it is useful in nearly all forms of diarrhœa. Like other starches, it is very liable to cause constipation under ordinary circumstances. This, however, may to some extent be obviated by putting the entire egg (yolk and white) in the mixture. Arrowroot is almost completely absorbed in the alimentary canal. It is therefore of great utility, not only in diarrhœa, but in mucous enteritis, and in all intestinal affections where it is desirable to avoid the ingestion of coarse fibrous material or to insure the food leaving as little residue as possible.

Starch.

By far the largest proportion of the substance of all cereals, leguminous seeds, tubers, and roots, which are used for food by mankind, consists of carbohydrates of a more or less digestible character. The fact that those vegetables which contain the most starch in a digestible form are the most commonly used by man is powerful evidence of the nutritive value of starch and a teleological argument for their existence. Foodstuffs such as arrowroot, corn-flour, tapioca, and sago, consist almost entirely of starch. Besides these forms, starch is prepared from potatoes, rice, wheat, and maize, on an enormous scale, chiefly for industrial purposes; but they are also used in various prepared foods and as adulterants of arrowroot, corn-flour, etc.

Potato Starch, sometimes sold as English arrowroot, forms a large percentage of the "starch" sold for industrial purposes. It is prepared by washing and scraping the potatoes, and reducing them to a pulp by proper machinery. The pulp is then received into a sieve, through which a constant stream of water washes the starch, and the fibre is left behind. The milky liquid is allowed to deposit the fecula, which is collected, washed, and purified, and finally dried in a kiln or a centrifugal machine.

Rice Starch.—Owing to the presence of gluten in the cereal, which holds the starch granules in a tangled mass, all grains require a different mode of treatmeat. The rice is soaked for twenty-four hours in a dilute alkaline solution, after which it is drained and ground to a fine meal. The meal is then soaked in a stronger alkaline solution, which dissolves out the gluten and liberates the starch. The liquid containing the nitrogenous matters is poured off; the sediment, being collected on a sieve, is washed by a stream of water which carries the starch through it. It is allowed to

stand for three or four days, during which it undergoes a mild fermentation, and the starch settles to the bottom, after which the water is poured off and the starch dried in a centrifugalizer.

Corn Starch, or **Corn-flour,** is obtained from maize by a similar method. The grains are soaked in hot water, ground to a pulp, and carried to cloth strainers, where it is agitated and washed by a stream of water. The starch is then separated from the nitrogenous matters by dilute caustic soda, and subsequently washed with water and dried, the final product containing about 10 per cent. of moisture. Corn-flour intended for human consumption is purer and whiter than the corn starch used in industrial pursuits.

Wheat Starch is also prepared in a similar manner, fermentation being a part of the *modus operandi ;* or the flour is made into dough, and the starch washed out by a stream of water, and afterwards freed from nitrogenous matters and other impurities by means of alkaline solutions. It is finally washed, collected, and dried as in the foregoing examples.

The Characters of Starch.—The granules of starch have characteristics which show their origin. This has already been referred to in the foregoing sections. It is thought proper, however, to give more details under this heading. Each granule consists of an envelope of **cellulose** or **farinose,** usually extremely thin, but of varying density, enclosing the starch, or **granulose.** The cellulose and granulose appear to be arranged in alternate layers, which appear under the microscope as more or less well-defined marks or **striæ.** The arrangement of these layers or strata, and the size and shape of the granules, is characteristic of the cereal, root, or fecula from which it is derived, and is distinguishable under the microscope. The starches may be arranged in types, of which Kenwood[1] recognizes the following :

1. Large round or oval granules, more or less flattened, showing *no marked striæ*, together with other granules, extremely small and ill-defined. They may be from wheat, barley, or rye.

Wheat starch consists of both large and small granules, with very few intermediate sizes. A linear hilum and striæ are visible under a high power ; the small granules are angular.

Barley starch consists of similar granules, but there are more of the intermediate-sized ones. *Striæ* are sometimes visible in large granules.

Rye starch also consists of similar granules, many of which have a rayed hilum and cracked edges. The granules are mostly of the larger kind, and are more circular and flatter than in wheat or barley.

2. Large pyriform or oval granules, having well-marked concentric striæ and a circular or linear hilum. These may be from potato or arrowroot.

Potato starch has the typical oyster-shell appearance, with the well-marked stellate hilum at the small end, and very visible con-

[1] " Public Health Laboratory Handbook."

centric striæ starting from it. The granules vary considerably in size.

Arrowroot consists of similar starch granules, but the hilum is at the larger end. True or maranta arrowroot granules are smaller, those from *Canna edulis* (*tous les mois*) are much larger, than potato starch. Those of cassava starch are flask-shaped or mullet-shaped.

3. Somewhat oval granules, with striæ not concentric and a central linear hilum. They may be from peas, beans, or maize.

Pea starch granules are large, and have a central longitudinal hilum which presents a puckered appearance.

Beans have larger starch granules, which are flatter and more uniform in size. The hilum is puckered or crossed with transverse lines.

Maize starch granules are much smaller and faceted; consequently they are irregular or polyhedric in shape. The hilum is generally stellate.

4. Minute angular faceted granules, with no hilum, or which can only be seen under a high power. They may be from rice or oatmeal.

Rice granules collect in *angular* masses; oat granules are larger, and collected into *round* masses.

5. Granules of irregular size, rounded, or having round edges; generally possessing a central hilum, and showing ill-defined concentric striæ. They may be from sago or tapioca.

Sago consists of granules which are of large size, irregular shape, but commonly elongated, round at one end, and truncated at the other. The hilum is stellate or linear.

Tapioca consists of similar but smaller granules, many of which have a tendency to a flask shape. The hilum is generally towards the rounded extremity.

Dextrin.

Dextrin is an accompaniment of starch in practically all artificial foods, especially in those prepared from cereals. It has the same food value as starch, but is more easily digested and quickly assimilated. Artificial foods are partly dextrinized by submitting them to a temperature of 200° to 210° C., the degree of heat at which starch is converted to dextrin. Dextrin is, however, separately prepared by submitting any starch, such as one of the foregoing, to the temperature mentioned. It is also prepared by submitting such starch to the action of dilute acids. Commercial dextrin, known as "British gum," is prepared by moistening starch with nitric acid, allowing it to dry in the open air, and afterwards heating it to 110° C. This product, however, could not be recommended as a foodstuff, unless properly purified. The proper mode of preparing dextrin as a food is that previously mentioned, and is commonly employed in preparing artificial foods—namely, by submitting cereal flours to a dry heat at 200° to 210° C., which insures the existence of a fair proportion of dextrin in the food. The proportion of dextrin and other principles in artificial foods is considered under that head.

CHAPTER XX

THE LEGUMES OR PULSES

THE pulses or seeds of the legumes, N.O. Leguminosæ, and their allies contain a large store of nutriment designed by Nature for the use of the future plant in its early growth. They have been used as food from time immemorial by various races of people in all parts of the world where the climate is suitable for their cultivation.

The consideration of the fresh edible pods of the immature beans and the young seeds known as French beans, kidney or string beans, green or Windsor beans, Lima beans, green peas, etc., is deferred until we treat of green vegetables. These are chiefly used as green vegetables, and they surpass almost all others in their composition and nutritive value. This section will therefore be devoted to a consideration of the dried legumes, which are those more properly known as **pulses.**

Peas.

The **Field Pea** (*Pisum arvense*) grows wild in Italy in hedges, forests, and mountainous regions. It is probably the progenitor of the garden pea, but the date of its cultivation is unknown. There are few varieties, and the dried seeds are inferior to those of garden peas, as they do not soften so well in cooking, and are therefore chiefly used for cattle fodder ; but the Canadian field pea is used in its immature condition, when about two-thirds grown, as a green pea.

The **Garden Pea** (*P. sativum*) is supposed to have come from Western Asia, but this is doubtful, as it has not been found wild. It is an ancient food. They have been found among the remains of the lake-dwellings of the Bronze Age in Savoy and Switzerland, but the seeds found there are smaller than those of our present species. Heer says they were also found among the relics of the Stone Age at Moosseedorf. The garden pea was cultivated by the Greeks in the time of Theophrastus. The nomenclature seems to show that the Aryans knew the plant when they arrived in Greece and Italy, and probably brought it with them. There is, however, no indication of its culture in ancient Egypt or India, and it was introduced into China from Western Asia. De

Candolle concludes that the Aryans introduced it into Europe, and that it existed in Asia from the Caucasus to Persia before it was cultivated. It no longer exists in a wild state, and may perhaps be a modification by culture of the field pea (*P. arvense*).[1] Garden peas, however, have by cultivation and hybridization been developed into many subvarieties, which, however, rapidly and easily revert to the original type. They are divided into shelling peas and edible-podded peas. The latter, called "sugar peas," are little known in England. They have a tender and fleshy shell, and are consumed like kidney beans or snap beans. Shelling peas consist of two chief varieties: (1) The smooth round-seeded variety; and (2) the wrinkled kind, of which "Marrowfat" peas are one of the chief. Some of the special strains are mentioned under Green Peas. Most of the references to peas in early English writings are to dried peas. There are records of green peas being eaten in Norman times. That the varieties and qualities of peas were carefully considered is also shown by a record in the time of Henry VIII. Most of the choice garden peas, however, were brought from Holland, and formed an expensive article of food even in Queen Elizabeth's time.

The Chick Pea, or Gram (*Cicer arietinum*).—This plant has not been found wild, but fifteen species are known in Western Asia, all of which belong to Greece except one. This pea was cultivated by the Greeks as early as Homer's time. It may have been known to the ancient Hebrews and Egyptians, but De Candolle does not think so. It was probably introduced among them from Greece or Italy at the beginning of our era. It is probable that its cultivation in Europe was begun by the Western Aryans (Pelasgians and Hellenes), and that they also carried it into India. De Candolle thinks it may have been indigenous to Southern Europe, but the species now only exists in cultivated ground, and it cannot be ascertained whether it came from a stock originally wild or from cultivated plants.[2] It is, however, largely cultivated in Southern Europe, Spanish America, India, and other Eastern countries. They are eaten boiled in soup or roasted (**parched peas**) in Spain and Oriental countries. During the heat of summer the leaves of this plant exude a viscous limpid liquid, which on examination is found to consist almost entirely of oxalic acid (Hogg).

Cow Peas (*Vigna catjang*).—The cow peas properly belong to the beans, but the name has long passed into common use, especially in the Southern States of America. There are several varieties, as the round *lady peas*, the mottled and speckled *whip-poor-will peas*, the black, red, black-eye, purple-eye, and others. These beans were originally brought from India or China, where their use is very common. Considerable quantities are eaten *green*, like kidney beans, and the dried beans are cooked like other beans, and have an agreeable flavour. The plant is indigenous in Equatorial Africa,

[1] De Candolle's "Origin of Cultivated Plants," pp. 328-330.
[2] *Ibid.*, pp. 323-325.

but is readily naturalized in many countries—*e.g.*, Asia and America. The seeds are a common food of the natives in many countries, and they are held in high estimation by many people, who consider them to be superior to garden peas. On the other hand, they are not esteemed in Jamaica, where they are used chiefly for feeding poultry and pigeons, and are called *Pigeon peas*. They will not grow in all climates, and seldom come to maturity in the New England States.

Lentils.

Lentils (*Ervum lens or Lens esculenta*).—They are believed to be a native of Southern Europe and Northern Africa, but the plant is no longer found in a wild state with certainty. Lentils are mentioned in the most ancient records, and were probably amongst the earliest foods cultivated by man. They have been cultivated in the countries around the Mediterranean, in the East, and even in Switzerland, from prehistoric time. According to Herodotus and Theophrastus, the ancient Egyptians used them largely. They formed the mess of pottage for which Esau sold his birthright, the colour of the lentils being *red* because they were hulled. The practice of hulling the lentils is still common in Egypt. De Candolle[1] considers the lentil existed in Italy and Greece before it was cultivated. They have been found in lake-dwellings of the Age of Bronze. They appear to have existed in Western Asia (Greece) and in Italy, where their cultivation was first undertaken in early prehistoric time. They were introduced into Egypt before history began, and at a less remote period, but hardly in historic time, their cultivation appears to have extended east and west into India and Europe.

Lentils are now grown all over the South of Europe, but to a less extent than in Africa and Asia, because of the small proportion of straw. They are also grown to some extent in the United States, especially in New Mexico and Arizona. European markets are mostly supplied from Egypt, but three varieties are sold: (1) Egyptian or red lentils, grown in Egypt, Arabia, and Palestine; (2) European or yellow lentils (yellowish-red or brown), said to be superior to the former, grown chiefly in France and Germany; (3) a subvariety of the latter, called "German lentils," are dark green, and considered to be more palatable than the yellowish-red variety. The fruit consists of a pod containing two seeds about half the size of a pea, and having a strong flavour. They are much used in soup, etc. Lentils are consumed by Catholics during Lent, in place of meat, and lentil flour or meal is eaten by the Hindoos and other Orientals in addition to rice when engaged in laborious work. Lentil flour, by virtue of the high proportion of proteins, is extremely nutritious. When combined with sugar and other cereals, it is used as an invalids' food. **Revalenta** consists of Arabian lentil flour 12 parts, barley flour 6 parts, common salt 1 part.

[1] De Candolle's "Origin of Cultivated Plants," pp. 320-323.

Beans.

The following species of beans are used in a dried condition in many parts of the world :

Vicia faba : The horse bean and broad or Windsor bean.
Phaseolus vulgaris, with subvarieties white, navy, and red kidney bean.
Phaseolus lunatus : The Lima bean.
Phaseolus, species. : The frijole.
Phaseolus mungo : The mungo bean.
Dolichos sesquipedalis : The asparagus bean.
Dolichos lablab : The lablab bean.
Vigna catjang : The cow pea and varieties.
Glycine hispida : The soy bean.
Ceratonia siliqua : The locust or carob bean.

Broad Beans.—The common bean, *Vicia faba* or *Faba vulgaris*, alone constitutes the genus *Faba*. There are, however, many varieties, as the broad or Windsor bean, the Mazagan, the long-pod, the tick or horse bean, etc. The broad or Windsor bean is fully an inch in diameter ; the horse bean or tick is only ½ inch long and ⅜ inch broad. They are cultivated in gardens and fields for both man and beast.

There is considerable evidence that these leguminous seeds were a most important foodstuff in the time of the ancients. The origin of *F. vulgaris* is obscure, but De Candolle[1] considers it to be two-fold, one centre being in Asia, south of the Caspian Sea, the other in North Africa. Its area in Asia was more or less limited, but in Africa it was far more extensive in Pliny's time. The bean was cultivated in Europe in prehistoric ages. The inhabitants of Switzerland and Italy cultivated it in the Bronze Period, especially a small variety of *F. vulgaris*, which was very like a variety cultivated in Spain at the present day. The ancient Greeks were well acquainted with the common bean. It was mentioned in the " Iliad " as a cultivated plant, and has been found in the excavations of Troy. It formed a part in the ceremonies of the ancient Romans, and Pliny shows without doubt the antiquity and importance of the bean in Italy. It was cultivated by the ancient Egyptians, but Herodotus states that the priests would not eat it. The Hebrews were acquainted with it at least 1,000 years B.C. Its cultivation was probably introduced into Europe by the Western Aryans (Pelasgians, Kelts, and Slavs) at the time of their earliest migrations. It was taken later into China, about 100 years B.C., still later into Japan, and much more recently into India.[2] Therefore, although the common bean is now chiefly grown in Europe as a food for cattle, it was formerly much used as a human food. During the last few centuries bean flour has only been used in times of scarcity, to mingle with wheaten flour in making bread. It gives to the bread a beautiful golden bloom, and adds much nutriment to

[1] " The Origin of Cultivated Plants," pp. 316-321.
[2] De Candolle, *loc. cit.*

it, although it does not lighten the loaf. The principal variety now grown in Europe and America for human food is the broad or Windsor bean, which is eaten while young and tender, as a green bean.

The Common Haricot or French Kidney Bean (*Phaseolus vulgaris*). —There are many varieties of this bean, which comprise nearly all the kinds of beans eaten after being ripened and dried, such as the white or haricot beans, navy beans, and red kidney beans. It is believed to be a native of South America, and was introduced into Europe in the sixteenth century. The plants are naturally climbers, but dwarf and bush varieties have been developed. The sub-varieties are divided into (1) edible-podded, which include the string and snap or stringless beans eaten in their green state ; and (2) tough-podded, which are shelled and eaten while young and tender, or are allowed to mature and then dried. The dried beans of the scarlet runner (*P. multiflorus*) are inferior to the other varieties of *P. vulgaris*. Other varieties are the haricot de Soissons (*P. compressus*), the Princesse and Flageolet Nain (*P. tumidus*), and Haricots de Prague (*P. sphæricus*).

The common haricot is undoubtedly a plant of ancient cultivation, but was little known in Europe until the sixteenth century. It is doubtful if the species was known in Asia before the Christian era, and its cultivation in Africa is not ancient. It has not been found in the remains of Troy, although De Candolle considers it was known in ancient Greece. The Romans did not possess it in Cato's time, although the writers at the time of the Empire speak of it. It has not been found in the lake-dwellings of Italy, Savoy, Switzerland, or Austria. On the other hand, the species was indigenous in South America, and in general cultivation and use there at the time of the conquest ; and the seeds have been found among the deposits in the ancient tombs in South America—*e.g.*, at Ancon in Peru, where they were evidently deposited before the conquest. De Candolle[1] thus sums up the evidence respecting the species : (1) *P. vulgaris* has not long been cultivated in India, Western Asia, and Egypt ; (2) it is not certain that it was known in Europe before the discovery of America ; (3) at that epoch the number of varieties in European gardens suddenly increased, and writers began to mention them ; (4) the majority of the species of the genus to which it belongs are indigenous to South America ; (5) seeds belonging to the species were discovered in Peruvian tombs of uncertain date, mixed with other seeds of American origin. The evidence therefore is in favour of its American origin. The possibility of its having existed in both hemispheres prior to its cultivation is extremely doubtful, as it has not been found wild in both hemispheres.

The **Lima** or **Sugar Bean** (*Phaseolus lunatus* and *P. lunatus macrocarpus*) is widely diffused in tropical countries. It consists of a short pod having flat kidney-shaped seeds. It is a favourite shelled

1 " Origin of Cultivated Plants."

bean, both green and dried, in the United States. There are several varieties. The Lima bean has been cultivated in gardens since the beginning of the last century in America, tropical Africa, and India. Bentham believes it to be of American origin, specimens having been found growing wild from the Amazon to Brazil, and seeds of the large variety were found in the Peruvian tombs at Ancon. De Candolle considers it to be a Brazilian species, diffused by cultivation, introduced into Guinea by the slave trade, and thence into the interior of Africa, where it is much cultivated.

The **Three-lobed Kidney Bean** (*Phaseolus trilobus*) is one of the most commonly cultivated beans in India. It is found wild from Ceylon to the Himalayas, and has been cultivated for 3,000 years.

The **Frijole** (*Phaseolus*, species) is a bean of somewhat local importance. It is largely cultivated in Mexico, where, green or dry, it forms an almost daily food of the Mexican and the Spanish-Indian natives. It is a staple food next in importance to maize. It is also used in the green state as a vegetable in the South-Western States of North America, and in the dried state they are consumed all over the United States like common haricot beans or in soup. The bean is small and flat, frequently of a reddish-brown or light tan colour, but other colours also occur.

The Mungo Bean (*Phaseolus mungo*).—This species of *Phaseolus* is grown in Africa, India, China, and other Oriental countries. It is found growing wild in India. It is cultivated in the Nile Valley, but its introduction into Africa is recent. They are eaten by the Chinese wherever they locate. There are two varieties: (1) *Green* seeds, small, slightly flattened at the ends, and having a rather long hilum; (2) *red* seeds, which are larger and more spherical. *P. radiatus*, a species grown in Japan and having red seeds, is considered by some authorities to be the same as the red mungo bean. They all have a similar composition to varieties of *P. vulgaris*, as seen by the table of analyses.

The **Lablab Bean** (*Dolichos lablab*). There are crinkle-podded and flat-podded varieties. The entire pods are eaten green as well as the dried seeds. They are much cultivated in India and tropical Africa, Egypt, and the West Indies. The **Asparagus Bean** (*D. sesquipedalis*) has white seeds with a prominent black ring round the hilum, and a very tough cuticle, which is easily removed by soaking the dried seeds in water. The young and tender pods are eaten in America, China, etc., as a string or snap bean, and in Egypt and China for making soup.

The Soy Bean (*Dolichos soja, or Glycine hispida*).—The soy bean is a native of Cochin-China, Java, and Japan, where it has been cultivated from the remotest antiquity. It is said to be the *shu* mentioned in the writings of Confucius, although the modern name is *ta-tou*. Its introduction into India is comparatively modern. It was introduced into Southern Europe and America in 1880, where it is now cultivated chiefly as a forage plant. There are numerous varieties of the plant, but, excepting in colour, the seeds

do not differ much from each other in size and appearance. Those sold in the Chinese markets of Australia and Western America are either yellow or black. The seed resembles a pea, but the botanical characteristics of the whole plant are those of the bean. The seeds are one of the most important beans of China, Japan, and some other Oriental countries, where they are eaten like other beans—viz., boiled or baked. But in China and Japan they are elaborated into a variety of products, all of which are valuable for their high proportion of protein, and, when eaten with rice—the staple food of the people—make a fairly well-balanced dietary. Some of these articles are eaten at every meal by rich and poor alike, particularly in the interior of China. Some of these preparations are as follows :

1. **Soy Sauce,** or *Shoyu*, is prepared from a mixture of cooked beans, roasted wheaten flour, and salt, which are put into a cask and allowed to undergo a prolonged fermentation. The result is a thick brown liquid, of pungent and agreeable taste. It is used in Europe as a basis for various proprietary sauces.

2. **Bean Cheese,** *or Tao-hu.*—There are several preparations. According to Prinsen-Geerligs,[1] bean cheeses are made from white beans, which are soaked in water for three hours, afterwards being reduced to a paste and cooked. The milky fluid is then strained through a coarse cloth to remove starch and fibre, and when cool is precipitated by the addition of crude salt—*i.e.*, salt containing calcium and magnesium as well as sodium chloride. The precipitate, which is rich in protein and fat, is then kneaded and pressed into cakes, called fresh **Tofu,** or "Taahuor tofu." They are then dipped into an alkaline solution of curcuma. An analysis of fresh tofu gives the following composition : Water 81·35, protein 11·46, fat 5·19, carbohydrate 0·81, ash 0·79, per cent. There are several varieties of the cheese, known as "Natto," "Miso," and "Tofu." **Natto** is made[2] from beans which have been boiled for several hours until they are soft. The hot mass is then pressed into small cakes, wrapped in bundles of straw, and kept in a warm, tightly-closed cellar for twenty-four hours, when the action of minute organisms from the air or straw work a change in the mass, and produce an agreeable flavour. **Miso** is made by boiling the beans until they are soft, when they are beaten to a pulp, mixed with concentrated sea-brine or crude salt, and boiled rice. The substance is then put into a barrel which has previously contained a fermented liquor, and allowed to ferment. It is ready for use in two months, and is eaten like butter. **Soy Milk** : When beans have been boiled until they are soft, and beaten to a pulp, a considerable portion of the vegetable casein passes into solution, and forms a milky-looking liquid. It further resembles milk by a thin pellicle or skin forming on its surface when it is boiled, just as in the case of boiled cow's milk, and the casein can be precipitated from solution by rennet or acids. Such milk has many uses. **Tofu** is also prepared from soy

[1] *Chem. Zeit.*, 1896, 67-69.
[2] Abel, Farmers' Bulletin 121, U.S. Department of Agriculture.

milk by the addition of sea-brine, which precipitates the casein by virtue of the calcium and magnesium salts. The coagulum is then pressed into tablets, which are snow-white. Tofu made in this way is prepared fresh daily, and therefore but little bacterial action occurs. Moreover, dried cheeses are made in China and Japan by freezing such cakes, afterwards thawing them and drying them in the sun.

The Locust or Carob Bean.—The pods of the leguminous evergreen tree *Ceratonia siliqua* are called " St. John's bread," " locusts," or " carob beans." The tree is a native of Syria and Anatolia, and is much prized as a food for man and beasts in the hotter countries of the Mediterranean Basin. Its cultivation began in historic time. The Greeks knew it, and diffused its use throughout Greece and Italy ; but it was afterwards more highly esteemed by the Arabs, who propagated the plant and its use as far as Morocco and Spain at the beginning of the Christian era. The ripe seeds are surrounded by a sweet mucilaginous pulp, and when dried the pods yield 50 per cent. of sugar. They are not much used in England, but they are sometimes seen in the confectioners' shops. The pods of the honey locust (*Gleditschia triacanthos*) are also eaten to a limited extent.

Butter Beans.—The dried seeds of *Vateria indica*, N.O. Dipterocarpaceæ, are much used as beans in Southern Europe, India, and the United States. They are eaten stewed or baked, and have a pleasant flavour. They contain much fat, which is of a greenish-yellow colour and resembles mutton suet. The tree is grown largely in India, and especially in Malabar, for the gum-resin known as " copal."

The Composition of Legumes or Pulses.—Most vegetable foods are characterized by the proportion of carbohydrates, and their comparative poverty in protein and fat. The pulses, on the other hand, contain a store of nutriment designed by Nature for the future use of the growing plant, which is particularly rich in protein or nitrogenous substances. It is the high proportion of proteins in this group of foodstuffs which makes them of special interest. The legumes are further remarkable by being able to take up nitrogen from the atmosphere. They possess this property by virtue of certain nodules which appear upon the rootlets of the plant—nodules which are produced by a large number of beneficent bacteria or nitrifying organisms. The leguminous plants have thus a double supply of nitrogen : that contained in the nitrates and nitrites of the soil, and that which is obtained from the atmosphere by means of the nitrifying bacteria.

The Proteins.—The legumes or pulses in their green state contain from 2·5 to 9·5 per cent. of protein ; in their mature and dried condition it amounts to from 18 to 35 per cent. According to Church, all the nitrogenous matter, excepting about 3 to 5 per cent., exists in the seeds in the form of proteins, the remainder consisting of amides or amino-acids. There is more nitrogen in im-

mature peas than in those which are fully ripe. Egyptian lentils and beans are the richest in nitrogen, but those of Auvergne are more nitrogenous than the seeds obtained from Spain, Bohemia, Moravia, and Russia.[1] The distinctive albuminoid of the Leguminosæ is called **legumin,** vegetable casein, plant casein, or phytocasein, from its general resemblance to the casein of milk. Legumin is a nucleo-albumin,[2] or phospho-protein according to the modern classification. It is remarkably different from the gluten of cereals, for pea and bean flour do not form a dough when mixed with water. They do not make a porous and spongy loaf, pannification being most difficult. According to Drackendorff, legumin has the following percentage composition : C 51·47, H 7·02, O 24·09, N 16·82, S 4·40. Ritthausen found that it is not a simple body, but composed of several constituents—legumin, conglutin, and glutin-casein —which differ little from each other. They are all soluble in water, easily soluble in dilute alkaline solutions and dilute acids. They, are precipitated from alkaline solutions by rennet and acids. Their solubility in water is largely due to the presence of a small amount of alkaline phosphates in the seeds. These caseins, moreover, always contain phosphoric acid, which is only partly combined with bases. Thus, Voelcker found 1·38 to 2·18 per cent. of phosphorus in the legumin of peas and beans. The amount of legumin found by Ritthausen amounts to 11 per cent. in dried French beans, 5·4 to 9·4 per cent. in peas, and 5·2 per cent. in lentils. More recently, however, these proteins were investigated by Osborne,[3] ho found—

1. The **legumin of peas** consists of—
   Legumin, a globulin not coagulated by heat, forming 10 per cent. of the peas.
   Vicellin, another globulin soluble in salt solution, also forming 10 per cent. of the peas.
   Legumelin, an albumin soluble in salt solution, forming 2 per cent. of the peas.
   Proteoses, two, a smaller proportion.
2. The **legumin of beans** consists of—
   Phaseolin, a globulin, forming 20 per cent. of dried beans.
   Phaselin, another globulin, forming 2 per cent. of dried beans.
   Proteose, a trace.
3. The **legumin of lentils** is similar to that of beans.

Phaselin is very soluble in dilute saline solutions, and is coagulated by heat, etc. **Phaseolin** dissolves in pure water *by the aid of salts in the ground bean*, but a 2 per cent. sodium chloride solution will extract 15 per cent. of this protein. It is insoluble in hot or

[1] *Compt. Rend.*, 1897, cxxv., July 5.
[2] *Maly's Jahr-Berichte*, 1897, 21.
[3] *Jour. Amer. Chem. Soc.*, xx. 348 ; and Report of the Connecticut Experimental Station, 1897.

cold distilled water without the aid of salts, and it is precipitated from salt solution by hydrochloric acid. It has a composition nearly like oat-myosin, but has less sulphur. Osborne[1] gives the following as the percentage composition of these proteins :

	Phaseolin.	Oat-Myosin.	Phaselin.
Carbon	52·58	52·74	51·60
Hydrogen	6·84	7·21	7·02
Nitrogen	16·47	16·88	14·65
Sulphur	·56	·88	·49
Oxygen	23·55	22·69	26·24

4. The **legumin of soy beans** was found by Osborne and Campbell[2] to consist of **glycinin,** combined with 1·5 per cent. of legumelin, and a small amount of proteose. Meissl and Böcker[3] found the proteins of soy beans consisted of vegetable casein 27·6 per cent., albumin 0·5 per cent., and another proteid 2·5 per cent.

The protein of the pulses was called " vegetable casein," from its resemblance to the casein of cow's milk, but it is more insoluble and less easily digested than the latter. However, it resembles the casein of cow's milk by being capable of precipitation from solution by rennet and various acids and salts, which property is taken advantage of in Oriental countries in the manufacture of soy cheese. All the proteins are marvellously influenced by metallic ions. Thus, sodium salts cause the legumin to soften and dissolve in water. When peas are soaked in water containing sodium bicarbonate they readily soften on boiling. But calcium and magnesium have a more powerful influence than sodium, and will precipitate the legumin from solution—a fact which is also taken advantage of in the precipitation of the proteins from soy milk in the preparation of cheese. This influence is also exemplified by the fact that peas and beans do not readily soften when cooked in hard water. According to Strumpell, magnesia has no influence upon the legumin of peas, but the addition of soda to the water in which they are cooked has a double effect : it precipitates some of the lime from the water, and at the same time softens and renders the legumin more soluble.

The proteins of the pulses contain a larger proportion of sulphur than other proteins, but beans contain more sulphur than peas, while lentils contain the least of all. During the changes which these proteins undergo in the alimentary canal some of the sulphur is split off by bacterial action, giving rise to sulphuretted hydrogen (H_2S) and methyl-hydrosulphide (CH_4S).

[1] *Chemical News*, 1894, ii. 272.
[2] Connecticut State Report, 1897, part iv., 374-382.
[3] *Amer. Jour. Chem.*, 1890, 51-60.

COMPOSITION OF DRIED LEGUMES AND THEIR PREPARATIONS—NUTRIENTS PER CENT.

	Water.	Protein.	Fat.	Carbo-hydrate.	Cellulose.	Ash.	Authority.
Dried peas : Minimum	10·60	18·80	1·20	56·20	2·90	2·20	Balland.
Maximum	14·20	23·40	1·40	61·10	5·50	3·50	
Minimum	6·90	20·40	·80	58·00	1·20	2·20	Atwater and Bryant.
Maximum	15·00	28·00	1·30	67·40	7·90	4·30	
Average	9·50	24·60	1·00	62·00	4·50	2·90	
	13·00	21·00	1·80	55·40	6·00	2·60	Hutchison.
	14·00	23·50	?	50·00	10·00	2·50	Johnston.
	8·30	23·80	2·10	58·70	3·50	2·10	Payen.
Pea meal or pea flour	11·50	25·00	3·00	58·00	—	2·50	Kenwood.
Lentils : All reports, average ..	10·50	24·40	1·45	57·30	3·47	3·70	
Minimum	10·00	20·30	·50	56·00	2·90	1·90	Balland.
Maximum	20·40	24·20	1·40	62·40	3·50	2·60	
Minimum	6·40	24·50	·70	58·60	—	3·20	Atwater and Bryant.
Maximum	10·70	26·60	1·50	59·80	—	8·60	
Average	8·40	25·70	1·00	59·20	—	5·70	
	13·00	24·00	?	50·50	10·00	2·50	Johnston.
	11·50	25·20	2·60	56·00	2·40	2·30	Payen.
	12·50	24·81	1·85	54·78	3·58	2·47	Bauer.
	11·70	23·20	2·00	58·40	2·00	2·70	Hutchison.
Lentil flour	10·00	26·50	2·00	59·00	—	2·50	Kenwood.
Revalenta arabica	9·10	22·00	1·50	65·20	—	2·20	Hutchison.
Dried beans : Horse beans ..	12·50	30·80	1·90	48·30	3·00	3·50	Payen.
Broad or Windsor beans	8·40	29·05	2·00	58·85	1·05	3·65	
Butter beans	10·50	20·60	2·00	62·60	—	4·20	Hutchison.
Haricot beans : Minimum ..	10·00	13·80	·90	52·90	2·40	2·30	Balland.
Maximum ..	20·40	25·10	2·40	60·90	4·20	4·20	
Minimum ..	9·60	19·90	1·40	57·20	3·20	2·70	Atwater.
Maximum ..	15·50	26·60	3·10	63·50	7·20	4·40	
Average ..	12·60	22·50	1·80	59·60	4·40	3·50	
French : Minimum	9·00	17·00	1·10	52·20	2·10	2·20	Balland.
Maximum	14·00	22·00	1·90	63·50	6·60	6·50	
Cooked	73·60	4·40	·50	20·80	—	·70	Hutchison.

Frijoles (Mexican) : Minimum	6·30	20·90	1·00	60·70	—	4·00	Atwater.
Maximum	9·90	24·40	1·50	66·90	—	4·40	
Average	7·50	21·90	1·30	65·10	—	4·20	
Lima beans, average	10·40	18·10	1·50	65·90	—	4·10	
Mesquitê beans	4·80	12·20	2·50	77·10	—	3·40	
Navy beans	12·60	22·50	1·80	59·60	—	3·50	
Bean flour	11·50	26·25	2·50	57·50	—	2·35	Kenwood.
Cow peas : Minimum	10·00	19·30	1·10	53·10	3·40	2·90	Atwater.
Maximum	20·90	23·00	1·60	65·40	5·00	3·80	
Average	13·00	21·40	1·40	60·80	4·10	3·40	
Varieties : Clay	10·77	21·94	1·78	61·79	—	3·72	Bulletin 187, U.S. Department of Agriculture.
	13·37	23·19	1·45	58·49	—	3·50	
Lady	11·32	25·50	1·73	57·88	—	3·57	
	10·27	22·38	1·75	62·15	—	3·45	
Whip-poor-will	8·08	23·00	1·35	63·94	—	3·93	
	12·84	19·44	1·48	22·17	—	3·57	
Lalab beans (*Dolichos lablab*)	10·98	22·74	2·66	55·57	2·80	2·86	Blasdale.
	12·10	24·40	1·50	57·80	1·20	3·40	Church.
Locust or carob bean	15·00	5·90	1·30	75·30	—	2·40	
Mungo beans	8·83	22·64	1·34	48·54	4·53	2·85	Blasdale.
Red	10·47	21·06	·61	49·01	5·02	3·22	
	12·20	18·30	1·42	59·42	6·05	2·60	Kellner.
Green	10·80	22·20	2·70	54·10	5·80	4·40	Church.
Soy beans	10·80	34·00	16·80	33·70	—	4·70	Abel.
Black	8·25	36·35	17·22	14·18	5·43	4·75	Blasdale.
Yellow	8·33	36·00	17·87	12·42	4·79	4·69	
Soy cheese (*tao-hu*)	76·15	13·15	7·09	1·40	—	2·41	
Tofu : Fresh	89·00	5·00	3·40	2·10	—	·50	
Frozen	18·80	48·80	?	2·00	—	1·60	
Dry matter	—	60·10	?	2·50	—	2·00	
Natto	15·32	41·42	23·65	15·05	1·48	3·08	Farmers' Bulletin 121, U.S. Department of Agriculture.
Miso : White	50·70	5·70	2·40		12·60	6·60	
Red	50·40	10·08	18·77		8·25	12·60	
Swiss	12·53	26·43	13·91	19·54	1·41	26·18	
Soy sauce : *Tao-yu*	57·12	7·49	16·03		—	17·76[1]	Blasdale.
Shoyhu	63·29	8·31	—	5·10	—	19·46[1]	Farmers' Bulletin 121.
	67·42	7·37	—	4·06	—	17·47[1]	

[1] Including about 17 per cent. of crude salt.

The Fats.—The legumes contain a small amount of fat, with some cholesterin and lecithin. The fat of these seeds has not received any considerable attention. It is usually small, averaging 1 per cent. in peas, 1·5 per cent. in lentils, and 1 or 1·5 per cent. in beans, and, excepting in soy beans, never exceeds 2 or 3 per cent. Soy beans, however, contain 16 or 17 per cent. of fat, which, according to Meissl and Böcker,[1] consists entirely of neutral triglycerides of stearin and palmitin, together with another fatty body which gives the substance a characteristic leguminous taste. The Chinese express the oil from these beans, and use it largely in cooking. It contains no free acids, and does not become rancid when kept for two years.

The **Carbohydrates** are fairly high, but their proportion is smaller than in the cereals, owing to the comparatively large amount of proteins. The amount varies from 25 to 60 per cent., and consists of starch, sugar, dextrin, and gum. The *sugar* is chiefly cane-sugar, and varies from 1·5 to 4·5 per cent. Mungo beans, according to Jenman and Harrison,[2] contain 3·68 per cent. of cane-sugar, and 0·71 per cent. of reducing-sugar. Soy beans contain only cane-sugar, which Blasdale[3] says amounts to 6 or 7 per cent. The gum, dextrin, and pectose, is small, and only amounts to 1·8 per cent. in mungo beans. The *starch* amounts to from 20 to 50 per cent. or more. The granules have the following sizes : In broad beans 0·075, lentils 0·067, haricot beans 0·063, peas 0·053, millimetre. In peas the granules are large, oval, and have a central linear hilum of puckered appearance extending nearly the whole length of the granule, and striæ which are not concentric. Beans have similar granules, but they are larger, flatter, and more uniform in size. The hilum is puckered or crossed by transverse lines. Bean meal turns red on the application of nitric acid followed by ammonia. It is thus distinguished by chemical changes as well as by its microscopic appearance. Pure wheat meal or flour, mixed with plenty of water, turns pink on the addition of iodine ; but if potato be mixed with it it turns purple. The amount of *sugar* in legumes is much greater in young growing seeds than in mature ones. Young, small *green peas* have a much sweeter taste than old ones, and Schwarz and Riechen[4] found that the sugar varies from 2·7 to 30 per cent. of the dried substance. Frerichs and Rodenburg[5] found that the sugar is cane-sugar, and varies from 2·5 to 28·4 per cent. of the dried substance, whereas the total carbohydrate only varies from 50·2 to 55·9 per cent.

There is considerable difference of opinion as to the nature of the carbohydrates in soy beans. Blasdale found—[6]

[1] *Sitzberich. Math. Cl. Akad. Wiss.* (Vienna), 1883, 372-381.
[2] Report of Botanic Gardens, British Guiana, 1891-92, 72.
[3] " Chinese Foods," Bulletin 68, p. 33, U.S. Department of Agriculture.
[4] *Zeit. f. Unters. Nahr. Genussm.*, 1907, vii. 550.
[5] *Archiv d. Pharm.*, 1907, ccliii. 675.
[6] " Chinese Foods," Bulletin 68, p. 33.

CARBOHYDRATES IN SOY BEANS—PERCENTAGES.

	Starch.	Cane-Sugar.	Reducing-Sugar.
Black beans	6·80	7·38	nil
Yellow beans	5·87	6·55	nil

It has been asserted that they contain *no* starch. Providing this were so, they would form an admirable food for diabetics ; indeed, they have long been used for this class of patients in the form of cake and biscuits. Meissl and Böcker (*loc. cit.*) found less than 3 per cent. of starch in the form of small granules, which differed considerably in appearance from the typical bean or pea starch. Hanausek[1] found that the starch grains are deposited in the seeds at the junction of the cotyledons, and could not be detected by ordinary methods, as they are embedded in fat, which prevents the coloration by iodine. Hartz[2] found starch only in seeds which did not ripen properly or come to maturity, and considered it was likely to be more abundant in some varieties than others. Inoyne[3] also says starch does not occur in fully ripened seeds. According to La Vellois,[4] the carbohydrate of soy beans consists of 6 or 7 per cent. of sugar, and 9 to 11 per cent. of a carbohydrate which is soluble in alcohol, and does not reduce Fehling's solution, but which Tollens identified as **Galactan.** Maxwell[5] also separated another carbohydrate, which he identified as *paragalactan.*

Most legumes contain a bitter principle, by reason of which they are unpalatable to some persons. This substance is readily perceived when masticating a raw dry haricot bean, but it is little noticeable when they are boiled.

The **Mineral Substances** of peas and beans amount from 2 to 6 per cent. According to Johnston,[6] the ash has the following composition :

PEAS AND BEANS: COMPOSITION OF THE ASH—PERCENTAGES.

	Peas.	Beans.
Potash, K_2O	45·40	42·50
Soda, Na_2O	2·00	3·34
Magnesia, MgO	8·00	7·30
Lime, CaO	5·50	6·00
Ferric oxide, Fe_2O_3	·85	·40
Phosphoric anhydride, P_2O_5	32·55	34·66
Sulphuric anhydride, SO_3	4·73	3·50
Silica	·67	·90
Chlorine	·30	1·40

[1] *Zeit. Allegman. Œstr. Apoth. ver.*, 1884, 474. [2] *Ibid.*, 1885, 40.
[3] Bull. Univ. Coll., Tokyo, vol. ii., No. 4.
[4] *Compt. Rend.*, 1881, p. 281. [5] *Amer. Jour. Chem.*, 1890, 51-60.
[6] " Agricultural Chemistry," p. 272.

Cooking.—Dried legumes require long soaking in water to soften the skins—not less than eight hours. They should be cooked in soft water, or ordinary water to which some bicarbonate of soda has been added. The changes produced by cooking are softening of the skin, absorption of water, loss of a small amount of protein, and removal of most of the bitter principle. Dried peas take up 14 to 73 per cent., and dried beans from 9·7 to 86·9 per cent., of their weight of water.[1]

Fuel Value of Legumes.—A comparison of the heat value of dried legumes, cereals, meat, etc., is here given. Most of the figures are those ascertained by Atwater and his coadjutors, who used for the purpose a bomb calorimeter :

Material.	Calories per Pound.	Material.	Calories per Pound.
Beans, dried, average ..	1,605	Bread : White	1,215
Frijoles ,, ..	1,675	Brown	1,050
Lima ,, ..	1,625	Rye	1,180
Mesquite	1,765	Crackers	1,885
Navy, average ..	1,605	Wheat flour, entire ..	1,675
Lentils, average	1,620	,, ,, fine white..	1,625
Peas, average	1,655	,, breakfast foods	1,700
Cow peas, average ..	1,590	Barley meal	1,640
Chick peas, average ..	1,690	Oatmeal	1,860
Soy beans, average ..	1,970	Rice	1,630
St. John's bread (carob bean)	1,565	Lean beef	730
		Leg of mutton	900
		Milk	325
		Cheese, Cheddar ..	2,145

[1] Katherine Williams, *Jour. Chem. Soc.*, 1892, lxi. 226.

LEEDS & WEST RIDING
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CHAPTER XXI

GREEN VEGETABLES

The leaves of green plants consist of a framework of fibrous tissue or *fibro-cellulose* upon which the protoplasmic cells are spread out. This breadth of surface serves for the purpose of respiration and nutrition by exposing the chlorophyll-bearing cells to the air and light. As respiration is the chief function of the leaves, we cannot expect them to contain a large amount of nutriment. As a matter of fact, the solid material is small, and varies from 5 per cent. to a maximum of 15 per cent. in cabbage, while the water has a corresponding range of 85 to 95 per cent. It is not surprising, therefore, that chemical analysis proves them to be defective as a source of nutriment for mankind. The nitrogenous matters in leaves do not exceed 2 or 3 per cent., about half of which is protein, and the remainder consists of amides, ammonia salts, including nitrates, and other bases. Chief among the cellular constituents of the leaves is the protoplasm of the cells, which is differentiated into the nucleus and the plastids—leucoplastid and chloroplastid—the latter containing chlorophyll, which is said to be of no nutritive value, and leaves the body unchanged. The amount of fat is very little, and usually negligible as a nutrient. It varies from 0·1 to 2·5 per cent., and in some plants is of such a character that it is apt to disturb the gastric functions. The non-nitrogenous materials include from 0·0 to 2·5 per cent. of sugars, besides starch and pentosans, making a total of carbohydrate from 2 to 10 per cent., and 0·5 to 2·5 per cent. of fibro-cellulose.

The value of vegetables to mankind cannot, however, be correctly estimated in terms of protein, fat, and carbohydrate. Fresh green vegetables are absolutely essential for our well-being. The experience of travellers who go beyond the bounds of civilization, and of sailors who go beyond the reach of fresh green vegetables, is that scurvy and other signs of ill-health arise after being deprived of them for any considerable time. It is also believed that many forms of ill-health are fostered, if not created, by the absence of vegetables from the dietary of people living both in town and country. Why this is so is not quite clear to us. But all vegetables contain important salts, malates, oxalates, tartrates, citrates, phosphates, and sulphates, besides *free* organic acids, which undoubtedly play an important rôle in our physiological economy. Such salts are quite as necessary for our blood and secretions as the proteins for renewing our tissues and carbohydrates for producing energy. It is usually

said that our foodstuffs contain more minerals than we require. But it is possible that the *condition of these constituents in fresh vegetables and fruit is the source of their value.* It is known that the salts enter the vegetables by their roots in the form of **ions,** and circulate as ions through their fluids and tissues. It is suggested by the writer that such ionized salts are the source of the great value of fresh vegetables. In *dried* vegetables, fruits, and cereals, the salts are no longer in the ionized form, and therefore have not the same physiological value in the organism. That scurvy does not arise from a change of climate merely is shown by the fact that it was a prevalent disease in England and other civilized countries when the cultivation of vegetables for food was less common than in the present age. Even now instances of true scurvy arise in European countries among people who are deprived of fresh vegetables or fruit for any length of time, and the occurrence of eczema and other diseases has been associated with their absence. It is therefore considered essential that a fresh vegetable, such as cabbage, cauliflower, potato, lettuce, or other salad (or fruit), should constitute a portion of at least one meal a day. The mineral salts render the blood and urine more alkaline, and the indigestible fibre or cellulose acts as a stimulus to the movements of the alimentary canal, promotes intestinal secretion, and counteracts a tendency to constipation. In the treatment of disease, fresh vegetables play the same important rôle, and are of especial value to people who suffer from constipation (provided that there is no obstruction), liver disease, gout, gravel, rheumatism, diabetes, scurvy, purpura, anæmia, and various cutaneous affections.

Vegetables are cooked by boiling, roasting, or baking ; some are equally good food cooked either way. It is better to boil vegetables in *soft* water, because, when hard water is used, a layer of lime and magnesia salts is deposited upon them, and prevents the penetration of heat into the interior, thereby delaying cooking, and sometimes spoiling their appearance. Most vegetables lose a considerable proportion of the contained nutrients, especially the soluble materials, by being boiled. This is well shown in the following table by Kraus :[1]

Loss of Nutrients by boiling Vegetables—Percentages.

	Carbohydrates in Raw Vegetables.	Carbohydrates after Boiling and Straining.
Asparagus	3·30[2]	1·60
Cauliflower	2·10	1·40
Savoy cabbage ..	6·00[2]	2·70
Spinach	2·97	·85
Turnip cabbage ..	3·09	2·43
Winter cabbage ..	6·75	3·20

[1] *Zeit. f. Diat. und Physik. Therap.*, 1898, i. 69.
[2] These figures are supplied by the writer.

It should be observed that when vegetables are boiled they *gain* 5 to 15 per cent. of water, which of course reduces the percentage of all the other constituents ; but they actually lose almost all the soluble nutrients, including the non-protein nitrogen, 5 to 10 per cent. of the contained protein, 30 to 50 per cent. of the carbohydrates, and about 50 per cent. of the salts, the average loss being one-third of the total nutrients.

Respecting the digestibility of vegetables, much depends on the amount and character of the cellulose. In edible leaves the cellulose amounts to 0·1 to 1·5 per cent., but the proportion increases with the age of the plant, or, rather, as the vascular tubes and framework which supports the cells become more fibrous. The more rapid the growth of the vegetables, the less time there is for the formation of fibrous tissue. Slow growth, on the other hand, favours the formation of fibrous tissue. Persons in robust health, leading active lives and having healthy stomachs, are able to digest all sorts of vegetables, unless they are consumed in excess. In youth and early manhood the digestive functions are very energetic, vigorous physical exercise producing an appetite and digestive power which few articles can resist. But in aged persons, in those whose occupations are sedentary, and in invalids, the digestive functions are neither so powerful nor so energetic. Such people cannot digest *all* kinds of vegetables. Their digestion is slower and the motor power of their stomach more feeble, for which reasons vegetable matter is apt to remain longer in the stomach, to cause pain, to generate flatus, and give rise to other unpleasant symptoms. Some vegetables remain longer than others in the stomach, even in healthy people. Thus, while 5⅓ ounces of boiled cabbage required three and a half hours to pass through the stomach, the same amount of cauliflower had passed through in two and a half hours. Rubner found that *the average loss through non-digestion* of green vegetables amounted to 15 per cent. of the total dry substance, including 18 per cent. of the proteins, 15·4 per cent. of the carbohydrates, and 22·8 per cent. of the minerals. Atwater found the coefficients of digestibility of vegetables to be as follows : Protein 83 per cent., fat 90 per cent., and carbohydrates 95 per cent. ; and therefore the losess by non-digestion are, according to his estimation : Protein 17 per cent., fat 10 per cent., and carbohydrates only 5 per cent. Possibly Rubner's estimate for carbohydrate includes the undigested fibre.

Experience as well as science has established the fact that a dinner is not complete without the combination of animal and vegetable food. Nevertheless, many people cannot eat vegetables in their ordinary form after cooking without suffering from dyspepsia and other discomfort for several days. Such people should consume their vegetables in the form of a purée or consommé. The ordinary French consommé is a soup made by boiling meat and vegetables together until the whole forms a liquid of the consistence of pea soup, and will set into a jelly. The olla-podrida of Spain is

Such a preparation, and Irish stew is a similar concoction. But the latter preparations are not intended in this connection, and should not be consumed by persons having a delicate stomach. Purée and consommé are similar preparations, but purée—*e.g.*, mashed potato—is thicker than consommé. In their preparation for invalids, the cooked vegetable is pounded in a mortar until it is reduced to a pulp, rubbed through a sieve to remove skin and fibre. It is then warmed in a stewpan or saucepan with a little clear stock or milk or cream, and flavoured with pepper and salt. If but little stock is added, the mixture remains thick enough to be eaten with a fork, and is a *purée*. When the sieved vegetable is added to sufficient stock and cream to make it of the consistence of pea soup it is called a *consommé*. Other examples of consommé are clear soup thickened with mashed potato, revalenta, pea flour, wheat flour, or arrowroot ; and the preparation should have no more consistence while hot than will cause a slight adhesiveness to the spoon. Persons who suffer from indigestion, flatulence, and various gastric and intestinal disorders, will be able to consume most vegetables in these forms without suffering from any injurious effects.

Cabbage and Other Greens.

The entire natural order of Cruciferæ provides green food for consumption by man, and almost every family of the order provides a leaf or root of estimable value for their antiscorbutic and other salutary properties. Their action is peculiar and rapid, being general stimulants to the system, or what is called " antiscorbutics." Some, however, have a specially stimulating action to the stomach and bowels, to the skin, kidneys, or generative system ; but with their medicinal properties we here have little to do. The properties which characterize the order are especially observable in the members of the cabbage family, which provides by far the most abundant supply of greens. This family of plants has been evolved by natural or artificial selection from the wild colewort (*Brassica oleracea*), a plant of European origin found wild on the seashores in the South of England and Ireland, the Channel Isles, the Isle of Laland (Denmark), Heligoland, and on the northern coasts of the Mediterranean Ocean near Nice, Genoa, and Lucca. Its cultivation was begun very early, probably before the Aryan invasion.[1] But there is no doubt the wild plant was eaten before it was cultivated, for the use of coleworts is spoken of by early writers. Cauliflower was known to the Greeks and Romans, but was not much clutivated in England until the seventeenth century.

The following are the chief cultivated species :

Colewort, or collard (*Brassica oleracea*), the native plant of our shores.
Borecole, kale, or winter greens (*B. acephala*), a plant with open leaves.
Savoy cabbage (*B. bullata*), a head formed of blistered or crinkly leaves.
Drumhead, red and white heart cabbage (*B. capitata*), with smooth glaucous leaves ; head round, conical, or flattened ; early, late ; tall or dwarf.

[1] De Candolle, " Origin of Cultivated Plants," p. 86.

Brussels-sprouts (*B. gemmifera*), with small knob-like heads.
Turnip-cabbage, kohlrabi (*B. caulo-rapa*), with a bulbous root.
Broccoli (*Botrytis asparagoides*).
Cauliflower (*Botrytis cauliflora*).

These forms are also classified as—(1) Kale or greens, having open active leaves. (2) Brussels-sprouts, in which the leaf-buds form small heads. (3) Cabbage, savoy, drumhead, red and white heart, in which only the terminal bud forms a head. (4) Cauliflower and broccoli, in which the terminal bud is active and forms a flower, the others aborting. Cauliflower is the head of the plant, modified to form a compact succulent mass ; broccoli merely differs from it in form, colour, and hardness. (5) Broccoli-sprouts, consisting of the active open leaf-buds springing from the axil of the leaves. It is important to know when particular vegetables may be obtained. By means of planting the seeds at different times, several crops of vegetables are grown, and one or other may be had all the year round.

SEASON FOR VEGETABLES.

Borecole—October to April.
Broccoli—November to June.
Brussels-sprouts—October to April.
Cabbages—All the year.
Cardoons—October to March.
Coleworts (*i.e.*, greens)—October to March.
Cauliflower—May to November.
Celery—October to April.
Green beans—June to September.
Green peas—June to August.
Savoys—October to March.
Seakale—November to April.
Vegetable marrow—July to November.

The varieties of these vegetables need hardly detain us. Starting with the simplest form of cabbage plant, we have the true colewort, or collard. Kale or borecole has two principal varieties—the curly kale and the asparagus kale. The former is mild in flavour, and tender when well cooked ; the latter is a dwarf variety, which throws out long shoots which, when properly cooked, are as tender and delicious as asparagus. The cabbages include the sugar-loaf, white heart, and red cabbage, there being many strains of them. The savoy includes the drumhead (which is the largest), the sugar-loaf, and the green curled-leaf varieties. Brussels-sprouts consist of many strains. Cauliflower and the related broccoli are grown in various strains—*e.g.*, the Walcheren broccoli, spring and winter broccoli, spring and autumn cauliflowers.

Spinach (*Spinacia oleracea*, N.O. Chenopodiaceæ) is a vegetable of ancient date. It is a native of Northern Asia, and comes from the ancient empire of the Medes and Persians, and was common at Nineveh and Babylon.[1] It is of far more recent cultivation in Europe, where it was new in the sixteenth century. Two varieties of the plant are grown : the winter or " perpetual " spinach, having

[1] De Candolle, " Origin of Cultivated Plants," p. 99.

COMPOSITION OF CABBAGE AND OTHER LEAVES—PERCENTAGES.

	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Ash.	Authority.
1. UNCOOKED.							
Cabbage, average of 36 reports, including 200 analyses	88·53	2·31	·67	5·12	1·71	1·66	Tibbles.
As purchased (refuse, 15 per cent.)	77·70	1·40	·20	6·20	—	1·80	Atwater, Bulletin 28, U.S. Department of Agriculture.
Edible part: Minimum	86·00	·20	·10	3·40	·50	·40	
Maximum	94·30	2·90	·70	8·00	1·60	2·40	
Average	91·50	1·60	·30	5·60	1·10	1·00	
Brussels-sprouts	93·70	1·50	·10	3·40	·50	1·30	
	86·00	4·83	·46	6·22	1·57	·80	König.
Cabbage	89·97	1·89	·20	4·87	1·84	1·23	König.
Cabbage-sprouts, edible	88·20	4·70	1·10	4·30	—	1·70	Atwater.
Carrot-tops	84·00	3·20	—	7·20	3·10	2·50	Johnston, "Agricultural Chemistry."
Cauliflower and broccoli: Average	90·95	2·05	·45	4·80	1·00	·75	Tibbles.
Minimum	90·80	1·60	·21	3·40	·88	·50	
Maximum	93·80	2·50	·58	6·00	1·20	·80	
Average	90·39	2·53	·38	5·01	·87	·82	König.
Chinese cabbage	96·50	·78	·10	·77	4·6	·65	Bulletin 68, U.S. Department of Agriculture.
Colewort, or collards	87·10	4·50	·60	6·30	—	1·20	Atwater.
Curly kale, or greens	87·30	4·10	·60	6·20	—	1·80	Atwater.
	82·90	3·80	·90	9·90	1·50	3·50	Hutchison.
Dandelion-leaves	81·40	2·40	1·00	10·60	—	4·60	Atwater.
Drumhead cabbage, white: Young leaves	91·80	2·10	—	4·50	—	1·60	
Outer leaves	91·08	1·63	—	5·06	—	2·23	Anderson.
Inner leaves	94·48	·94	—	4·08	—	·60	Anderson.
	89·42	1·50	·08	7·01	1·14	·85	Voelckler.

Lettuce-leaves	94·33	1·41	·31	2·19	·73	1·03	König.
Mangold-leaves	90·00	2·00	—	3·80	2·60	1·60	Johnston.
Orache, or amaranthus	89·62	1·38	·30	3·20	1·54	·69	Bulletin 68.
Parsnip-leaves	85·70	2·00	—	6·30	2·60	2·40	Johnston.
Red cabbage	90·00	1·80	·19	5·80	1·20	·70	Hutchison.
Savoy cabbage	87·00	3·30	·70	6·00	1·20	1·60	
Seakale	93·30	1·40	—	3·80	·90	·60	
Shantung cabbage	95·70	1·19	·15	1·79	·52	·56	Bulletin 68.
Spinach	90·26	3·15	·54	3·34	·77	1·94	König.
	90·60	2·50	·50	3·80	·90	1·70	Hutchison.
Sugar-beet, or beet-chard	89·50	2·20	3·40	3·20	—	1·70	Atwater.
Turnip-cabbage, kohlrabi	87·30	3·90	1·50	5·60	—	2·10	Tibbles.
	87·10	2·60	·20	7·10	1·30	1·70	Hutchison.
Turnip-tops	86·70	4·20	·60	6·30	—	2·20	Atwater.
White	88·00	2·50	—	3·80	3·90	1·80	Johnston.
Swede	86·50	3·20	—	4·30	4·20	1·80	
2. Cooked.							
Cabbage	97·00	·60	·10	·40	1·30	·13	Hutchison.
Brussels-sprouts (canned)	93·70	1·50	·10	3·40	·50	1·30	Atwater.
Beet-tops, with sauce	89·50	2·20	3·40	3·20	—	1·70	
Celery	97·00	·30	·06	·80	·50	1·00	Hutchison.
Lettuce	97·20	·50	·16	·50	·90	·40	
Seakale	97·95	·40	·07	·30	1·10	·20	
Spinach, with sauce	89·70	2·10	4·10	2·60	—	1·40	Atwater.
,, without sauce	—	—	—	·85	—	—	Krauss.
Savoy cabbage	—	—	—	2·70	—	—	
Turnip-cabbage	—	—	—	2·43	—	—	
Cauliflower	—	—	—	1·40	—	—	
Winter cabbage	—	—	—	3·20	—	—	

small prickly leaves; the other or smooth-leaved variety having thick fleshy and crimped leaves. It is of special value as a vegetable, owing to the small amount of cellulose which it contains.

New Zealand spinach (*Tetragonia expansa*) is a hardy annual, native of Australia, especially interesting as being the only cultivated plant brought from that country. It is sometimes grown in England, and is recommended by horticulturists as bearing the drought better than ordinary spinach, and is capable of replacing it where the growth of the latter fails.

Orache, or amaranthus (*Atriplex hortensis*), is a member of the same family as spinach, and is sometimes called "winter spinach." It is a native of Tartary, and was introduced into Europe in 1548. The leaves have a slightly acid flavour, for which they are esteemed. Several other species of amaranthus are cultivated for vegetables in France, America, China, and other Oriental countries, especially *A. oleracea*, *A. giganteus*, *A. caudatus*, and *A. paniculatus*.

Seakale (*Cakalina* or *Crambe maritima*) is a native of the cliffs and shores of England. For centuries before it was known at the tables of the wealthy classes, it was an object of especial regard by the inhabitants of our southern and western shores, who collected the young and tender shoots of this delicious vegetable from the sides of the cliffs. It is now brought to a high state of perfection by cultivation, and properly cooked is delicate, easy of digestion, and nutritious. It is blanched, like celery, by exclusion from light during its growth, and unless this is attended to the shoots are likely to have an acrid taste.

Chinese Cabbage, or Pak-tsai (*Brassica chinensis*), is grown largely in Oriental countries, and to some extent wherever Orientals settle. Samples bought in San Francisco usually consist of the young and tender leaves or etiolated stalks of the leaves derived from the central axis of the plant. Shantung cabbage (*B. Pe-tsai*) resembles a cos or cabbage lettuce more than a true cabbage in appearance, and consists of a loosely compacted cluster of tender white leaves. It is grown in China and other Eastern countries.

In addition to the foregoing, the green tops of turnips, swedes, parsnips, lettuce, mallow, dandelion, sorrel, and other vegetables, are eaten in the same way, and as a substitute for other boiled green vegetables.

The protein in **green vegetables** is small in proportion, but the smaller and younger the leaves, the richer they are in protein. About half the nitrogenous material consists of amides, ammonia salts, and nitrates. The fat is small and is undesirable in the members of the cabbage family, where it consists chiefly of an acrid oil, which is apt to disagree with the consumer. The carbohydrates consist of starch and pentosanes, amounting to 3 per cent. in cabbage, 3·7 in cauliflower, 6·22 in Brussels-sprouts, 3·2 in spinach, 2 in lettuce, and 3 or 4 per cent. in turnip-tops. Most of them contain sugar—*e.g.*, cabbages have 2·29 per cent., cauliflower 1·27, spinach 0·08, celery 0·77 per cent. Unfortunately, they lose a very

large proportion of these nutriments by being boiled, as is seen by a comparison of the foregoing table of the composition of raw and cooked vegetables. Little need be added to the remarks at the beginning of this chapter on the dietetic value of these vegetables, which is mainly of an antiscorbutic character, but nevertheless important. They should all be eaten while young. The more rapidly they have grown, the less fibre and the more protein there will be in their composition, and consequently the more tender and succulent the vegetable will be. Most greens are better for having had a touch of frost, which is said to make them more tender. The older the leaves are, the more fibrous and indigestible they become, and the more likely they are to cause dyspepsia and flatulence. Cabbage is heavier and requires a longer time to digest than cauliflower or spinach. The experiments of Rubner merely confirm the results of long experience. Cauliflower is usually more suitable than cabbage for persons with a delicate stomach, although intestinal flatulence is said to be quite as common after cauliflower as after cabbage, and some people find it more common. Spinach is perhaps the most delicate vegetable. It is soft and succulent, and deserves the highest appreciation. It is more easily digested than an equal (original) weight of any of the Brassicæ. It loses much of its bulk in boiling. It is light, wholesome, somewhat laxative, useful for chronic constipation, and is suitable in most cases of chronic gastro-enteric troubles where cabbage cannot be recommended. Lettuce is also a very light and easily-digested vegetable, and when boiled may be allowed in the same class of cases as spinach. Orache and New Zealand spinach and beet-chard are all equally light, and can be allowed in the same cases. Turnip-tops, swede-tops, and other green leaves, are quite as easily digested as cabbage. Turnip-tops when young are more easily digested, owing to their greater freedom from fibre. They do not contain much nutriment, but are valuable for their juices and salts.

Cucurbits.

The natural order of Cucurbitaceæ includes the cucumber, vegetable marrow, pumpkin, squash, and various other gourds. The principal are as follows: Cucumber, *Cucumis sativa;* vegetable marrow, *Cucurbita ovifera;* squash, *Cucurbita melopepo;* pumpkin, *Cucurbita pepo;* luffa, *Cucumis acutangulus;* Chinese melon, *Benincasa cerifera;* gooseberry gourd, *Momordica charantia.*

There are fifty-five varieties of pumpkin, squash, and vegetable marrow, according to Goff, all derivatives of *C. pepo.* He divides them into—Pumpkin and vegetable marrow, *C. pepo;* summer squashes or bush varieties of *C. pepo;* and winter squashes (those kept for winter use), varieties of *C. maxima,* which do not cross with the former; and another important type, *C. moschata,* including the cushaws, sweet-potato-pumpkin, etc. Pumpkins are generally round or tending to oblong. They are cut up and used in soup or

COMPOSITION OF THE CUCURBITS—NUTRIENTS PER CENT.

	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Ash.	Authority.
Cucumber: Average	94·91	·73	·21	3·10	·60	·54	Tibbles' mean of eight reports, including twenty analyses.
Minimum	94·50	·50	·10	2·10	·50	·30	
Maximum	96·50	1·00	·50	4·00	·90	·60	
Cooked	97·40	2·20	·20	2·90	2·10	·90	Hutchison.
Vegetable marrow: Average ..	91·90	1·00	·10	5·20	·70	·50	Tibbles.
Raw	94·80	·60	·20	2·60	1·30	·50	Hutchison.
Cooked	99·17	·09	·04	·20	·37	·05	
Pumpkin, edible part: Minimum	92·30	·90	·10	3·90	·90	·60	Atwater.
Maximum	94·40	1·10	·20	5·90	1·20	·70	
Average ..	93·10	1·00	·15	5·20	1·10	·60	
Squash, edible part: Minimum ..	79·90	·60	·10	3·50	·50	·40	
Maximum ..	95·20	3·10	1·40	16·10	1·20	1·60	
Average ..	88·30	1·40	·50	9·00	·80	·80	
Wax gourd (*Benincasa cerifera*) ..	96·24	·50	·16	1·28	·57	·35	"Chinese Vegetable Foods."[1]
Luffa: *Cucumis acutangulus* ..	94·90	·68	·24	2·03	·72	·43	
Luffa cylindrica	94·66	·51	·19	3·31	·46	·41	
Gooseberry gourd (*Momordica charantia*)	93·61	1·18	·20	1·73	1·07	·34	

[1] Bulletin 68, U.S. Department of Agriculture.

made into pies, or the ripe pumpkin, having the seeds scooped out through an opening made at one end, is filled with sliced apples, sugar, and spice, and baked as a whole. Squashes, which are more extensively grown in America, are flat, and have prominent angles or ribs at the sides. Vegetable marrow, which is long, is grown more extensively in Europe than America. Some gourds, such as the warty gourd, are used in America as a sauce to meat. Other cucurbits are the luffa (*Cucumis acutangulus*), which resembles the cucumber, but is ribbed. It is eaten raw, cooked like squash or marrow, and in soup, in Arabia, China, India, and other Oriental countries. The wax gourd or Chinese melon (*Benincasa cerifera*), grown in Japan, China, India, etc., is of the size of a water-melon, smooth, covered with a white wax, and has an interior consisting of solid white flesh and seeds. The mature fruit is used as a vegetable, also for making preserves and sweet pickles. The gooseberry gourd (*Momordica charantia*) is largely cultivated in China, California, etc., where it receives local names. The immature fruit is largely used in salads, curries, etc.

The fruits of the cucurbit or gourd family contain very little nutriment of any description. Atwater found that cucumbers contain protein 0·8 per cent., of which only 0·4 per cent. was albuminoid ; in squash the nitrogenous matter is 0·6 per cent., including 0·5 per cent. of protein. The carbohydrates are starch and sugar. Cucumber contains 0·02 per cent. of free acid. The composition of other gourds is similar. They are, however, valuable as fresh vegetables, to be used in alternation with other vegetables and to vary the monotony of the diet.

Asparagus.

Asparagus consists of the young shoots of *Asparagus officinalis*, N.O. Liliaceæ and varieties. *A. officinalis* is a native of Great Britain, especially found in the fens of Lincolnshire and on various sea-coasts, such as Kynance Cove in Cornwall, where a part is known as Asparagus Island, from the quantity of this vegetable found wild there. Other species of asparagus are also eaten wherever they grow—*e.g.*, *A. sarmentosus*, *A. racemosus*, *A. acutifolius*, and *A. adscendens*. The young plants are wholesome and nutritious food, having aperient, diuretic, and deobstruent properties.

Other vegetable products are sometimes dressed and eaten in the same way as asparagus. The French or Prussian asparagus is the fleshy flower-stalk of *Ornithogalum pyrenaicum*. It is sometimes used in Gloucestershire, and has been sold in the markets of Bath as " Prussian asparagus." The stalks of salsify are similarly eaten, and the midrib and leaf-stalk of the great white or sugar beet, called " beet-chard " is cooked and eaten in the same manner. The young shoots of several species of *Typha*, bulrush or reed-mace, are eaten in a similar way by the Cossacks. In Asia the young shoots of bamboo (*Bambusa arundinaria*) are generally eaten as asparagus, or made

into broth with animal food, and are also pickled in vinegar throughout the East, and are exported to this country under the name of *achiar*.

All these vegetables are wholesome and nutritious. *Asparagus officinalis* is, moreover, one of the greatest delicacies of the garden, and is especially valuable for its early appearance. The cellular tissue contains a nutritive substance similar to sago, besides albumin or gluten, asparagin, mannite, malic acid, carbonates and phosphates of lime, potash and other salts.

Composition of Asparagus Officinalis—Nutrients per Cent.

	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Ash.
Average, from eight authorities ..	93·58	1·91	·24	2·6	·87	·8
Minimum ..	—	1·50	·10	2·2	·50	·5
Maximum ..	—	2·30	·39	3·4	1·90	1·2
Atwater's report:						
Minimum ..	93·60	1·60	·20	3·1	·70	·3
Maximum ..	94·30	2·10	·30	3·6	·80	1·6
Average ..	94·00	1·80	·20	3·3	·80	·7
Cooked ..	91·60	2·10	3·30[1]	2·2	—	·8
Hutchison's report:						
Cooked ..	91·70	2·20	·20	2·9	2·10	·9

Kraus found that the carbohydrate was reduced to 1·6 per cent. by boiling.

The nitrogenous substance is only half protein. The chief non-protein nitrogenous substance is asparagin (amido-succinamic acid), which acts as an aperient, and soon passes out of the system in the urine, to which it gives a characteristic odour. This amide also occurs in potatoes, lettuce, chestnuts, and various other vegetables. Asparagus is credited with being especially valuable to persons suffering from nervous affections, palpitation, and neuroses of the heart.

Artichoke.

The green or true artichoke is the flower-bud of *Cynara scolymus*, N.O. Compositæ, a kind of cultivated thistle, and a well-known garden plant. It is a native of the South of Europe, introduced into England in 1548, and is greatly appreciated in France and other countries. The flower-head is gathered before the flower expands; the succulent base, with the central disc and leafy scales, furnish a delicious and most delicate-flavoured vegetable. The term *chard* is applied to the leaf-stalks, which are blanched by tying them up, when they become white and tender and suitable for the table. Like Jerusalem artichokes (*q.v.*), they are boiled in plain water or

[1] With butter.

in milk, and are eaten with white sauce, pepper and salt, or other condiment. They are diuretic, and, as they contain no starch, may be eaten by diabetics. Analysis shows that they contain **inulin** and the ordinary constituents of vegetables, and have the following composition: Water 79·5, protein 2·6, fat 0·2, carbohydrate 16·7, fibre 0·8, salts 1·0, per cent.

The fleshy receptacle of the carline thistle (*Carlina caulescens*), also a native of Southern Europe, is eaten in the same way, and equals the true artichoke in flavour and exceeds it in size. The flower-buds of the Scotch thistle (*Onopordon acanthium*) are boiled and eaten.

Cardoon.

The cardoon (*Cynara cardunculus*) resembles the artichoke; the thick fleshy leaves, when boiled, resemble it in flavour. The leaf-stalks become blanched and crisp, like celery, when banked with earth. The juice is bitter and possesses diuretic properties. It is grown and eaten as a vegetable or in soup, and as a salad, in all the countries upon the Mediterranean. The tender leaf-stalks of Scotch thistle and Our Lady's thistle are eaten like cardoons, either boiled or raw. The young leaves and stalks of the mallow (*Althea officinalis*) are much used as an article of food in the East; when boiled and afterwards fried with onions and butter, they form a very palatable dish. The root is made into a sweetmeat. The whole plant contains **asparagin,** with starch, saccharine matter, and much mucilage.

Okra, or Gombo.

Okra (*Hibiscus esculentus*) is cultivated as a pot-herb in all warm countries of Southern Europe, the Levant, Asia, and America. It belongs to N.O. Malvaceæ, and is of African origin, where its propagation appears to have begun at the beginning of the Christian era. The parts used are the long pyramidal seed-pods, which are gathered while green. They are boiled and eaten with butter and spices as an accompaniment to meat; they also form an admirable ingredient of soup (gombo soup), and are boiled to form a pickle with vinegar or oil and salt. The young seed-pods contain a large proportion of mucilaginous substance, which forms a jelly of the water in which they are boiled.

Composition of Okra—Nutrients per Cent.

	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Ash.
Fresh pods, average ..	90·2	1·6	·2	7·4	3·4	·6
Canned pods, cooked ..	94·4	·7	·1	3·6	·7	1·2
Gombo and chicken soup	89·2	3·8	·9	4·7	—[1]	1·4

Onions and Leeks.

All the members of the genus *Allium* are characterized by the possession of an acrid volatile principle, which gives to them remarkable and valuable properties. They form an important class of vegetables, whether used in the cooked or raw state.

[1] Bulletin 28, U.S. Department of Agriculture.

The onion (*Allium cepa*) is one of the earliest cultivated plants. Kunth says its original country is unknown ; but it has been found wild in Beluchistan. The ancient Greeks and Romans knew several varieties ; the Egyptians consumed it largely and gave it divine honours. It is said to have come originally from India, through Egypt and Greece to Italy, whence it was distributed over Europe, where it has been cultivated from time immemorial. According to De Candolle, its cultivation in Asia and the countries surrounding the Mediterranean dates from a very early period, extending over a vast area in Western Asia from Palestine to India. It now grows wild or semi-wild in many countries. The species of *Allium* in America are rare, although Humboldt says the natives have always been acquainted with onions. Acosta, however, asserts that the onions and garlics of Peru are of European origin.

The spring or Welsh onion (*A. fistulosum*) is found wild in Siberia. The ancients were not acquainted with the plant. It probably came into Europe through Russia in the Middle Ages, or a little later. The shallot (*A. ascalonicum*) takes its name from Ascalon in Judæa, whence it was brought ; but it has not been found wild with certainty, and De Candolle thinks it is not a species, but a modification, of *A. cepa*, dating from the beginning of the Christian era. Garlic (*A. sativum*) is very ancient, having been much used by the Egyptians, Greeks, Indians, and Chinese. De Candolle considers it was cultivated by the earliest peoples of Europe and Western Asia, as they found them from Spain to Tartary. Leeks (*A. porrum*) are a cultivated variety of *A. ameloprasum*, common in the East and the Mediterranean regions, and became naturalized in the vineyards and around ancient cultivations in Southern Europe, and is found wild in Algeria and other places. The onion was introduced into England at a very early period, but the shallot and spring onion were not known before the sixteenth century.

The varieties of **onion** are very numerous ; seventy-eight kinds grown from seed have been exhibited at horticultural shows, being classified into geographical races, and again according to the colour and shape of the bulb. Yellow Danvers and Red Wethersfield are old varieties ; but White, Red, and Yellow Globe are now the chief commercial varieties, some others being the Queen, Portugal, Pearl, Barletta, Bermuda, and the large Italian sorts, which are desirable for their mild flavour. Onions grown in warm countries have a mild flavour, owing to their possessing less of the acrid principle than those of colder countries. Spanish onions are very mild and sweet, and are eaten raw, boiled, fried, or roasted. They form an excellent vegetable, highly esteemed for their salutary properties. When taken raw they promote appetite and stimulate digestion, if eaten in moderate quantities. But an excessive consumption may occasion indigestion and flatulence ; the acrid oil irritates the gastric mucosa, and causes a sense of uneasiness in the stomach, and a corresponding mental excitement or irritability. Much of the acrid oil is removed or volatalized by boiling them. Many people can digest boiled onions who cannot digest raw ones, and others can digest fried ones who cannot tolerate them in either of the former ways.

Garlic, used chiefly as a condiment, also stimulates appetite, promotes digestion, and expels flatus ; it quickens the circulation, excites the nervous system, and acts as a tonic and carminative. **Shallot** has a similar but not such a powerful action. **Chives** (*A. schœnoprasum*), eaten as a salad or pickle all over Europe and

America, are found wild in Italy and Greece, and were certainly known to the ancient Greeks and Romans.

Composition of Onions and their Allies—Nutrients per Cent.

	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Ash.
Onions, raw: Minimum	81·50	·20	·1	4·2	·70	·1
Maximum	95·20	4·40	·8	15·5	1·30	1·2
Average	87·60	1·60	·3	9·9	1·30	·8
,, cooked ..	91·20	1·20	1·8[1]	4·9	—	·9
Green onions: Minimum	85·40	·80	·1	9·9	—	·5
Maximum	88·70	1·50	·2	12·4	—	·7
Average	87·10	1·00	·1	11·2	—	·6
Leeks, edible part: Average	91·80	1·20	·5	5·8	·60	·6
Garlic	57·08	2·53	?	33·98[2]	3·41	—

These plants and their bulbs all contain albumin, gluten, mucilage, sugar, free organic acids, salts, and an acrid volatile oil (*allyl sulphide*); according to Semmler, the latter has the formula $C_6H_{12}S_2$. The sugars are dextrose and lævulose, and may amount to 10 per cent. in fresh raw onions. The mucilage varies in amount, but is so abundant in garlic that the juice cannot be filtered without previous dilution. The salts are phosphates, acetates, and citrates of lime, soda, potash, magnesia, silica, and iron; the free acids are citric and phosphoric.

Green Peas and Beans.

A consideration of peas and beans in the mature state is to be found under the heading of Leguminous Seeds or Pulses.

Green peas and beans in their unripe or immature condition are used extensively as vegetables. Peas when young are tender and sweet; they contain a fair amount of nourishment, which is a forecast of their great value in the mature and ripe state; but they are never, of course, of the same nutritive value as the ripe seeds. They are, with the exception of sugar peas, removed from the pod to be cooked, as the parchment-like lining of the "shells" is uneatable. The young peas become soft and tender when boiled; but old peas are not softened by boiling—indeed, the longer they are boiled, the harder they become. There are numerous varieties, which have arisen from *Pisum sativum* by cultivation through 2,000 years. We may divide them into (*a*) tough-podded or shelling peas, and (*b*) the edible-podded pea. The former are divided into two groups—(1) wrinkled and (2) smooth seeded varieties, which number about 150. They include *early* varieties, such as the American Wonder, Daniel O'Rourke, Kentish Invicta, Chelsea Gem, Early Morn, Marrowful, and Bountiful; and *late* ones, as

[1] With butter [2] Including mucilage.

COMPOSITION OF GREEN PEAS AND BEANS—NUTRIENTS PER CENT.

	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.	Calories per Pound.	Authority.
Green peas (shelled)	79·74	6·06	—	13·03	1·12	—	Blyth.
Green kidney beans	91·34	2·04	—	5·99	·63	—	
Kidney or string beans	89·20	2·30	·3	7·40	·80	195	"Legumes as Food," Bulletin 121, U.S. Department of Agriculture; mostly from Bulletin 28, by Atwater and Bryant.
Asparagus beans	79·90	4·50	·5	13·90	1·20	365	
Sugar peas (edible pod)	81·80	3·40	·4	13·70	·70	335	
Green butter beans	58·90	9·40	·6	29·10	2·00	740	
Shelled cow peas	65·90	9·40	·6	22·70	1·40	620	
,, peas	74·60	7·00	·5	16·90	1·00	465	
,, kidney beans	59·80	9·40	·6	29·10	2·00	740	
,, Lima beans	68·50	7·10	·7	22·00	1·70	570	
Canned peas	85·30	3·60	·2	9·80	1·10	255	
,, kidney beans (shelled)	72·70	7·00	·2	18·50	1·60	480	
,, haricot verts (unshelled)	95·20	1·10	·1	2·50	1·10	70	
,, string beans (unshelled)	93·70	1·10	·1	3·80	1·30	95	
,, ,, ,, little green	93·80	1·20	·1	3·40	1·50	90	
,, Lima beans	79·50	4·00	·3	14·60	1·60	360	
,, wax beans	94·60	1·00	·1	3·10	1·20	80	
Dried peas	9·50	24·60	1·0	62·00	2·90	1,665	
,, lentils	8·40	25·70	1·0	59·20	5·70	1,620	
,, beans	12·60	22·50	1·8	59·60	3·50	1,605	
,, broad beans	8·40	29·05	2·0	56·90	3·60	—	Payen.
Cooked kidney or string beans	95·30	·80	1·1	1·90	·90	95	Atwater.
,, green peas	73·80	6·70	3·4	14·60	1·50	540	
Baked beans	68·90	6·90	2·5	19·60	2·10	600	

the Marrowfat, Champion of England, Telephone, Majestic, and Stratagem. Many gardeners produce special strains of peas, to which they give fancy names, but their qualities are unendurable. The edible-shelled pea or sugar pea consists of a tender pod in which the parchment-like lining is almost absent, and therefore the whole pod is cooked and eaten.

Green beans are eaten in the pod, excepting broad beans, which are removed from the shells. The following varieties are used in the young and immature condition almost all over the world: *Phaseolus vulgaris*, the kidney bean or dwarf kidney bean, is the origin of many subvarieties which are eaten in the shell or pod. French beans, string beans, stringless beans, snap beans, and wax beans, are names applied to various subvarieties. The plants are naturally climbers, but bush or dwarf varieties have been developed. *P. multiflorus*, or scarlet-runner, a native of South America, is a familiar plant, and one of the chief varieties of string or snap beans used in England.

Wythes, in his "Book of Vegetables," divides beans into—(1) Dwarf beans, with the following examples: Lyon House, Ne Plus Ultra, Progress, Triumph, Perfection, Canadian Wonder, the small haricot or French bean, and butter beans. (2) Runner beans: (*a*) The climbing French bean, with many subvarieties and strains—*e.g.*, Excelsior, Epicure, Earliest of All, Princess of Wales, etc. (*b*) The scarlet-runner, with examples Chelsea Giant, Masterpiece, Abundance, Champion Runner, etc.

Others are the asparagus bean (*Dolichos sesquipedalis*), eaten as a string or snap bean in America, China, etc.; the frijole (*Phaseolus*, species), the immature pod of which is eaten as a snap bean in South America.

Green beans eaten *out of the shell* are the broad or Windsor bean (*Vicia faba*), Lima bean (*Phaseolus lunatus*), the frijole, and scarlet-runner bean. The broad or Windsor bean usually contains four large seeds of a deep green colour, but there are other varieties containing eight or ten fine white seeds. The seeds are surrounded by a thick envelope or episperm, which is easily separated from the endosperm after boiling, and is tough and indigestible.

The Bambarra groundnut (*Glycine subterranea*) was cultivated in Madagascar at the time of our earliest explorers of that country, and is now commonly grown in the gardens of tropical Africa. The pod or seed is dressed and eaten like peas or French beans. It resembles the peanut by the flower-stem curving down and plunging the young pod or fruit into the earth.

Salads and Pickles.

In addition to the foregoing vegetables, which are chiefly eaten in a cooked condition, there are vegetables which are eaten raw, chiefly as salad or pickles. The fresh vegetable may be eaten alone or in combination with others. **Salads** consist of a mixture of raw vegetables dressed with condiments, such as vinegar, salad oil, and spices. Like other fresh vegetables, they are chiefly valuable for their juices, containing valuable salts, and for the iron which is connected with the chlorophyll. They are cooling,

COMPOSITION OF SALADS AND PICKLES—PERCENTAGES.[1]

	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Ash.	Calories per Pound.
FRESH VEGETABLES—Beetroot, average	87·50	1·60	·10	9·70	·90	1·00	215
Celery, edible: Average	94·50	1·10	·10	3·30	—	1·00	85
Minimum	93·10	1·00	·10	3·00	—	·90	75
Maximum	95·00	1·40	·20	4·60	—	1·10	115
Mean of analyses	93·22	1·30	·18	3·50	1·00	·80	—
Cucumber as purchased[2]	81·10	·70	·20	2·60	—	·40	70
,, edible portion: Minimum	94·70	·50	·10	2·20	·50	·30	65
Maximum	96·30	·90	·50	4·00	·90	·60	95
,, all reports, mean	95·37	·72	·22	2·75	·62	·42	—
Dandelion leaves	81·40	2·40	1·00	10·60	—	4·60	285
Egg-plant, edible	92·90	1·20	·30	5·10	·80	·50	130
Endive	93·00	1·10	·06	3·10	·60	·81	—
Lettuce, edible portion: Minimum	91·50	·70	·10	1·60	·40	·50	65
Maximum	97·00	1·80	·60	4·90	1·20	1·20	150
Mean of all reports ..	93·86	1·31	·39	2·71	·70	1·04	—
Onions, fresh—edible: Minimum	81·50	·20	·10	4·20	·70	·10	90
Maximum	95·20	4·40	·80	15·50	1·30	1·20	335
Average	87·60	1·60	·30	9·90	·80	·60	225
Green or spring onions: Minimum	85·40	·80	·10	9·90	—	·50	205
Maximum	88·70	1·30	·20	12·40	—	·70	265
Average	87·10	1·00	·10	11·20	—	·60	230
Radishes: Minimum	86·60	·50	—	3·40	·70	·70	85
Maximum	94·80	3·00	·30	8·30	·70	1·80	225
Average	91·80	1·30	·10	5·80	·70	1·00	135
Tomatoes: Minimum	91·30	·30	·20	2·20	·50	·30	75
Maximum	96·30	1·30	1·40	6·50	1·20	·80	160
Average	94·30	·90	·40	3·90	·60	·50	105
Watercress	93·00	·70	·50	3·90	·60	1·30	—
PICKLED VEGETABLES—Beetroot	88·60	2·30	·10	7·40	—	1·60	—
Cucumber	92·90	·50	·30	2·70	—	3·60	—
Horse-radish	86·40	1·40	·20	10·50	—	1·50	—
Mixed pickles	93·80	1·10	·40	4·00	—	·70	—
Onions	86·00	1·60	·10	10·80	·70	·70	—
Sauerkraut	88·80	1·70	·50	3·80	—	5·20	—
Spiced pickles	77·10	·40	·10	20·70	—	1·70	—
String or kidney beans	93·70	1·10	·10	3·80	·50	1·30	—
Tomato catsup	82·80	1·50	·20	12·20	—	3·20	—

[1] Analyses chiefly from Bulletin 28, U.S. Department of Agriculture: Atwater and Bryant. [2] Refuse, 15 per cent.

appetizing, and antiscorbutic. Most of the Cruciferæ contain allyl sulphide. Sometimes salads cause dyspepsia, and, because of the indigestible cellulose in them, many people require the addition of vinegar to aid their digestion. The bulk of salads consist of lettuce, to which is added one or more of the following : Onion, cucumber, endive, cress, radish, tomato, beetroot, etc., in varying proportion. The following recipe for " salat," quoted from Cury,[1] shows that numerous green vegetables, such as borage, radish, turnip, mint, parsley, cabbage, mustard, rue, spinach, onion, coriander, rosemary, fennel, and chervil, were in common use by our Saxon ancestors, for the book was written in the fourteenth century : " Take Psel, Sawge, garlee, chibol'i, oynons, leek, borage, mynt, fenel, poneet, and ton tresses (cresses), rew, rosemarye, and purslaye ; laue and waische hem clene, pike hem, pluk hc̄ small wip phu (with thine) hand, and myng hem with rawe oyle, lay on vyngr and salt and sue it forth."

Lettuce (*Lactuca sativa*, N.O. Compositæ) is considered to be a descendant of wild-lettuce (*L. scariola*), a native of Southern Europe, Central and Eastern Asia. It was introduced into England from Flanders about 1520. But it has long been used as a salad, and was cultivated by the ancient Greeks and Romans for that purpose. It was also early cultivated in the East, and De Candolle is of opinion it was introduced into China from the West, but says Boisier speaks of a species of *L. scariola*, with crinkled leaves similar to our garden lettuce, which is obtained wild in the mountains of Kurdistan. There are several species and about 100 varieties, of which cos lettuce and cabbage lettuce are the best. The former has long and upright leaves, which are tied together for the purpose of being blanched ; while the latter are rounder, of a more spreading character, and grow nearer the ground.

Lettuce supplies a wholesome, digestible, cooling, and agreeable salad, but it is sometimes boiled and eaten as a vegetable. It is chiefly valuable for the juice, which is bland, pellucid, has little taste or smell, is cooling and soothing. The juice is milky and possesses mild soporific properties, and, when the plant is mature, is collected, inspissated, and forms the *lactuarium*, or lettuce-opium, once prized as a medicinal agent. Lactuarium is in opaque white or brownish pieces, having an odour of opium ; it consists of 44 per cent. of **lactucone,** a crystalline, colourless, and tasteless substance, together with **lactucin,** lactucic acid, and lactuco-picrin, besides mannite, sugar, asparagin, and caoutchouc. The fresh plant contains these principles, and also traces of **hyoscyamine,** but the latter is not discoverable in lactuarium. The salts are oxalate, malate, nitrate and sulphate of potash, chloride of potash, phosphates of lime and magnesia, oxides of magnesia and iron, and silica. König gives the composition of the ash as follows : Potash 37·63, soda 7·54, lime 14·68, magnesia 6·18, iron oxide 5·31, phosphoric acid 9·19, sulphuric acid 3·76, chlorine 7·65, silica 8·14, per cent.

[1] Smith's " Foods " (I.S.S.), p. 207.

Endive (*Cichorium endivia*, N.O. Compositæ), also called "white chicory." The plant is found wild in all countries surrounding the Mediterranean, and as far as Algeria, Palestine, and the Caucasus. It is very common in the Grecian Archipelago. Its name suggests a cultivation of Græco-Roman origin, but De Candolle found no positive proof of this in ancient writings. English gardeners began to cultivate it in 1548, about the same time as many other plants. The green tops are eaten as a salad. They can be blanched like lettuce or celery, and are reputed to be good for indigestion, liver and similar complaints.

Chicory (*C. intybus*) is also cultivated as a salad, as well as for the root. It grows wild throughout Europe, and is also found in Northern Africa and Asia. Its cultivation is ancient, for their writings show that the Greeks and Romans used both the cultivated and wild varieties.

Dandelion Leaves (*Taraxacum officinale*), when young and tender, are highly prized as a salad by many people, who consider them to have the same properties as endive and chicory.

Chervil (*Anthriscus cerefolium*, N.O. Umbelliferæ) is a native of South Europe. It has a strong, agreeable odour, especially when rubbed, with a pungent and slightly bitter taste. It is valued as a salad plant and pot-herb.

Celery (*Apium graveolens*, N.O. Umbelliferæ).—Celery grows wild in damp and marshy places in Europe, Asia, and Africa, but it is extensively cultivated for consumption. Its cultivation is very ancient, for it is spoken of in the "Odyssey" under the name of *selinon*. There are now about forty named varieties, and many more subvarieties, which have arisen during the long course of cultivation. The long blanching leaf-stalks are the result of cultivation. The variety which differs most widely from the wild plant is the turnip-rooted celery, or **celeriac** (*A. graveolens*, var. *rapaceum*). Not only are the leaf-stalks eaten, like ordinary celery, but the roots are cooked and eaten like turnips. The cultivated plants, the result of careful selection aided by natural development, have lost the rank odour and coarse taste of the wild plant. Some of them are of superior quality, large and compact, crisp and juicy, and have a fine nutty flavour. There are large and dwarf, pink and white varieties, besides the turnip-rooted kind, which is preferred to the others by the Germans. The leaf-stalks of all varieties readily become blanched or etiolated when banked with earth. They form a most useful vegetable whether eaten as a salad or boiled in soups or stews. The odoriferous principle consists of an oil which is composed largely of sedanolide and an anhydride of sedanonic acid. The entire plant and seeds possess stimulant, carminative, nervine, and diuretic properties, and has been specially recommended for people suffering from chronic rheumatism.

Comfrey (*Symphytum officinale*, N.O. Boraginaceæ).—The leaf-stalks become etiolated when banked with earth, and are eaten like celery; the young leaves are boiled and eaten like spinach. **Borage** (*Borago officinalis*) is used in salads and as a decoration for various dishes.

Sweet Fennel (*Fœniculum dulce*, N.O. Umbelliferæ).—The leaf-stalks become blanched when banked with earth, and are eaten in Italy as a salad and in soup, etc.

Lovage (*Levisticum officinale*), of the same order, is grown in gardens as a salad plant. The leaves have a strong and peculiar odour, and the juice contains much resinous substance.

Corn-Salad, fetticus or mâche, of France and England, is *Valerianella olitoria*, N.O. Valerianaceæ, a native of Europe; used both as a salad and pot-herb, and also eaten like spinach. *Cetrantus ruber*, another member of the family, is used as a salad in Sicily.

Sorrel.—(1) Common or garden sorrel (*Rumex acetosa*, N.O. Polygonaceæ): The leaves, which are acid, are eaten as a salad along with dandelion, endive, and similar vegetables. Boiled together, sorrel and dandelion form an agreeable accompaniment to veal, pork, or duck. They are stomachic, mildly laxative, and indirectly increase the activity of the liver and kidneys. Sorrel contains much free acid, especially oxalic and tartaric acids, besides oxalates of calcium and potassium, and is therefore prejudicial to persons suffering from gout, gravel, or calculus. It is now seldom used as an article of food in England, but in the time of Henry VIII. it was found in almost every garden. It is still rather extensively employed in France, and is considerably improved by cultivation. (2) Wood Sorrel or Shamrock (*Oxalis acetosella*, N.O. Oxalidaceæ), a native of the woods of England, Europe, and America, has an agreeable acid taste, which renders it an agreeable addition to salads and sauces.

Purslane (*Portulaca oleracea*, N.O. Portulacaceæ) is one of the most ancient garden plants; it was formerly much cultivated as a salad plant, pot-herb, and to be eaten as "greens" with meat. It is cooling and diuretic. The leaves of *Talinum patens*, of the same order, found abundantly by the seashore in the West Indies and South America, are used for the same purposes as purslane.

Radish (*Raphanus sativus*, N.O. Cruciferæ).—The radish is unknown in a wild state; it is probably a development of the wild charlock (*R. raphanistrum*), which is an annual weed in the Old World. It has been cultivated in gardens from the earliest historic times. The root presents forty-three varieties (Goff), being spherical, oblate, top-shaped, oval, and cylindri-conical, the colour being white, yellow, red, purple, or black. Some of these roots have a very fine flavour, and when young are crisp, juicy, and tender; but when old they contain much woody fibre, and are difficult to digest. They are stimulating to the stomach, promoting a flow of saliva and gastric juice, and by their pungency and warmth they encourage appetite. The roots of sea-radish (*R. maritimus*) are said to be preferable to horse-radish. Similar to the former is *Crambe tartarica*, called "Tartar bread," eaten largely in Hungary, the root being peeled, sliced, and mingled with salt and oil. It is allied to seakale.

Cresses.—There are several cruciferous plants called "cress." **Watercress** (*Nasturtium officinale*) is, however, by far the most important. It grows in rivulets, clear ditches, and ponds, and is extensively cultivated. The leaves have a moderately pungent taste, but are highly esteemed as a salad for their valuable antiscorbutic properties. According to some authorities, they contain iodine. **Garden Cress** (*Lepidium sativum*), of which there are curly-leaved and broad-leaved varieties, is also a valuable antiscorbutic salad. This plant is very ancient; it is cultivated in Europe, Asia,

and North Africa. Its origin is obscure. De Candolle believes it came from Persia, and was probably spread after the Sanskrit period into India, Syria, Greece, Egypt, and thence into Europe. **Winter** or **Upland Cress** (*Barbarea vulgaris*) is much cultivated, and used as a salad plant in the spring ; it, however, has a nauseous or bitter taste, and is more or less mucilaginous. The French call it *herbe de Ste. Barbe.* In Sweden the leaves are boiled and eaten like kale. *Barbarea precox* is much more agreeable ; it has the flavour of watercress, and is cultivated and much esteemed as a salad under the names of American cress and Belle Isle cress. **Nasturtium** is the popular name of *Tropæolum majus*, or Indian cress, an annual grown in gardens chiefly for its flowers. The leaves, like those of other cresses, have a pungent taste, and are used for a salad ; the fruit is also used in salads, pickles, and as a substitute for capers. The entire plant contains an oil which consists of 85 per cent. of benzyl thiocarbamide. The pungent property of the cresses named above is also due to an oil which consists partly of allyl sulphide. The land cresses can be grown all the year round ; the smaller varieties are frequently grown with mustard, and the combination " mustard and cress " forms a salad which is highly appreciated in the early months of the year, when lettuce and other green salads are more or less scarce.

Tarragon (*Artemisia dracunculus*) is cultivated in gardens as a salad-herb, and as a condiment to give flavour to soup and make tarragon vinegar. It has a smart, pungent, but agreeable odour and a somewhat aromatic taste. It is used comparatively little in Europe, but much more extensively in Persia, Siberia, and Tartary. Tarragon vinegar is highly esteemed.

Red Cabbage is a variety of *Brassica oleracea*, used chiefly for pickling.

White Cabbage is sometimes used as a salad. A crisp white-heart cabbage, cut into fine shreds and mingled with other ingredients, makes a salad of considerable value when other salad vegetables are scarce in the winter.

Sauerkraut is prepared from the leaves of a cabbage. The leaves are deprived of their stalk and midrib, cut into pieces, and placed in a tub or vat, with alternate layers of salt. They are subjected to pressure, and allowed to remain until fermentation occurs and they become sour. The product is cooked by stewing it in its own liquor. *Composition :* Water 88·8, protein 1·7, fat 0·5, carbohydrate 3·8, mineral substances 5·2, per cent. Another substance, known as " kraut " in Western Germany, and " muss " in Oriental regions, is a solution or extract of fruit, turnips, carrots, etc., which is evaporated to a paste, and eaten spread on bread. In Russia a kind of sauerkraut forms an important part of the national dish called " shtshi." " The great staple vegetable of the country is the cabbage, which grows in great perfection—fine, large, solid, white, and crisp. It supplies a chief portion of the subsistence of the people all the year round. At the beginning of winter every

family lays in a store. At that time the plants are cut down, and chopped up or shred into thin slices. Being packed in barrels with vinegar and salt, a kind of fermentation takes place, the cabbage becoming a kind of sour crout. This is made with meat into a cabbage broth, called 'shtshi,' which is the most characteristic national dish in Russia, and forms the daily food of the mass of the people."[1]

Preserved Vegetables.

It is not customary in England to consume **tinned** ordinary vegetables, but it is conceivable that there are many occasions on which they might be used. Particular kinds of vegetables cannot be had fresh from a garden all the year round. It is obvious, however, that, by properly sterilizing them, all kinds of vegetables can be preserved in hermetically sealed tins, wherein they retain almost their fresh condition, absolutely free from decomposition, for an indefinite time, and for use at any season of the year. All kinds of vegetables which are usually cooked before consumption can be canned or tinned in the same way as meat or fish. They are usually preserved on Appert's principle. Being thoroughly cleansed from dirt, grubs, insects, and other extraneous substances, and refuse removed by trimming, they are put into tins, jars, or bottles, with a little salt and enough water to cover them, the covers being *loosely* fixed to allow the escape of gases and liquids. They are then slowly heated in a strong brine or a calcium chloride bath to a temperature of 230° F., which is maintained for a few minutes. They are then allowed to cool before removal from the bath. The corks are pressed into bottles and covered with paraffin wax, and the small aperture left in tins is hermetically sealed by solder. Another method employed is to submit them to the action of steam at a pressure of 35 to 40 pounds per square inch in a proper chamber. The duration of boiling or exposure to steam varies with the time required to sterilize the vegetable. This varies with different substances. That a proper degree of heat and regulation of the time of exposure are essential is proved by the fact that when it is insufficient certain germs and spores are not destroyed. Green Indian corn (*mealies*) require a longer exposure to heat than any other vegetable, whence it is customary to boil it. If the sterilization is incomplete, the undestroyed spores develop in the material, and produce lactic and butyric acids, and certain gases which cause the tin to swell ; and afterwards, when the tin is opened, gas escapes, and the material tastes sour or otherwise bad, owing to the decomposition of the carbohydrates, and possibly of the proteins. The products are not poisonous, but the food is spoiled.

The use of sterilized foods cannot escape criticism. Canned or bottled vegetables are very nice ; they are a source of supply when the particular material desired is out of season, and to this extent their use should be confined. It is considered that they have not

[1] *Pharm. Jour.*, 1871, pp. 788, 789.

COMPOSITION OF PRESERVED VEGETABLES—NUTRIENTS PER CENT.

	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Ash.	Salt.	Authority.
Asparagus	94·40	1·50	·10	2·80	·50	1·02	—	Atwater.
Artichokes, green	92·50	·80	5·00	·60	·60	1·70	—	Atwater.
Beans: Shelled green Lima	79·69	4·00	·30	13·24	1·16	1·62	·77	Wiley.
Broad beans	58·90	9·40	·60	29·10	—	2·00	—	Atwater.
Scarlet-runner beans	72·70	7·00	·20	18·60	·90	·90	—	Atwater.
Butter beans	77·00	4·80	·30	14·60	—	—	—	
Beans and tomato (*succotash*)	75·90	3·60	1·00	18·60	·90	·90	—	Atwater.
Baked beans	66·30	7·70	4·20	22·80	—	2·00	—	Atwater.
Kidney beans: String	94·33	·92	·06	3·03	·50	1·16	·80	Wiley.
	93·70	1·10	·10	3·80	·50	1·30	—	Atwater.
Haricot vert	95·20	1·10	·10	2·50	·50	1·10	—	Atwater.
Stringless	93·91	1·14	·07	2·91	·50	1·40	·92	Wiley.
Brussels-sprouts	93·70	1·50	·10	3·40	·50	1·30	—	Atwater.
Green Indian corn	75·50	3·51	1·25	17·58	·79	·93	·23	Wiley.
,, ,, with tomatoes	87·60	1·60	·40	9·60	·50	·80	—	Atwater.
Macedoine (mixed vegetables)	93·10	1·40	—	4·50	·60	1·00	—	Atwater.
Okra, or gombo	94·40	·70	·10	3·60	·70	1·20	—	Atwater.
,, with tomatoes	91·80	1·10	·30	5·20	·50	1·60	—	Atwater.
Peas, green	85·47	3·57	·21	7·79	1·18	1·14	·67	Wiley.
Potatoes, sweet	55·20	1·90	·40	41·40	·80	1·10	—	Atwater.
Pumpkin	91·60	·80	·20	6·70	1·10	·70	—	Atwater.
Squash	87·60	·90	·50	10·50	·70	·50	—	Atwater.
Tomatoes	93·59	1·29	·23	3·47	·60	·66	·60	Wiley.

the same health-giving properties which characterize *fresh-gathered* vegetables. The difference between vegetables recently taken from a garden and the same vegetables (preserved in bottles or tins) six months afterwards is very subtle. We do not know exactly wherein the difference lies. But it is a fact that reasonable newness or *freshness* of the vegetable is as essential to the health of the consumer as purity and freedom from decomposition and noxious bacteria.

Adulterations.—Green Indian corn (*sweet corn*) sometimes has the sweet flavour increased by the addition of sugar or saccharin, to improve the flavour of defective samples ; and starch has been added to give the substance a better appearance. Tomatoes occasionally have some preservative and colouring matter added to them. Green artichokes are steeped in water containing sodium bisulphite, to prevent them becoming discoloured during sterilization ; other firms treat both artichokes and spinach with sulphate of copper to render their colour permanent. Green peas are sweetened by saccharin and coloured by sulphate of copper. It should be observed that saccharin is benzoic sulphimide, and therefore is injurious to persons suffering from renal disorders. The continued use of saccharin as a substitute for sugar in various foods gives rise to dyspepsia.

The use of sulphate of copper for colouring vegetables is exemplified in the preservation of green peas. The peas are placed until they are soft in a bath of boiling brine containing sulphate of copper. They are then removed and thrown into a tank of cold water, and afterwards bottled and sterilized in the foregoing manner. Submerging the peas in boiling brine destroys the spores of moulds and other fungi, and removes soluble mucilage and vegetable acids, which would otherwise cause the liquor in the bottles to become turbid. The sulphate of copper *acts as a mordant*—that is, it fixes the natural green colour of the peas ; it will not make yellow or old peas green again. It forms a compound with the natural colouring matter or some protein substance in the external surface of the seed. This compound does not appear to be soluble when the peas are cooked, for practically no copper is found in the water in the bottle or tin in which they are cooked. Opinions differ as to whether this copper-protein compound is soluble in the stomach or intestinal canal. It would appear *prima facie* that the combination must be dissolved by the gastric or pancreatic secretions, the copper salt being set free and able to enter into the general circulation. This is, in fact, the opinion held by most authorities. But others assert that the copper-protein compound is insoluble in the human economy, and is therefore innocuous. The Departmental Committee on Preservatives in 1901 reported to the Local Government Board that they had not been able to obtain satisfactory evidence that vegetables containing copper are injurious to the consumer. It was stated in evidence, by Sir Lauder Brunton, that the quantity obtained in the peas which might be consumed once or twice a

week would not exceed 25 to 30 milligrammes of sulphate of copper, and would not be injurious. Care, however, should be taken that the amount of sulphate of copper in peas and other vegetables does not exceed that which is necessary to act as a mordant. It has been found to be present in amounts varying from $\frac{1}{16}$ grain to 6·5 grains of metallic copper, or from $\frac{1}{4}$ grain to 26·5 grains of sulphate of copper, in a pound of vegetables. Such variability is unjustifiable, and the larger amounts are absolutely unnecessary. It was estimated by Copeman that the *minimum* which is necessary to insure a good colour in the peas is 2 grains of sulphate of copper (equivalent to $\frac{1}{2}$ grain of metallic copper) to a pound of peas, and he recommended that a *maximum* of 2·7 grains of sulphate of copper (equivalent to $\frac{3}{4}$ grain of metallic copper) per pound should be fixed by law.

Compressed Vegetables.—Fresh vegetables are dried and pressed in such a manner that all the commoner vegetable foods can be obtained in that form without any loss of flavour or nutriment. The advantages are claimed to be obtained by the Gye process. Good sound plants or roots are chosen, and prepared as if they were about to be cooked at once, by carefully washing and trimming them to free them from dirt, grubs, uneatable portions, and extraneous matters. The materials are then dried in a room at 145° F., being spread on wicker trays. By this means they are deprived of 15 to 25 per cent. of their weight by evaporation of water, albumin is coagulated, bacteria and spores of fungi destroyed. The material is then compressed by machinery into tablets, and loses more water. Each tablet weighs about an ounce, and the material consists of 9 to 12 per cent. of water, 3 to 6 per cent. of mineral matter, the remainder being the nutritive and fibrous material of the original vegetable. One tablet supplies enough vegetable for each person at a meal. It requires to be soaked in water previous to being cooked.

CHAPTER XXII

FUNGI—LICHENES—ALGÆ

Fungi.

THE classification of the fungi by various authorities is so diverse that I shall not attempt to do more than give a general grouping of the families which include the edible varieties. Berkeley divided **edible fungi** into—(*a*) The Agarics, Boleti, and Lycoperdeæ, which have their spores naked (*Basidiomycetes*) ; (*b*) Morels and Truffles, which have their spores in sacs (*Ascomycetes*). We may add to these (*c*) Lichens, which consist of a fungus and an alga living in intimate connection, or symbiosis, the most important edible lichen being Iceland moss ; and (*d*) Algæ, which are plants of the simplest structure, living in water or upon moist surfaces, including carrageen, dulse, laver, and agar-agar.

Fungi have been used for food from the earliest times. They are low down in the vegetable kingdom. They contain no chlorophyll, form no starch, and they take up their carbon from previously organized carbon. By far the largest number of fungi used for food belong to the subclass Basidiomycetes, which are the most highly developed members—*e.g.*, mushrooms, boleti, and puff-balls. There are 10,000 kinds of fungi, of which comparatively few are edible ; but the edible varieties are far more numerous than is generally known, many being edible which are not in general use. Species which are not eaten in England are highly esteemed for food on the Continent. In some quarters of the globe fungi are much more extensively used than in Europe ; thus, in Tierra del Fuego a mushroom, *Cyttaria darwinii*, forms an important part of the food of the people, and in Australia many species of boleti are largely eaten, *Mylitta australis* having gained the name of "native bread."

BASIDIOMYCETES ; SUBORDER HYMENOMYCETES.

The fleshy Hymenomycetes of the mushroom type belong almost entirely to the temperate zone, or to high elevations in warm climates. About 4,000 species of Agaricineæ have been found in temperate climates ; 2,800 belong to Europe, and many of the same to the United States, but there are 500 in the United States which do not appear in Europe. The Lactarius and Russula type also belong to the temperate zone—Europe, the United States, and

Australia. Cyprinus belongs to Europe and the United States. The Boletus family, including 257 species, also belongs to the temperate zone.

I. Agaricineæ.

The Agarics are soft, fleshy, putrescent fungi of the mushroom type.

The Common Mushroom (*Agaricus campestris*) is found in pastures and open spaces. The young fungus consists of a small round or spherical growth of a white or fawn colour, fixed to the earth by a solid stalk, or *stipe*. As it grows, the cap, or *pileus*, expands and exposes the stalk. The under-surface of the pileus consists of gills, or *laminæ*, which at first are pink, and after a time become of a brown, liver, or black colour, the discoloration being due to the formation of innumerable spores. The pileus varies from 1½ to 3 inches in diameter. The flesh is white, of brittle texture, delicious odour and flavour, forming a tasty, appetizing, and agreeable adjunct to other food. Many thousands of people in Great Britain will not recognize any other "mushroom" as fit for food, but in Italy there is a great prejudice against it. It, however, seems to be preferred in Vienna, although the markets are less abundantly supplied with it than with other fungi. It is a common article of consumption in France and Germany. It is cultivated enormously, and different subvarieties have arisen from cultivation, which vary in their colour, scaliness of the pileus, and other minor features, whilst remaining true to the characteristics of the species. It is never poisonous, but fatal accidents occur from other fungi being confounded with it. Cooke says :[1] "If it be remembered that the spores are purple, the gills at first pink and afterwards purple, that there is a permanent collar or ring around the stem, and that it must not be sought in woods, fewer accidents will occur." McIlvaine says : "All agarics (except Amanita) which are mild to the taste when raw, and otherwise commend themselves, are edible." Taking this as a safe rule, he has never failed from April to December to obtain an ample supply of healthy, nutritious, and delicate mushrooms for himself and family, and these include 100 out of the 300 known species of fungi which he has personally tested and found to be edible.[2]

The Meadow or Horse Mushroom (*A. arvenis*) is similar to the former, but is 3 to 6 inches or more in diameter, and has been known to weigh several pounds. It grows in meadows and pastures. Great quantities are sold in the markets. Many people prefer it to the common mushroom ; it has a stronger flavour, but otherwise there is little difference. It is also preferred in France and Hungary, where it is considered to be a special gift of St. George.

The Hallimasche (*A. melleus*) is one of the most common fungi, but has no reputation in England, where it is considered nauseous

[1] "Fungi," International Science Series.
[2] Wiley, "Foods and their Adulteration," p. 439.

and disagreeable. Cooke says it is a sorry substitute for the common mushroom, but it makes a good sauce, and is much used for that purpose in Vienna.

St. George's Mushroom (*A. gambosus*) makes its appearance in pastures in spring (May or June), when other esculent species are scarce. It has a delicious flavour and is much esteemed. In France it is dried for winter use. *A. abellus* and *A. brevipes*, which are closely allied, have a similar reputation.

The Oyster Mushroom (*A. ostreatus*) is eaten universally. It has not the fine flavour of many other species, but it is perfectly wholesome if cooked young. *A. ulmaris*, which grows on elm-trees in Britain and America, is similar to it, and is preferred by many people. It has a lateral stem.

The Fragrant Mushrooms (*A. odoratus* and *A. fragrans*) have an odour of aniseed, which is long persistent. They are edible, form an exquisite dish, and are capable of being dried for winter use. The former is of a dirty pale green colour ; the latter is of a nearly white or pale tawny colour.

The Nail-Fungus (*A. esculentus*) is the smallest edible agaric ; the pileus does not exceed 1 inch in diameter. British species are bitter, but those of Austria are eaten and used to make sauces.

The Imperial (*A. cæsarius*) grows in great quantities in the oak forests of America ; it is wholesome, but has a disagreeable flavour.

"**Blewits**" (*A. personatus* or *Lepiota personata*).—This is a purplish fungus, common in England, Europe, and America. They were formerly sold in Covent Garden Market under the name of "blewits," and are called "blue-buttons" in Nottingham. The name, according to Dr. Badham, is a corruption of "blue hats." They are edible and wholesome ; but Tibbles has seen and reported several instances of poisoning from them, which probably occurred as the result of their not being fresh, or from the admixture of poisonous varieties, the symptoms resembling those of ptomaine-poisoning.

The Scaly-Capped Fungus (*A. procerus*), also called "the parasol mushroom," is much in request in France, Spain, and Italy, where it is highly esteemed. Cooke says it deserves to be better known in England.

Other edible varieties are—*A. prunulus* and *A. orcella*, neat white agarics growing in woods and open glades respectively. They have a mealy odour, and are highly esteemed. *A. maximus* or *giganteus* is a much larger fungus, often attaining 14 or 16 inches in diameter, and the stem 2 inches thick, and has a strong odour. *A. vaginatus* is a white variety, "inferior to few agarics in flavour" (Cooke). *A. rubescens* has the cap studded with warts of a paler colour ; it becomes red when cut or bruised. Cordier says it is one of the most delicate mushrooms in Lorraine. In England it is chiefly used for making ketchup. *A. dealbatus* is a crisp variety which is very good eating. It grows in old mushroom-beds and fir-plantations. *A. geotropes*, found in England on the borders of

woods, and also in Europe and America, is a robust variety of the former, and is also edible. *A. glandulosus, A. tesselatus, A. pomatus A. saliguus, A. amygdalus, A. frumentaceus,* and others, are edible species in America.

The Shaggy or Maned Mushroom (*Coprinus comatus*) is the best edible species of the *Coprinus* group. It is common at the roadside and other places, and is highly esteemed as a food when it is young and cylindrical, and the gills are whitish or of a roseate tint. The **Inky Coprinus** (*C. atramentarius*) is somewhat inferior, but it is very similar. In their early growth the cap, gills, and stem, are white, excepting the tip of the cap, which is dark. The pileus is covered with delicate scales. The juice of the young fungus is colourless, but as the plant develops it changes into an inky fluid. When it changes, the juice is at first a wine colour, and the fungus is still edible ; but when the juice becomes black the fungus is too old to be eaten. The overgrown mushroom begins to decay at the edges, to liquefy and disappear ; it soon looks like a half-closed umbrella, and within a day the whole dissolves into an inky fluid, which partly runs down the white stem to the earth. Both kinds are eaten in Europe and America.

In the genus *Cortinarius* there is a veil composed of arachnoid threads, and the spores are rusty-coloured. The edible species are few, but include the following : *Cortinarius violaceus,* of a beautiful violet colour, and often 3 or 4 inches in diameter ; *C. castaneus,* common in the woods of Britain and America, scarcely exceeds an inch in diameter ; *C. cinnamomeus* has a cinnamon-coloured pileus. with yellowish flesh, which has an odour and flavour of that spice : it inhabits all woods in the Northern Hemisphere, and is much esteemed in Germany ; *C. emodensis* is eaten in India.

The Milky Agaric (*Lactarius deliciosus*) is distinguished by the milky juice which exudes when it is wounded. It grows plentifully among fir-trees, and is one of the nicest edible fungi, all writers vying each other in praising it. It is eaten in all the countries of Europe, and sold in many markets. The flesh is orange-coloured, and assumes a livid green when bruised or broken. The juice is of a yellowish milky appearance, but changes to a saffron red, and afterwards to a greenish colour, on exposure to the air. It is liable to the attack of a reddish parasitic fungus, and is then unsafe to be eaten. *L. piperatus* is also eaten in the United States, and all the species of *Lactarius* are indiscriminately preserved in salt and vinegar by the Russians, to be eaten by them during their long religious fasts.

Russula resembles *Lactarius,* excepting that its species are without milk. *Russula heterophylla* is edible, and considered to be unsurpassed for flavour. It is common in the woods of England, France, etc. Other edible varieties are *R. virescens, A. alutacea, R. lactea, R. lepida, R. vesca,* and *R. decolorans.* The red species, *R. emetica,* **is very poisonous**. It has a red-coloured cap, with white gills, and might be confounded with some of the foregoing.

Paxillus giganteus is one of the best agarics. It has a dingy white exterior, creamy white gills, and yellow stains on the stem. It is found in August and September.

The Chanterelle (*Cantharellus cibarius*) grows in large numbers in the woods in autumn. It has a rich golden or orange yellow colour within and without ; its odour resembles that of apricots, and its flavour is delicious. It grows abundantly in France and Southern Europe, and is eaten in all countries where it is found, except England, where it is rarely eaten. It is perfectly innocent.

The Fairy-Ring Champignon (*Marasmius oreades*) is plentiful in pastures, where it forms rings or parts of rings. It is small, but one of the most delicious fungi. The cap and stem have a pinkish-buff colour, the gills being a shade lighter and of a creamy tint. The spores are white, the gills widely separated, and, when fully expanded, the cap has a knob-like appearance in the centre. It possesses the advantage of being easily dried and preserved for winter use. The odour is long retained. Cooke regrets that this excellent species is not cultivated for the markets. *M. scorodonius* is a small strong-scented fungus, found on heaths and dry pastures in Europe and America. It is much inferior to the champignon, but its garlic-like odour is a strong recommendation to its use for sauces.

II. Clavarieæ.

The Clavaroid fungi are small ; the majority of the white-spored species are edible, and none are poisonous. Curtis mentions thirteen species eaten in Carolina, including *C. flavia, C. aurea, C. botrytis*. The British edible species include *C. rugosa, C. coralloides, C. cinerea, C. fastigiata, C. amethystina*, etc. These and other species are also found in Europe.

III. Hydneæ.

Some species are edible ; none are poisonous. They are characterized by the spines or warts over which the fructifying surface is expanded. The **Urchin of the Wood**, or tooth-bearing fungus (*Hydnum repandum*), found in woods and woody places in England, Europe, and America, is one of the most delicious toadstools, having a flavour resembling an oyster. It is recognized by its buff-white colour and the teeth or spines under the pileus. It is best eaten young ; it is fleshy, but becomes waxy or leathery. When raw it has a peppery taste, but is highly esteemed when cooked. It is largely used on the Continent, where it is also dried for use in the winter. Other edible species are—*H. imbricatum*, which is eaten in France, Germany, Austria, etc. ; *H. lævigatum*, eaten in Alpine districts ; *H. coralloides, H. caput medusæ*, and *H. erinaceum*, which are not so common in England, but are eaten wherever they grow on the Continent.

IV. Polyporeæ.

The majority of edible species in this order belong to the *Boletus family*, including a large number of fungi which are quite innocent, may be safely consumed, and are easily recognized by having tubes, containing the spores, on the under-surface of the pileus, in place of the gills which characterize the Agaricineæ. They are soft and fleshy, often of large size, and resemble an ordinary mushroom.

Boletus edulis is very common in the beech-woods of the South of England and elsewhere. It does not please the English palate, but is much used on the Continent. In Germany and Austria it is cut into slices, dried, and sold in the same shops as a farinaceous food. It is believed to be the **suillus** eaten by ancient Romans, and obtained from Bithynia. It is made into soup in Hungary and Italy, the dried fungi being used for this purpose in the winter. The pileus is 4 to 6 inches in diameter, of light brown colour above, and white underneath, where it turns to a yellowish-green or wine colour. The flesh is firm when young, and softens as it ages. The stem is large and pear-shaped, somewhat brown, and surmounted by a fine network.

Nearly all boleti are edible; the safe ones are yellowish-white on the under-surface of the pileus; those which are red, brown, or change colour when cut or bruised, should be regarded with suspicion, unless well known to the collector. Cooke mentions the following additional edible varieties: *Boletus æstivalis*, which appears in early summer, and when raw has a nutty flavour, like a mushroom; *B. scaber* is also common in England, but not so good as the two former; *B. bovinus*, *B. castaneus*, *B. granulatus*, all much used on the Continent; *B. collinitus*, eaten in America; also *B. chrysenteron* and *B. subtomentosus*, which are poor eating, and said by some people to be injurious. There are also other edible species.

Polyporus.—Only a few species of true *Polyporus* are worth eating. Cooke mentions *P. intybaceus* and *P. giganteus* as European species, which are of large size and edible, but become leathery when old. *P. cristatus* and *P. poripes* are edible American species. The latter tastes like filberts or chestnuts when raw, but is too dry when cooked to be estimable.

"**Beefsteak**" **Fungus** (*Fistulina hepatica*) is allied to *Boletus*. It has been called "vegetable beefsteak" because it has a distinct meaty flavour and odour, and furnishes its own sauce when cooked. It is juicy and fleshy, of large size, sometimes 5 feet in circumference, and weighs many pounds. It is said to resemble beetroot when raw, and in Vienna it is sliced and eaten in salads. It grows upon oak, ash, beech, and other trees, and is everywhere included among edible fungi.

V. Lycoperdeæ.

The puff-ball fungi belong to the Gasteromycetes. Many kinds are edible. There are 480 species in Europe, America, and (most of all) in Australia.

The Common Puff-Ball (*Lycoperdon cyatheforme*) and Giant Puff-Ball (*L. giganteum*) are edible when young and cream-like, and are an excellent addition to the breakfast table, a giant puff-ball providing sufficient food for ten people. They are globose, brownish outside, white inside. After a few days the interior becomes soft, of a yellowish tint, and develops an amber-coloured juice. Finally it dries up, the exterior becoming tough, and the interior full of a fine powder consisting of spores. All the species which are white outside are edible when young, and are consumed wherever they grow.

ASCOMYCETES: SUBORDER DISCOMYCETES.

Family Helvelleacæ.

Genus Morchella—Morel.—The morel is a fungus having a hollow stalk and conical cap, which is pitted. There are various species growing plentifully in Britain; but they are usually imported in a dry state from Germany, and are used for making gravy, ketchup, sauces, and entrées. Probably all the morels are edible. The most common is *Morchella esculenta*, which is variable in size and colour, has a faint grateful taste, and is found in spring and summer. We also have *M. semilibera*, in which the pileus is partly free, and the much larger *M. crassipes*, which has a thick stem. On the Continent is also *M. rimosipes* and other edible forms. In the United States *M. caroliniana* and *M. smithiana* are also edible. The morels are almost exclusively inhabitants of the temperate zones, but *M. deliciosa*, so called on account of its flavour, and *M. gigaspora* are common in Java, Cashmere, and other places.

The Beche Morel (*Cyttaria gunnii*) resembles the ordinary morel, but is smaller and more gelatinous. It is parasitic on beech and other trees in the Southern Hemisphere, where they grow in clusters. They abound in Tasmania, and have a great reputation. *Cyttaria berteroi*, which grows in Chili, is eaten, but is not so good. *C. darwinii* grows in vast numbers in Tierra del Fuego, and is an essential article of food for the natives. Most Cyttarieæ are commonly eaten in South America, Chili, Peru, Patagonia, and New Zealand.

Genus Gyromitra.—These fungi are also closely allied to the morels. *G. esculenta* and *G. gigas* occur in Europe. They are seldom eaten in England, but much more commonly on the Continent.

Genus Helvella.—Intermediate between morels and *Helvella* is *Gyromitra esculenta*, formerly called *Helvella esculenta*. These fungi differ from morels in appearance, but their uses are similar. Several are edible; *e.g.*, *H. crispa*, having a curled or wrinkled pileus, is the most common British species. They can be dried for winter use, and serve as a flavouring for sauces, gravies, and soup; *H. lacunosa*, so called from the pileus being pitted or full of

holes, is less common in England; *H. sulcata*, with a furrowed pileus, occurs on the Continent and in North America; *H. monachella* and *H. ephippium* are doubtful species, but considered esculent by most authorities.

Genus Peziza.—Two or three species have the reputation of being edible, but they are of little value—*e.g.*, *Peziza acetabulum*, *P. cochleata*, and *P. venosa*. Cooke says he has seen basketfuls of *P. cochleata* gathered in Northamptonshire, to be used as a substitute for morels.

Family Tuberaceæ (Subterranean Fungi).

Genus Tuberacei—True Truffles.—There are about fifty species of truffles, whose habitat is very wide, as they grow in nearly all parts of the earth. But the chief species grow in Europe, where they are cultivated in France and Italy, and especially in Provence, Languedoc, Périgord, Dauphiné, Champagne, Burgoyne, and the environs of Paris. Most of the Tuberaceæ are edible; none are known to be poisonous. The best-known species are *Tuber cibarium* or *æstivum*, *T. brumale*, *T. magnatum*, and *T. melanosporum*. They grow in woods or forests, especially in the neighbourhood of oak, hornbeam, and nut trees, although old truffle-hunters say they found most in fir-plantations and under beeches. It is certain that some trees form a better environment for the fungi, and they prefer a calcareous soil. The spores of the fungus reach the forest by natural means, but artificial spreading of the spores in suitable areas is quite common. Their development is slow; the mycelium does not produce truffles for several years after it begins to grow, but when once they are formed they continue to be produced for several years. As the truffles mature and the spores develop they become very aromatic, whereby they attract flies, and their situation is thus indicated to the expert and to various animals, such as hogs and dogs, which are kept by the farmers for the purpose of hunting the fungi. Attempts have been made to grow them in the same way as mushrooms, but with little success.

In England truffles are found chiefly in Kent, Wiltshire, and Hampshire, where they were formerly hunted for; but for many years the industry has declined, because French truffles are cheaper and have a more exquisite flavour. The most prolific country for truffles is Italy, but the most celebrated for the table are those of France.

The African truffle (*Terfezia leonis*) has been eaten for ages by the natives, and can be imported from Bagdad and Biskra. There are also others—*e.g.*, *Cheiromyces*, which is as big as a man's fist, and *Elephomyces*, both of which are edible.

Truffles are red, white, and black. Their quality depends upon the size, aroma, and texture. Périgord truffles are black and highly esteemed, but some are grey (dirty white) and brown. The black ones are held in highest esteem, and have great repute for making gravy, soups, entrées, and for garnishing dishes. They are used fresh

or dried. They should be firm or elastic, and have the characteristic odour and flavour. Medium-sized ones weigh 40 to 60 grammes, choicer ones 60 to 100 grammes. Some grow to a larger size, but their value is not increased thereby. Small unripe truffles are deficient in flavour.

Truffles are highly stimulating and heating, properties which they owe chiefly to the nitrogenous constituents. The proportion of the latter is variously estimated, but may be as high as 9 per cent., including 6 per cent. of protein. They should be eaten moderately, as their digestion is somewhat difficult, and their wholesomeness is not beyond question.

Genus Hypogæi—The False Truffles.—The *Melanogaster* was formerly used and sold under the name of "red truffles," as a substitute for the genuine article. These fungi have a strong penetrating odour. The chief variety is *M. variegatus*, but there are other varieties which are of doubtful value.[1]

The **nutritive value** of "mushrooms" and other fungi has been over-estimated by many writers. This arose from two facts: the flavour and texture of many fungi when cooked, and the fact that all the nitrogen was estimated as albuminoid nitrogen, whereas from 30 to 40 per cent. of the nitrogen is in the form of amides and other non-protein condition. Thus, Cooke, in his admirable treatise "An Introduction to the Study of Fungi" (p. 84), says the nitrogenous constituents in *dried* agarics is greater than in dried peas and beans. This general statement is very misleading. Some of the fungi, notably *Fistulina hepatica*, *Boletus edulis*, and other agarics, are considered to resemble meat, and have been called "vegetable beefsteak," "beefsteak fungus," etc. They undoubtedly have a meaty flavour, and partake of other characteristics of meat, but there is no fungus which really deserves the encomium implied in those names. The nutritive value of these fungi is very small in comparison with that of meat, fish, eggs, or peas. Compare the proportion of protein in each.

Protein in Fungi and Various Foods.

Beefsteak, average	19·50 per cent.
Milk	4·00 ,,
Eggs	13·50 ,,
Codfish	16·50 ,,
Mackerel	18·70 ,,
Peas, green	6·05 ,,
,, dried	22·00 ,,
Common mushroom	4·89 ,,
,, boletus	3·70 ,,

[1] References have been made to the following works in compiling the foregoing account: Massee's "Textbook of Fungi"; Cooke's "Fungi: their Nature and Uses" (I.S.S.); Cooke's "Introduction to the Study of Fungi"; Phillips's "British Discomycetes" (I.S.S.).

THE COMPOSITION OF FUNGI—PERCENTAGES.

	Water.	Nitrogen.			Protein.	Amides, etc.	Fat.	Carbohydrate.	Cellulose.	Ash.	Authority.
		Total.	Albuminoid.	Non-Albuminoid.							
Agraricus campestris (common mushroom)	91·30	·60	·36	·24	3·75	—	·20	3·50	·80	·50	Bulletin 79, U.S. Department of Agriculture.
	93·70	—	—	—	2·20	1·30	·30	1·20	1·20	·30	Stahl-Schroeder.
A. campestris (cultivated)	91·01	—	—	—	4·68		·40	3·45	—	·46	Payen.
	91·10	—	—	—	2·57	—	·14	4·86	·68	·70	
Coprinus comatus (shaggy or maned mushroom)	92·19	·45	·15	·30	2·81	—	·26	1·40	·57	·98	Bulletin 79, U.S. Department of Agriculture.
C. atramentius (inky coprinus)	92·13	·36	—	—	2·25	—	·24	—	·72	1·29	
Lactarius deliciosus (milky agaric)	89·08	—	—	—	1·88	·91	·54	4·49	·32	—	Stahl-Schroeder.
Cantharellus cibarius (chanterelle)	90·93	—	—	—	1·19	·64	·64	5·09	·33	1·20	
Boletus edulis (boletus)	84·19	—	—	—	3·70	2·60	·40	4·65	·74	—	
Morchella esculenta (morel)	90·70	—	—	—	3·49	3·59	·25	·73	·67	—	
	89·54	·49	·37	·12	3·06	—	·50	1·60	·91	1·08	Bulletin 79.
	90·00	—	—	—	4·40		·56	3·68		1·36	Payen.
Tuber cibarium: Truffles	73·00	—	—	—	6·10	1·40	·60	6·02	6·40	2·00	Stahl-Schroeder.
Black truffles	72·00	—	—	—	8·76		·56	7·59		2·07	Payen.
White truffles	72·34	—	—	—	9·96		·44	15·16		2·10	
	72·50	—	—	—	8·91	7·52	·64	7·93		—	
Beef steak, for comparison	62·50	—	—	—	19·50	—	17·00	—	—	1·00	Atwater.

We must therefore admit that the protein value of fungi is very low, and is not to be compared with that of essential foodstuffs. There are several proteins in the fungi of an albuminoid character, which are considered to resemble those of meat. But a very large proportion of the nitrogen is in the form of amides and other extractives, which give flavour to these esculents, and are probably stimulating, like the extractives in meat, but cannot be regarded as nutritious. According to Mendel, the relation of the total nitrogen, protein and non-protein nitrogen, and percentage of digestible protein, is as follows :

NITROGEN IN FRESH FUNGI—PERCENTAGES.

	Agaricus Campestris.	Cantharellus Cibarius.	Boletus Edulis.	Lactarius Deliciosus.	Morchella Esculenta.
Total nitrogen	7·38	2·69	3·87	3·11	4·99
Protein	4·89	2·29	2·73	2·51	4·18
Extractives (amides, etc.)	2·49	·40	1·14	·60	·81
Digestible protein ..	3·64	·79	2·10	1·41	2·19
Indigestible protein ..	1·17	1·46	·65	1·05	1·90

TOTAL NITROGEN AND PROTEIN IN ONE HUNDRED GRAMMES OF DRIED SUBSTANCE.

	Nitrogen.[1]	Protein.[2]
Agaricus campestris	7·26	20·63 = N 3·25
Boletus edulis	4·70	22·82 = N 3·59
Cantharellus cibarius	3·22	10·68 = N 1·70
Clavaria flavia	—	24·43 = N 3·86
Helvella esculenta	—	26·31 = N 4·22
Morchella esculenta	—	35·18 = N 5·52
,, conica	—	29·64 = N 4·75
Lactarius deliciosus	4·68	—
Russula	4·25	—
Tuber cibarium	—	36·32 = N 5·73

Fats.—The amount of fat in most edible fungi is very small, and averages only about 0·5 per cent., except *Clavaria flavia*, which contains 5 or 6 per cent. Large quantities of fat are, however, present in the reproductive bodies of many species, where it is a special reserve material, the mycelium of *Lactarius deliciosus* having 6 per cent. Cholesterin and lecithin have also been observed in various fungi, notably *Lactarius*, and these substances are very unstable when exposed to the air.

Carbohydrates.—Fungi contain no chlorophyll, and therefore must take up their carbon in the form of complex compounds,

[1] Schlosenberger and Doepping; *cf.* Schutzenberger, "On Fermentation" (I.S.S.).

[2] Kohlrausch, *Year-Book of Pharmacy*, 1878, 371.

instead of the simple carbon dioxide. There is no starch. Glycogen, however, occurs in many fungi—*e.g.*, truffles—and in various Hymenomycetes and Physomycetes. It is usually most abundant in the stem and in the vicinity of the soil, and particularly abundant at an early period of their growth. Errara contends that it plays the same part in fungi as starch does in other plants. It is the first visible product of the absorption of carbon. It is not formed from the free carbonic acid gas in the atmosphere, but from pre-existing organic carbon compounds. Gummy substances also occur in most species. The cell walls consist of metacellulose, or **fungin**; there is no lignin or woody fibre. Agaric resin occurs in many species, and especially in *Boletus laricis*, when it may reach 25 per cent.

The **Sugars** are mannose, trehalose, and glucose. Mannite (the predecessor of mannose) occurs in most fungi. Glucose is the chief sugar in young plants, and becomes transformed to mannite as the plants mature. Mannite alone is present in *Russula*, trehalose in *Coprinus*. *Boletus* has no saccharine matter in the tubes; Bourquelot found the following amount in the stem and pileus of 1 kilo of *Boletus edulis*:

	Trehalose.	Glucose.
Stem	24·5 grammes	·77 gramme.
Pileus	13·8 ,,	·71 ,,

Enzymes.—Fungi contain an abundance of enzymes, which are of great importance to the metabolism of the plant. Bourquelot[1] obtained from *Aspergillus* invertase, maltase, inulase, diastase, emulsin, and trypsin. All these are not present in every variety of fungus, but several are present in each one, and their use is indicated by their name.

Acids.—Citric, malic, fumaric, oxalic, and citric acids occur in a free or combined state; oxalate of lime and potassium are common. *Fistulina hepatica* contains 0·093 per cent. of acids. The *fungic acid* mentioned by earlier observers is a mixture of citric, malic, and phosphoric acids.

Minerals.—They are mostly a combination of potassium salts and phosphoric acid. The proportion varies in *fresh fungi* from 0·3 per cent. in common mushrooms to 2·1 per cent. in truffles; in *dried fungi* the variation is from 3·0 to 19·8 per cent. Kohlrausch[2] found as follows:

Minerals in One Hundred Parts of Ash.

	Potash.	Phosphoric Acid.
Agaricus campestris	50·71	15·43
Boletus edulis	50·95	20·13
Cantharellus cibarius	48·75	31·32
Clavaria flavia	51·47	35·07
Tuber cibarium	55·97	30·85

[1] Bull. Soc. Mycol., 1893, 231. [2] *Year-Book of Pharmacy*, 1878, 371.

Water is most abundant in the fleshy fungi : Agarics have 60 to 90 per cent. ; *A. campestris* 91 or 92 per cent. ; *Fistulina hepatica*, 86 per cent. ; *Boletus*, 67 to 84 per cent. ; truffles, 72 to 75 per cent. The **latex**, or juice, is of variable composition : that of *Lactarius is* resinous ; in *L. deliciosus* it is of a deep yellow colour, but turns green on exposure ; in *L. aspideus* it is first milky white, but afterwards becomes lilac-coloured ; in *Fistulina* it is more fluid, and contains tannin.

Colouring Matters.—Fungi contain no chlorophyll. But our yellow or orange colouring matters have been isolated—viz., xanthophyll *a* and *b*, like the ordinary colouring matters of leaves ; phytoxanthine, which is yellow ; and pezizoxanthine, which is orange. Certain boleti have a yellow colouring matter, which becomes blue on exposure to air, and is considered to be indigogen. Red colouring matters have also been separated ; also a violet colouring agent which is called " polyporic acid."

Poisons. See Poisonous Mushrooms.

Ketchup or **Catsup** is a sauce or condiment, made from the juice of mushrooms, obtained by sprinkling them abundantly with common salt. The juice is boiled with spices, such as allspice, cayenne, ginger, and mace. The mushrooms used for this purpose are *Agaricus campestris, A. arvensis, A. rubescens, Marasmius oreades, Coprinus comatus, C. atramentarius, Fistulina hepatica*, and *Morchella esculenta*. When mushrooms are scarce, doubtful species, such as *Agaricus spadiceus, A. lacrymabundus*, and many others, classed as nonpareils and champignons, are used.

Digestibility.—The composition of fungi shows that they do not possess the high nutritive value which was formerly assigned them. That they are " worthy on account of their chemical composition to be placed by the side of meat, the most important nitrogenous food of man,"[1] is not true. Taking 3·46 per cent. as the average proportion of protein in ten reports of analyses of the common kinds of fungi, and 19·1 per cent. (Atwater) as the average proportion of protein in rump steak of beef, then the steak is five and a half times richer than the fungi in protein, which means that five and a half times as much of the fungus must be eaten to obtain the same amount of protein as from meat, or 22 ounces of fungus equals 4 ounces of lean meat. The increased bulk would not make any material difference to some people, but the fungi must be placed at their proper value. The vegetation of fungi is so prolific in some years that a single person can collect enough to provide protein for a large family. In Germany a single fungus, *Fistulina hepatica*, often provides sustenance for ten or twelve people. Fungi shrivel during cooking, owing to coagulation of the constituents of the cells ; they gain slightly in water, but lose some of their non-protein nitrogenous constituents. They are not easily digested, owing to the cellulose and the coagulated condition of the cellular contents. Artificial experiments confirm this observation. Pain

[1] Husemann, " New Remedies," 1877, 100.

and discomfort arising from their indigestibility have been often attributed to poisoning, in consequence of which various species have been wrongly assumed to possess toxic properties. As regards the actual absorption of protein, Mendel's table (given on p. 577) shows that from 25 to 60 per cent. of protein, according to the variety of fungus, escapes digestion and remains unabsorbed. Saltet[1] found that 33·7 per cent. of protein was unabsorbed, and Uffelmann[2] found that, of *dried* mushrooms, 29 per cent. of the protein remained unabsorbed. As regards the carbohydrate, very little of the cellulose is digested. There is some doubt as to the assimilation of mannose and trehalose ; but Jaffé[3] does not consider that mannite is easily assimilated. When we compare this with the almost complete assimilation of the sugars prevalent in most vegetables, and the almost complete absorption of the protein in eggs and the fibres of various kinds of meat, we are compelled to the conclusion that, while many fungi are tasty and appetizing, their nutritive value is not any higher than that of other vegetables of similar composition.

Poisonous Mushrooms.

The following poisonous fungi are usually regarded as the most common ; most of them are powerfully toxic. There is no assumption of completeness in the list.

Amanita muscaria.
,, pantherina.
,, citrina.
,, virosa.
,, verna.
Volvaria globocephala, var. Speciosa.
Lactarius torminosus.
,, rufus.
,, zonarius.
,, piperatus.
,, pyrogalus.
Russula emetica.
,, fœtens.
,, queletii.
Phallus impudicus.
Boletus luridus.
,, fellens.
,, satanus.
,, erythropus.
Entomola lividum.

Many fungi are eaten with impunity all over the world. But some are eaten safely in France which are regarded as poisonous in England ; others are eaten in Russia and Prussia which are never eaten in France. The principal poisonous mushrooms in Great Britain are the *Amanita muscaria* (or *Agaricus muscarius*), the fly agaric, and *Lactarius torminosus*, one of the milky agarics. But all kinds of fungi are poisonous to some people ; others have a doubtful character, being eaten with impunity by one individual, and not by others. Indeed, the smallest piece of any mushroom will occasion poisonous symptoms in a person of peculiar idiosyncrasy, although the freshness of the fungi and cooking them properly influence their toxicity.

[1] *Archi. f. Hygiene*, 1885, iii. 443.
[2] *Ibid.*, 1887, vi. 105.
[3] *Zeit. f. Physiol. Chem.*, 1883, vii. 297.

Amanita muscaria is one of the most poisonous, as it is one of the largest and most handsome, of the fungi. Care must be taken to distinguish it from *Agaricus rubescens*, which is edible, and considered by authorities a most delicious mushroom. It received its name from the fact that it becomes red when cut or bruised. *A. muscaria*, on the other hand, is normally red ; it has a bright crimson pileus, studded with pale yellow or whitish warts, and a stem and gills of ivory whiteness. The cap or pileus is closed at first, which gives the fungus the shape of a club, but it opens during development, and reaches a diameter of 5 or 6 inches. The stem has a bulbous enlargement at the base, which adds to the club-like appearance of the immature fungus. The base of the stem has numerous thick scales, which extend about the bulbous portion where a broad and well-defined ring surrounds it.

Amanita verna (*Agaricus vernus*) is a white species which is not very common ; it has a bulbous base enclosed in a volva, and is scarcely less fatal than *A. muscaria*. The pink-spored species of agarics should also be looked upon with suspicion.

Russula emetica has a bright red pileus with white gills, a clear waxy and tempting appearance ; but it is so virulent that Cooke says it would be better to eschew all fungi having red or crimson colours rather than run any risk of eating this fungus.

Boletus luridus and *B. satanus* turn blue when cut or broken. The under-surface of the pileus or the orifice of the tubes is of a vermilion or blood-red colour.

The **poisons** are several. **Muscarin** is the chief poison in *Agaricus muscarius*, *A. pantherina*, *Lactarius torminosus*, and *Boletus luridus*. **Amanitin** is the chief poison in *A. phalloides*, a toadstool. **Phallin** is a poison also present in *A. phalloides*.

Muscarin ($C_5H_{13}NO_2$) is an active principle which is largely dissipated by cooking the fungi. It is very poisonous ; 0·003 to 0·005 gramme is enough to cause serious symptoms in a human being. Atropin is considered an antidote. It produces violent irritant symptoms—vomiting, purging, and intense abdominal pains of a colicky character, the symptoms being frequently of a choleraic character, and extremely rapid in their onset. Its effect on the circulation is that of a powerful depressant ; the merest trace will instantaneously arrest the heart of a frog. Under its influence the human heart becomes very slow and feeble, and ceases to act when the dose is sufficient.

Amanitin ($C_5H_{13}NO_3$) is an alkaloid of slower action, but having narcotic effects. The symptoms of poisoning from fungi containing it alone do not come on for several hours after its consumption. The person is at first quite well ; then arise severe headache, giddiness, confusion of the mind, delirium, and convulsions, or paralysis of various parts of the body. Although slow in action, it is so powerful that a small portion of the fungus containing it may prove fatal.

Phallin causes hæmoglobinæmia. Kobert found that when

diluted to 1 in 250,000 it causes a dissolution of red corpuscles and a diffusion of hæmoglobin throughout the serum.

These alkaloids are closely related to cholin and neurin, which are poisons of animal origin. It is probable that they are derived in a similar manner. Cholin and neurin are products of the decomposition of lecithin arising as the result of hydrolysis by cellular or bacterial enzymes. The amanitin and muscarin probably arise in a similar manner in fungi. In constructive chemistry cholin is derived from a quarternary ammonium base, such as is common among extractives. It is hydroxy-ethyl-trimethyl-ammonium hydroxide. Now, in *tetra*-methyl-ammonium hydroxide four methyl radicals are joined to ammonium hydroxide: $4CH_3 + NOH = C_4H_{13}NO$. If one of these methyl radicals (CH_3) is replaced by the hydroxy-ethyl radical (C_2H_5O), we have cholin ($C_5H_{15}NO_2$). If a molecule of water is split off from cholin, it becomes neurin ($C_5H_{13}NO$). When cholin is exposed to the influence of oxidizing agents, such as the almost ubiquitous OH ions, it loses two atoms of H, and becomes muscarin ($C_5H_{13}NO_2$). Robbed of another two atoms of H, it becomes betaïn $(C_5H_{11}NO)_2$; or if the H becomes water of crystallization, it is $C_5H_{15}NO_3$.[1] These substances are therefore closely related.

However, every poisonous fungus appears to contain more than one of these alkaloids, in consequence of which the symptoms are mixed. *Amanita muscaria* contains both muscarin and amanitin. *Boletus luridus*, according to Böhm, contains a large quantity of cholin and cholesterin, with muscarin and luridic acid. The latter principle crystallizes in red needles, and yields succinic acid on distillation. *A. phalloides* yields, besides phallin, practically the same substances, but the acid crystallizes in yellow needles.

The effects of *Amanita* are of endless variety, but are singular: "At first it generally produces cheerfulness, afterwards giddiness and drunkenness, ending occasionally in entire loss of consciousness. *The natural inclinations of the individual are stimulated.* The dancer executes a *pas d'extravagance*, the musical indulges in a song, the chatterer divulges his secrets, the oratorical delivers himself of a philippic, and the mimic indulges in caricature. A straw lying in the road may appear a formidable object, to overcome which a leap is taken sufficient to clear a barrel of ale or the prostrate trunk of an oak."[2] It appears well known that the same fungus will cause symptoms of irritant poisoning in one person, narcotic poisoning in another, and a combination of the two in a third. These variations are due to the combination of poison or the predominance of one poison over another. The care taken in cooking also influences their effect, for muscarine is more or less dissipated by heat, and is partly removed by peeling the fungi, washing them in vinegar, and afterwards in boiling water. But innocent fungi

[1] W. Tibbles, "Theory of Ions: its Place in Biology and Therapeutics," p. 69.

[2] *Cf.* Cooke's "Fungi" (I.S.S.), p. 87.

become toxic when too old, or even when gathered young, if they are kept until they are not fresh ; various constituents degenerate, cholin is produced, and various leucomaines or ptomaines arise from the action of enzymes upon the proteins.

The recognition of poisonous fungi is a matter of importance, and general rules have been formulated by authorities. These rules have reference to the appearance, taste, and situation, or place of growth, of the fungi. Thus—

1. The *colour* is pale yellow, sulphur, bright red, blood red, or greenish, or they turn blue when cut ; they may be warty. Exceptions : *Boletus edulis* is yellow or yellowish-green on the under-surface of the pileus ; but the poisonous boleti are red, pink, or orange. *Lactarius deliciosus* is of an orange colour, and the chanterelle is orange-yellow.

2. The *taste* is bitter, burning, astringent, or otherwise disagreeable.

3. The *place* of growth is a wood, moist or marshy places, refuse, dunghills, stumps of trees, and caves or underground passages.

Cooks have various rough tests for mushrooms—*e.g.*, if a silver spoon or fork is used to turn the fungi while cooking, the metal will not be affected by edible fungi ; but the acrid juice of poisonous mushrooms will corrode or blacken it. When the under-surface of the mushrooms is sprinkled with salt before cooking them, it abstracts some of the juice ; if the salt is turned brown or black, the fungi are regarded as safe ; but if it turns yellow, green, or red, they are considered to be poisonous.

Many species of fungi which are perfectly innocent when grown on pasture-land become exceedingly toxic by growing upon dung or near to decomposing animal or vegetable substances and stagnant water. But if it is remembered that edible mushrooms grow mostly in closely-fed pastures, and seldom in woods, there will be less danger of getting the poisonous varieties. The following advice, given by eminent mycologists, is interesting :

Gibson,[1] in " Edible Toadstools and Mushrooms," says :

" 1. Avoid every mushroom having a *cup*, or suggestion of such, at the base ; the distinctly poisonous ones are thus excluded.

" 2. Avoid those having an unpleasant odour, a hot, bitter, or unpalatable flavour, and a tough consistency.

" 3. Avoid those infested by worms or in advanced age or decay."

Atkinson,[2] in " Studies of American Fungi," advises as follows :

" 1. Reject all fungi which have begun to *decay*, or are infested by larvæ.

" 2. Reject all in the *button stage*, since the characters are not yet shown which enable one to distinguish between genera and species. Buttons found in pasture-land at the surface of the soil, and not deep-seated, would very likely not belong to poisonous kinds.

" 3. Reject all fungi which have a *cup* or sac-like envelope near the base of the stem, or which have a scaly close-fitting layer at the base of the stem and loose warts on the pileus, especially if the gills are white. Exceptions : *Amanita cæsarea* has a sac-like envelope, or ' death-cup,' at the base of the stem, with yellow cap and gills ; *but it is edible*. *A. rubescens* also has remnants of a scaly envelope at the base of the stem, and the flesh when wounded becomes red ; *but it is edible*.

" 4. Reject all fungi having a *milky juice*, unless the juice is reddish. Exceptions : Several species having a copious *white* milk, sweet or mild to the taste, are edible.

[1] *Cf.* Wiley's " Foods and their Adulteration," pp. 433, 434. [2] *Ibid.*

" 5. Reject all *brittle fungi* with gills nearly all of equal length where the cap is thin, and especially when the cap is bright.

" 6. Reject all boleti in which the *flesh changes colour* when bruised or cut, those in which the tubes have reddish mouths, or which have a bitter taste. *Strobilomyces strobilaceus* changes colour when cut, but is edible.

" 7. Reject all fungi which have a cobwebby *veil* or a *ring* when young, and those with slimy caps or clay-coloured spores.

" 8. Proceed cautiously in all cases ; become familiar with a few species first rather than attempt to eat a large number of different kinds."

Lichenes.

Iceland Moss (*Cetraria islandica*) is by far the most important dietetic and commercial lichen. It is indigenous to Britain, and is found on lofty mountains in many places, but is especially prevalent in Arctic regions. It is used for foods in the Northern countries of Europe, being made into bread or boiled with the milk of the reindeer. It contains a bitter principle which is removed to some extent by washing it in water or weak alkalies. Jellies are made by boiling it in water, wine, or milk, with sugar ; a 5 per cent. decoction gelatinizes on cooling. The lichen is hard when dry, but softens when moistened.

Composition of Iceland Moss.[1]

Total nitrogen	·56 per cent.
Protein nitrogen	·32 ,,
Extractive nitrogen	·24 ,,
Fat (ether extract)	1·20 ,,
Carbohydrate soluble in water	43·30 ,,
,, soluble in alcohol	16·10 ,,
Fibre	5·30 ,,
Ash	2·20 ,,

Proteins.—According to the foregoing analysis, the amount is only 2 per cent. ($N \times 6{\cdot}25$). Church, however, found 8·7 per cent., which most authorities consider excessive. If all the nitrogen found by Brown were reckoned as protein, it would be 6·12 per cent., but a part is in the form of extractives, which, according to Church, amounts to 0·748 ($N \times 3{\cdot}12$). Even the small amount of protein present proves to be indigestible in artificial experiments.

Fats consist of ordinary fats and lichenin-stearic acid.

Carbohydrates are—**Lichenin,** or moss-starch ($C_6H_{10}O_5$), which is not deposited in granules as in the cereals and roots, but is universally distributed throughout the cells. It appears to be ordinary soluble starch, which gives characteristic reactions with iodine, is readily converted to dextrose and maltose by diastase,[2] and by dilute acids into dextrin and dextrose. It is obtainable as a brittle transparent mass, which dissolves in hot water and gelatinizes on cooling. **Iso-lichenin,** which is isomeric with the former, is soluble in water and coloured by iodine. Two gums have also been isolated. The amount of carbohydrate, according to Brown,

[1] Brown, *Amer. Jour. Physiol.*, 1898, i. 455.

[2] Thorpe's " Dictionary of Applied Chemistry," vol. iii., art. " Lichens."

is 59 or 60 per cent. ; but Church estimated it at 70 per cent., which is probably correct. Hutchison[1] says that lichenin is unaffected by digestion, and probably does not form glycogen. This, however, cannot be correct, for Iceland moss is one of the chief foodstuffs of the natives in the austere regions where it grows most abundantly, and also of the reindeer, upon which they depend for their supplies of milk, and to a considerable extent for their fresh meat. *Cladonia rangiferina*, or reindeer moss, is the chief food of these animals on the moors ; it is also used by the Laplanders in the same manner as *Cetraria islandica—i.e.*, boiled in water or milk, which gelatinizes on cooling. Iceland moss is chiefly used in England to form a demulcent beverage (decoction) and a jelly, which are valuable to invalids, especially in pharyngitis, laryngeal affections, and catarrhal conditions of the stomach. But it can also be made into bread or cake, and was recommended by Senator in this form as a food for diabetics under the impression the starch is indigestible.

Other lichens are also used for food, especially those of the genus *Gyrophora*, which the Canadians term *tripe de roche*. Lichens of this genus were consumed by Franklin and his party in their celebrated Arctic explorations.

Algæ.

Various natural orders of algœ supply food for men and animals.[2]

N.O. FUCACEÆ : *Sargassum vulgare*, the Sargasso or Gulf weed ; *Fucus vesiculosus*, or bladder-wrack, is much used by Icelanders and Greenlanders, but chiefly for cattle fodder in winter. It yields a considerable quantity of mannite, a gelatinous carbohydrate, and fat, with about 0·01 per cent. of iodine. It forms the basis of numerous antifat remedies.

N.O. LAMINARIACEÆ : *Alaria esculenta*, edible alaria, or " murlins," abounds on the Atlantic coasts of Britain and Ireland and other Northern countries. It is consumed in some parts of Scotland, Ireland, the Faroe Isles, Iceland, etc., the midrib only being eaten, after stripping off the membranous portion. It is rather sweet to the taste, but more or less insipid and indigestible. *Laminaria digitata*, or tangle, which is common all round the coasts of the Northern Hemisphere, on rocks below the reach of the tide, is eaten ; and also *Laminaria saccharata*, which contains 12 per cent. of mannite.

N.O. RHODYMENIACEÆ : **Dulse or Dillisk** (*Rhodymenia palmata vel Ulva palmata*) has a coriaceous or membranous leaf, purple-coloured, wedge-shaped, and irregularly cleft. Its variations in form have given rise to many synonyms. It grows on rocks within high and low tide marks. In Scotland and Ireland this seaweed is much used as a food by the poor or as a relish to other food. It is eaten raw, unwashed, the flavour being brought out by long

[1] " Food and Dietetics," p. 259.

[2] Murray's " Study of Seaweeds " and Harvey's " Synopsis " have been referred to.

chewing. "On the west coast of Ireland it forms the only addition, in many poor families, to the potatoes on which they subsist. The variety which grows on mussel-shells, between tide-marks, is preferred, as being less tough than other forms, the minute shellfish which adhere to its fronds being nowise unpleasing to the consumers of this simple luxury, who enjoy the additional *goût* imparted by the craunched mussels."[1] It is also dried and stored for use. In the Mediterranean regions it is made into ragouts and other cooked dishes. It forms the chief ingredient in St. Patrick's soup, which was one of the special soups recommended by M. Soyer to the Irish peasantry. *Iridæa edulis*, *Sacrophyllus edulis*, or *Fucus edulis* was long confounded with *Rhodymenia palmata*, and in the West of England is still called "dulse." Withering was the first to apply the term *edulis* to this. Harvey says it may be food for sea-worms, but is scarcely a human food, *R. palmata* being the truly edible fucus or dulse.

Agar-Agar, called Bengal isinglass, Japanese or Chinese gelatine, is obtained from various Rhodymeniaceæ—*e.g.*, *Sphaerococcus lichenoides* or *compressus*, *S. spinosa*, *S. tenax*, *S. mamillosus* (*i.e.*, *Gigartina mamillosa*), *Gelidium corneum*, *G. cartilagineum*, *Euchemia spinosa*, etc. Agar-agar occurs as thin transparent strips of the thickness of a straw, which dissolve almost entirely in hot water, forming a gelatinous, tasteless, and odourless jelly. The dried seaweed called "Ceylon moss" (*Gracilaria lichenoides*) is also imported from Singapore.

N.O. Nostocaceæ: *Nostoc* is a genus of green-spored gelatinous algæ so closely resembling the genus *Collema* that the species have been regarded as merely barren lichens. Many species are edible, *Nostoc edule* of China being a favourite ingredient of soup. The species are common, especially in sandy soils and immediately after rain in summer; they are commonly called *witches' butter*, *fallen stars*, etc.

N.O. Gigartinaceæ: **Irish Moss** (*Chondrus crispus*,) carrageen, ling-bye, or the curled chondrus. It is very abundant on rocky shores, extending from three-quarter tide to below low-water mark. There are ten or more varieties. In estuaries, where fresh-water streams mix with the tide, the chondrus attains a large size, and is frequently much fringed. It is used in the place of isinglass or gelatine to prepare jellies and blancmange, the frond being boiled down to a clear, tasteless gelatine. *Gigartina mamillosa*, a common seaweed on all coasts, has often been confounded with chondrus.

N.O. Ulvaceæ: Laver, *Porphyra lanciniata* and *P. vulgaris* both are called "laver," and grow within range of the tide. The lanciniated porphyra has the fronds deeply and irregularly cleft. It varies, being thicker or thinner, bright purple or olive green, having a flat-lobed frond or at other times a cup-shaped frond fixed by a central point, according to locality. The common porphyra is much brighter than the former, but its brilliancy varies,

[1] Professor Harvey, "Synopsis of British Seaweeds," p. 108.

and the frond is perfectly simple instead of being irregularly cloven. Both species are eaten, being boiled for many hours until the fronds are reduced to a somewhat slimy pulp of a dark brown colour, which is known as "laver" in England and Wales, "slaak" in Scotland, "slouk" or "sloukawn" in Ireland. It is then made into a cake by covering with oatmeal and frying it in butter. It is also eaten with pepper and lemon-juice or vinegar, and has an agreeable flavour. As a sauce it is not sufficiently appreciated. In Iceland it is eaten with fish, and a fermented liquor is made from it. Green laver is *Ulva latissima*.

COMPOSITION OF ALGÆ—PERCENTAGES.[1]

	Water.	Dry Matter.	Nitrogen in Dry Matter.	Protein in Dry Matter.
Alaria esculenta	17·91	80·09	2·424	15·15
Chondrus crispus, bleached ..	18·86	81·15	1·510	9·43
,, ,, unbleached ..	20·22	79·29	2·326	14·53
Gigartina mamillosa	21·55	78·45	2·198	13·73
Laminaria digitata	21·38	78·62	1·588	9·92
Porphyra lanciniata	17·41	82·59	4·650	29·06
Rhodymenia palmata	16·56	83·44	3·465	21·65
Sacrophyllus edulis	19·61	80·39	3·088	19·30

Chondrus Crispus, Carrageen, or Irish Moss.—It appears from the foregoing analyses that *all the nitrogen* is reckoned as protein—viz., that Irish moss has 9·43 per cent; but this is incorrect, as no allowance is made for extractives. Hutchison[2] finds it amounts only to 6·3 per cent; other authorities give 7 per cent. If therefore we assume the figures to be protein 6·5 per cent. and extractives 1·59 per cent., it will probably be correct. The composition of dried moss, according to Church is—Water 18·8, nitrogenous matter 9·4, mucilaginous substance, etc., 55·4, cellulose 2·2, mineral matters 14·2, per cent. The chief materials are those included in mucilaginous. The principal constituent is **Carrageenin,** a carbohydrate apparently identical with lichenin or moss starch, which varies in amount from 55 to 65 per cent. It swells up and forms a gelatinous mass, and yields sugar on hydrolysis. According to Brown, this sugar is dextrose, but Hutchison found it did not ferment with yeast, and gave a *pentose* reaction with phlorglucin. But the same moss from Ireland yielded in Hutchison's hands a considerable amount of reducing-sugar which did not give the phlorglucin reaction. It also contains a gum which is soluble in water, insoluble in ammonia-sulphate of copper solution, and yields *mucic acid* when oxidized by nitric acid.

Although Irish moss is considered nutritive by many authorities, and is largely consumed in some countries, the mucilaginous sub-

[1] Thorpe's "Dictionary of Applied Chemistry," vol. i., p. 47.
[2] "Food and Dietetics," p. 258.

stance is not affected by saliva or pancreatic juice in artificial experiments. It is therefore not easily digested, and its nutritive value, like that of Iceland moss, is open to question. It is used for making soup and jelly, and with it a kind of bread has been made for diabetics. Irish moss jelly is made for invalids. The decoction is a bland and soothing beverage which is very useful in irritable conditions of the throat and alimentary canal.

Agar-Agar consists chiefly of **gelose,** or pararabin ($C_6H_{10}O_5$), a carbohydrate closely related to galactin, and converted into that substance by dilute sulphuric acid.[1] Gelose is insoluble in cold water, alcohol, dilute acids, and alkalies, but is soluble in warm water, 1 in 500 forming a jelly on cooling. It also occurs in sugar-beet and carrots, and is similar to the galactin in peas, beans, etc. To make a jelly for invalids, 1 part of agar-agar is dissolved in 200 parts of boiling water (1 drachm in 25 ounces). Its use in making jam and commercial jellies is referred to in the section thereon.

The **Edible Birds' Nest** of China are formed, by swallows, of gelatinous seaweeds (*Gelidium*), which are partly digested by the bird, and afterwards disgorged to be made into a nest. They are found in caves on the seashore in the Malayan Archipelago, and are much prized by the Chinese as an article of food and for making soup.

[1] Bauer, *Jour. f. Prakt. Chemie*, xxx. 367.

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CHAPTER XXIII

FRUIT

The natural distribution of fruit over the surface of the earth is more or less an index of man's necessity. Fruit is a far more abundant product in tropical and subtropical than in temperate regions, while the colder parts of the earth produce very little fruit. The fact that fruit and vegetables abound in the hot and are deficient in the cold regions of the earth teaches that fruit and non-stimulating vegetables are better adapted for the denizens of the regions where they grow, while their absence from the colder regions indicates that the more stimulating animal foods are better for the inhabitants. Even in temperate regions, the appearance of fruits in the hotter months of the year, and their absence in the colder period, is a teleological argument in favour of the consumption of more fruit and less animal food in summer, and the reverse in winter.

The number of kinds of fruit natural to temperate regions is very small compared with those of the tropics, many of the fruits cultivated in these regions having been imported from warmer countries. Some of the fruits native to the temperate zone still grow wild; but the cultivated varieties of apples, pears, plums, strawberries, raspberries, and other fruits, have undergone great modification in flavour, size, and appearance, by natural or artificial selection. The cultivated apples are far different from the original crab apple, and the delicious dessert plums show a great contrast when compared with the parent sloe.

But even if the number of fruits grown in temperate climes is small, our modern methods of transportation and storage have placed the superabundance of the tropics within our reach. Many tropical fruits, which a few years ago were scarcely heard of by Europeans, are now seen in the markets and shops of all large towns. Bananas are now as common as oranges and lemons, pineapples are fairly abundant, pomelos or grape-fruits are becoming common, and we may soon expect to have avocadoes, mangoes, sapodillas, mangosteens, persimmons, etc. As the improved methods of transportation have increased the number of kinds of fruit, so have they given rise to an improvement in the quality of foreign fruit; they have placed the fruit of the whole world within our reach, and it can now be obtained from those places where the finest qualities are produced.

Apples, pears, plums, bananas, tomatoes, oranges, lemons, pine-apples, and other fresh fruit, are brought to England from many parts of the world. Some of these fruits, formerly seen in the shops only for a season, are now never absent.

The following is a list of the fruits most cultivated ; it is taken chiefly from L. H. Bailey's " Principles of Fruit-Growing," third edition. Completeness is not claimed for it, but it is an inventory of the staple fruits of temperate and subtropical climates, and of the less-known species whose cultivation has been tried in these regions, and either give promise of successful cultivation or have been made more or less prominent subjects of discussion.

CLASS I.—TREE FRUITS.

1. Pomaceous Fruits.

Apple, *Pyrus malus.*
Crab apple, *P. baccata.*
Prairie crab, *P. joensis.*
Atlantic crab, *P. coronaria.*
Pear, *P. communis.*
Sand pear, *P. sinensis.*
Quince, *P. cydonia.*
Japan quince, *P. japonica.*
Chinese quince, *P. cathayensis.*
Medlar, *Mespilus germanica.*
Loquat, *Eriobotyra japonica.*

2. Drupaceous or Stone Fruits.

Plum, *Prunus domestica.*
Myrobalan plum, *P. cerasifera.*
Japan plum, *P. triflora.*
American plum, *P. americana.*
Wild-goose plum, *P. hortulana.*
Chickasaw plum, *P. angustifolia.*
Sand plum, *P. watsoni.*
Beach plum, *P. maritima.*
Pacific plum, *P. subcordata.*
Apricot plum, *P. simonii.*
Sweet cherry, *P. avium.*
Sour cherry, *P. cerasus.*
Sand cherry, *P. besseyi.*
Peach and nectarine, *P. persica.*
Apricot, *P. armeniaca.*
Japan apricot, *P. mume.*
Purple apricot, *P. dasycarpa.*

3. Citrous Fruits.

Orange, *Citrus aurantium.*
Tangerine orange, *C. nobilis.*
Citron, *C. medica.*
Lemon, *C. medica,* var. *Limon.*
Lime, *C. medica,* var. *Limetta.*
Sour lime (U.S.), *C. medica,* var. *Acris.*
Kumquat, *C. japonica.*
Grape-fruit or shaddock, *C. decumana.*
Trifoliate orange, *C.* (*Ægle*) *trifoliata.*
Glycosmis, *Glycosmis aurantiaca.*
Limeberry, *Triphrasia trifoliata.*
White sapota, *Casimiroa edulis.*

4. Moraceous Fruits.

Fig, *Ficus carica.*
White and Russian mulberry, *Morus alba.*
Black mulberry, *M. nigra.*
Red mulberry, *M. rubra.*
Downing mulberry, *M. multicaulis.*
Japan mulberry, *M. japonica.*
Bread-fruit, *Artocarpus incisa.*

5. Anonaceous Fruits.

Sour-sop, *Anona muricata.*
Sugar apple, *A. squamosa.*
Cherimoya, *A. cherimolia.*
Pond-apple, *A. laurifolia ;* and other anonas.
Northern papaw, *Asimina triloba.*

6. Myrtaceous Fruits.

Guava, *Psidium guajava*, and others.
Rose apple, *Eugenia jambos*.
Surinam cherry, *E. uniflora*; and other eugenias.

7. Sapotaceous Fruits.

Sapodilla, *Achras sapota*.
Marmalade-tree, *Lucuma mammosa*.
Star apple, *Chrysophyllum cainito*; and others.

8. Anacardiaceous Fruits.

Mango, *Mangifera indica*.
Jew plum, *Spondias dulcis*.

9. Ebenaceous Fruits.

Persimmon, *Diospyrus virginiana*.
Japan persimmon, *D. kaki*.

10. Leguminous Fruits.

St. John's bread or carob, *Ceratonia siliqua*.
Tamarind, *Tamarindus indica*.

11. Nut Fruits.

Walnut, *Juglans regia*.
Japan walnut, *J. sieboldiana*.
Black walnut, *J. nigra*.
Butternut, *J. cinerea*.
Pecan, *Hickoria pecan*.
Hickory-nuts, *H. orata* and *H. laciniosa*.
European chestnut, *Castanea vesca*.
American chestnut, *C. americana*.
Japan chestnut, *C. japonica*.
Chinquapin, *C. pumili*.
Filbert, *Corylus avellana*.
Litchi, *Nephelium litchi*.
Ginkgo, *Ginkgo biloba*.
Almond, *Prunus amygdalus*.
Russian almond, *P. nana*.
Tropical almond, *Terminalia catappa*.
Cashew, *Anacardium occidentale*.
Pistachio, *Pistacio vera*.

12. Palmaceous Fruits.

Date, *Phœnix dactylifera*.
Cocoanut, *Cocos nucifera*.

13. Miscellaneous Tree Fruits.

Olive, *Olea europæa*.
Pomegranate, *Punica granatum*.
Papaw, *Carica papaya*.
Hovenia, *Hovenia dulcis*.
Myrica, *Myrica nagi* vel *rubra*.
Sea-grape, *Cocoloba uvifera*.
Spanish lime, *Melicocca bijuga*.
Otaheite gooseberry, *Phyllanthus disticha*.
Alligator pear, *Persea gratissima*.
Strawberry-tree, *Arbutus unedo*.
Mammee apple, *Mammea americana*.

CLASS II.—VINE FRUITS.

1. Ampelidaceous Fruits.

Wine grape, *Vitis vinifera*.
Fox grape, *V. labrusca*.
Summer grape, *V. æstivilis*.
Post-oak grape, *V. æstivilis*, var. *Linsecomii*.
Muscadine and Scuppernong grapes, *V. rotundifolia*.
Sand grape, *V. rupestris*.
River-bank grape, *V. vulpina*; and other species of grape.

2. Passifloreous Fruits.

Granadilla, *Passiflora edulis*; and others.

CLASS III.—SMALL AND BUSH FRUITS.

1. Bush Fruits.

Raspberry, *Rubus idæus.*
Black-cap raspberry, *R. occidentalis.*
Red raspberry, *R. strigosus.*
Wineberry, *R. phœnicolasius.*
Blackberry, *R. villosus.*
Northern dewberry, *R. canadensis.*
Southern dewberry, *R. trivialis.*
Pacific dewberry, *R. vitifolius.*
Currant, *Ribes rubrum.*
Black currant, *R. nigrum.*
Buffalo currant, *R. aureum.*
Gooseberry, *R. grossularia.*
American gooseberry, *R. oxyacanthoides.*
June berry, *Amelanchier oblongifolia.*
Buffalo berry, *Shepherdia argentea.*
Goumi, *Elæagnus multiflora.*
Caraunda, *Carissa carundas.*

2. Strawberries.

Garden strawberry, *Fragaria chilœnsis.*
Hautbois strawberry, *F. moschata.*
Alpine strawberry, *F. vesca.*
Virginian strawberry, *F. virginiana.*

3. Cranberries.

Common cranberry, *Vaccinium macrocarpon;* and others.

CLASS IV.—HERB-LIKE FRUITS.

Banana, *Musa sapientum.*
Plantain, *M. paradisaica.*
Pineapple, *Ananas sativus.*
Prickly pear, *Opuntia tuna,* etc.
Indian fig, *O. ficus-indica.*
Barbadoes gooseberry, *Pereskia aculeata.*
Cyphomandra, *Cyphomandra betacea.*
Ceriman, *Monstera deliciosa.*

The Place of Fruit in the Diet.

Fruits are wholesome and a palatable addition to our food. As sources of protein they are very inferior. Most of them contain only 0·5 per cent., and very few more than 1·0 per cent.; even dried fruits, such as dates, figs, and raisins, contain no more than 2 to 4 per cent. They are therefore a very poor source of nitrogenous matter. The same remarks apply to fat. The carbohydrates, however, are fairly abundant, and range from 2 per cent. in blackberries to 21 per cent. in bananas. The carbohydrate consists chiefly of sugar, which is a mixture of dextrose and lævulose, and sometimes sucrose. This is shown in the following table by Buignet, quoted by König :

The Sugar in Fruits—Percentages.

	Disaccharides or Sucroses.	Monosaccharides or Reducing-Sugars.
Apples	5·28	8·72
Apricots	6·04	2·74
Cherries, English	·00	10·00
Figs, fresh	·00	11·55
Grapes, hothouse	·00	17·26
Oranges	4·22	4·36
Pears	·36	8·42
Pineapples	11·63	1·99
Raspberries	2·01	5·22
Strawberries	6·33	4·98

The balance of carbohydrates consists of a little starch, dextrin, gum, and pectose bodies. It has been estimated that fruit supplies 3·7 per cent. of the total carbohydrate consumed in the average diet of the Americans. But as a source of protein and energy it is more expensive than cereals, as a source of protein or nitrogen alone being five to ten times more costly than meat. The consideration of the correctness of a " fruitarian " diet is, however, deferred to a later chapter.

As regards *digestibility*, fruit occupies the same position as vegetables ; that is to say, 80 per cent. of the proteins, 90 per cent. of the fat, and 95 per cent. of the carbohydrates, are digested. Fruit must be well masticated, when eaten raw, in order to bring it to a fine state of subdivision and enable it to pass through the pylorus. Even with this precaution, ripe apples remain in the stomach from three and a half to five and a half hours, and unripe ones a longer time. The organic acids in unripe fruit are very apt to upset the digestive organs, and especially to cause spasmodic contractions, and, by irritating the mucous membrane, to set up diarrhœa.

There is an apparent increase in amount of acidity after cooking fruit, but this is due to the inversion of cane-sugar to dextrose and lævulose, and not to increase of acids. As a matter of fact, Sutherst found that boiled fruit contained less acid than raw fruit, owing to the volatility of some of the acids. The difference in the sugars in raw and boiled fruit respectively is well exemplified in gooseberries, all the cane-sugar being inverted by hydroylsis.

	Cane-sugar.	Invert-sugar.[1]
Raw berries	1·16 per cent.	5·84 per cent.
Boiled berries	·00 ,,	6·91 ,,

When raw fruit is eaten, the skins of gooseberries, plums, etc., are rejected. Now, the skins of such fruit contain more acid than the pulp, but it is not tasted except when they are masticated. When the fruit is cooked the skins are not rejected ; but the acid is extracted from them, and becomes evenly distributed throughout the semiliquid mass, and inverts not only the native cane-sugar, but most of that added by the cook. The difference in the acidity of gooseberries is as follows[2] : In the skins 2·66 per cent., in the pulp 1·80 per cent., expressed as tartaric acid.

We must not, however, calculate the value of fruit merely by the amount of organized nitrogen and carbon in its composition. Fruit is of great value for hygienic purposes, as well as on the ground of palatability and æsthetic considerations. Supplies of protein, carbohydrate, and energy, can be obtained in a far more handy form than in fruit—*e.g.*, meat, sugar, starch, and fat. But it has been shown that a diet consisting of the latter articles does not satisfy the demands of the human organism. People who live upon such concentrated foods are not so healthy or strong as those who take fruit and vegetables. It has been suggested that this is because of the absence of some vital property from sugar, starch,

[1] *Chemical News*, 1905, ii. 163. [2] *Ibid.*

fat, and other such foods, which is present in the fruit and vegetables. At any rate, it has been shown by experiment that the presence of salts in the food is absolutely essential for the well-being of man. They are necessary to keep the globulins of the blood and tissues in solution. The nitrogenous products of metabolism cannot be eliminated without them.[1] Dogs and pigeons fed by Forster upon food consisting of proteins free from salts, together with fat, starch, and sugar, died in less time than if they had been deprived of all food.[2] People who live largely upon a diet which does not include fresh vegetables and fruit are liable to scurvy and other diseases. Indeed, the value and importance of fresh fruits, especially to the inhabitants of large towns, cannot be too much insisted upon. They are equal in importance to fresh green vegetables. This is chiefly due to the salts contained in them. These consist largely of organic acids—malic, citric, acetic, tartaric, etc.—alone or in combination with potassium, sodium, calcium, and other bases, mingled with smaller quantities of phosphates, carbonates, sulphates, and chlorides. The organic acids arouse the appetite and aid digestion by provoking a flow of saliva, and indirectly of gastric juice; they are sialogogues and stimulants. When the fruit reaches the intestines, the acids increase the acidity of the chyme, and stimulate the secretions of the liver, pancreas, and intestinal glands. They also stimulate the muscular activity of the intestines. Their influence upon the blood is marked; they render it less alkaline, *but never acid*, by combining with a portion of the alkaline salts of the serum. The salts of the organic acids, in fact, become transformed to alkaline carbonates. The phosphoric acid increases the phosphates in the red blood-cells, and the potassium salts promote the formation of white blood-cells; hence fruits are antiscorbutic, and of value in anæmia, general debility, and convalescence from acute illness; and this is particularly true of apples, which contain a fair proportion of iron. Malic acid exists in considerable quantities in apples, pears, red and white currants, blackberries, raspberries, pineapples, quinces, and Morella cherries; malates in rhubarb, sweet cherries, etc.; oxalates in tomatoes, plums, gooseberries, strawberries, and raspberries; citric acid and citrates in limes, lemons, oranges, quinces, tomatoes, strawberries, raspberries, and gooseberries; and tartaric and racemic acids are found especially in grapes and raisins. As the final stage of the digestion of fruits includes the conversion of the organic acids and salts into alkaline salts (chiefly carbonates), their consumption is useful in scurvy, skin diseases, rheumatism, gout, and allied diseases. They increase the secretion of the urine and its alkalinity; indeed, they are a valuable means of stimulating the skin and kidneys, of rendering the urine alkaline, and directly aiding in the excretion of inorganic salts and nitrogenous materials. By their bulk, and especially by their residue of cellulose and their acid salts, they stimulate intestinal activity and overcome constipation; but their excessive consumption may lead to diarrhœa.

[1] Bunge, "Physiological and Pathological Chemistry," p. 83.
[2] *Zeit. f. Biol.*, 1873, ix. 297.

The fruits upon which reliance is placed as a chief source of nutriment and energy are figs, dates, raisins, and bananas. These fruits, either fresh or dried, are the staple food of large masses of people in the regions in which they are grown. Dried dates are to the inhabitants of Northern Africa as important as rice is to the Oriental races. There is, however, a vast difference in the digestibility of the carbohydrates derived from rice and that from dates. The former has to be converted to sugar; the latter is a sugar ready for assimilation. A meal consisting of ½ pound of dates (carbohydrate) and ½ pint of milk (protein and fat) is ample. It contains 20·5 grammes of protein and 175 grammes of carbohydrate, and yields about 900 calories. The same amount of figs and milk has nearly an equal value. Bananas contain a large amount of carbohydrate, including about 20 per cent. of sugars; the protein is very small, but can be made up by drinking milk or eating nuts.

The Composition of Fruits.

The composition of fruits of the same family, and even from the same garden or tree, varies. These variations are considered in the paragraphs relating to special fruits in the following pages. The following table, taken from Langworthy's "Fruit as Food,"[1] shows the average percentage of protein, fat, carbohydrate, and inorganic matters, according to him. Where it is known, the carbohydrate is given separately from the crude fibre. As starch and sugar of various kinds have the same nutritive value, this table shows the value of fruits fairly well. A more extended account of the analysis of fruits is to be found in the following pages and in König's "Chemie der menschlichen Nahrungs- und Genusmittel, vol. i., pp. 820-898. The mode of their analysis is the same as that of other vegetable foodstuffs.

Division A: Pomes.

Fruits are conveniently divided into pomes, drupes, berries, etc. A pome is a form of indehiscent fruit, in which the epicarp and mesocarp, together with the calyces, form a fleshy mass; the endocarp forms scaly-walled cells which enclose the seeds. They mostly belong to the natural order Rosaceæ, and the chief examples are as follows: Pears, apples, crabs, fruit of service-tree, medlar, quince, loquat, etc.

Apples.

Apples are the fruit or pomes of *Pyrus malus* and many varieties—genus Pomeæ, N.O. Rosaceæ. The apple is essentially a fruit of the temperate regions of the earth, over which it is universally cultivated, as far north as 60 degrees north latitude. All the cultivated varieties have been derived from the crab or wild apple, and its cultivation is prehistoric. This tree is indigenous to most countries of Europe, and in almost all countries where the oak thrives. The facility of multiplying varieties by grafting a cutting on a crab stock has led to an amazing number of varieties,

[1] Farmers' Bulletin 293, U.S. Department of Agriculture.

THE AVERAGE COMPOSITION OF FRUITS—PERCENTAGES.

Kind of Fruit.	Refuse.	Edible Portion.						
		Water.	Protein.	Fat or Ether Extract.	Carbohydrate.		Ash.	Fuel Value: Calories per Pound.
					Nitrogen-free Extract.	Crude Fibre.		
FRESH FRUITS: Apples	25·0	84·6	·4	·5	13·0	1·2	·3	290
Apricots	6·0	85·0	1·1	—	13·4		·5	270
Avocado	29·0	81·1	1·0	10·2	6·8		·9	512
Bananas	35·0	75·3	1·3	·6	21·0	1·0	·8	460
Blackberries	—	86·3	1·3	1·0	8·4	2·5	·5	270
Cactus fruit	—	79·2	1·4	1·3	11·7	3·7	2·7	375
Cherries	5·0	80·9	1·0	·8	16·5	·2	·6	365
Cranberries	—	88·9	·4	·6	8·4	1·5	·2	215
Currants	—	85·0	1·5	—	12·8		·7	265
,, black[1]	—	79·0	·5	·3	13·1	6·1	1·0	370
Figs	—	79·1	1·5	—	18·8		·6	380
Gooseberries[1]	—	85·6	1·0	—	13·1		·3	255
Grapes	25·0	77·4	1·3	1·6	14·9	4·3	·5	450
Guava[1]	—	82·9	1·3	·7	8·0	6·6	·5	315
Huckleberries	—	81·9	·6	·6	16·6		·3	345
Lemons	30·0	89·3	1·0	·7	7·4	1·1	·5	205
Loquat	—	77·9	·2	—	20·2	·6	1·1	395
Mango[1]	40·0	87·4	·6	·4	9·9	1·2	·5	220
Medlar	—	74·6	·5	·3	16·5	7·5	·6	455
Mulberry[1]	—	84·7	·4	—	14·3		·6	280
Musk melons	50·0	89·5	·6	—	7·2	2·1	·6	185
Nectarines	6·6	82·9	·6	—	15·9		·6	305
Olives	17·9	67·0	2·5	17·1	5·7	3·3	4·4	407
Oranges	27·0	86·9	·8	·2	11·6		·5	240

Peaches	18·0	89·4	·7	·1	5·8	3·6	·4	190
Pears	10·0	80·9	1·0	·5	15·7	1·5	·4	163
Persimmons	25·0	66·1	·8	·7	29·7	1·8	·9	630
,, Japanese	24·0	80·2	1·4	·6	15·1	2·1	·6	174
Pineapples	40·0	89·3	·4	·3	9·3	·4	·3	200
Plums	5·0	78·4	1·0	—	20·1		·5	395
Pomegranates	30·0	76·8	1·5	1·6	16·8	2·7	·6	460
Prunes	5·8	79·6	·9	—	18·9		·6	255
Raspberries, red	—	85·8	1·0	—	9·7	2·9	·6	255
,, black	—	84·1	1·7	1·0	12·6		·6	310
Red bilberry	—	89·6	·1	·3	3·8	6·0	·2	190
Rhubarb stalks (pie plant)	40·0	94·4	·6	·7	2·5	1·1	·7	105
Roselle calyx	—	86·5	2·1	·3	10·3		·8	235
,, pod	—	84·0	1·7	1·0	12·2		1·1	290
Sapodilla[1]	40·0	77·9	·5	1·6	16·6	2·8	·6	425
Scarlet haws	20·0	75·8	2·0	·7	18·6	2·1	·8	212
Strawberries	5·0	90·4	1·0	·6	6·0	1·4	·6	180
Surinam cherry	—	85·4	·4	—	13·9		·7	260
Water melons	59·4	92·4	·4	·2	6·7		·3	140
Whortleberries	—	82·4	·7	3·0	10·3	3·2	·4	390
DRIED FRUITS: Apples	—	26·1	1·6	2·2	62·0	6·1	2·0	1,350
Apricots	—	29·4	4·7	1·0	62·5		2·4	1,290
Bananas[1]	—	29·2	5·3	2·3	55·8	2·1	5·3	1,240
Citrons	—	19·0	·5	1·5	78·1		·9	1,525
Dates	10·0	15·4	2·1	2·8	74·6	3·8	1·3	1,615
Figs	—	18·8	4·3	·3	68·0	6·2	2·4	1,475
Pears	—	16·5	2·8	5·4	66·0	6·9	2·4	1,635
Prunes	15·0	22·3	2·1	—	71·2	2·1	2·3	1,400
Raisins	10·0	14·6	2·6	3·3	73·6	2·5	3·4	1,605
Raspberries	—	8·1	7·3	1·8	80·2		2·6	1,705
St. John's bread, Locusts	—	17·3	5·7	1·1	67·0	6·4	2·5	1,480
Zante currants (English currants)	—	17·2	2·4	1·7	71·2	3·0	4·5	1,495

[1] European analysis.

THE AVERAGE COMPOSITION OF FRUITS—PERCENTAGES—*Continued.*

Kind of Fruit.	Refuse.	Edible Portion.						
		Water.	Protein.	Fat or Ether Extract.	Carbohydrate.		Ash.	Fuel Value : Calories per Pound.
					Nitrogen-free Extract.	Crude Fibre.		
PRESERVED AND COOKED FRUITS, ETC. :								
Apple sauce	—	61·1	·2	·8	37·2		·7	730
Apricot sauce	—	45·2	1·9	1·3	48·8		2·8	1,000
Apricots, canned	—	81·4	·9	—	17·3		·4	340
Blueberries, canned	—	85·6	·6	·6	12·8		·4	275
Cherry jelly	—	21·0	1·1	—	77·2		·7	1,455
Figs, stewed	—	56·5	1·2	·3	40·9		1·1	785
Olives, green, pickled	27·0	58·0	1·1	27·6	11·6		1·7	1,400
,, ripe ,, ...	19·0	64·7	1·7	25·9	4·3		3·4	1,205
Orange marmalade	—	14·7	·6	·1	84·5		·3	1,585
Peaches, canned	—	88·1	·7	·1	10·8		·3	220
Pears, canned	—	81·1	·3	·3	18·0		·3	355
Pineapple, canned	—	61·8	·4	·7	36·4		·7	715
Prunes, stewed	—	76·6	·5	·1	22·3		·5	430
Strawberries, stewed	—	74·8	·7	—	24·0		·5	460
Angelica stalks, candied	—	10·4	·1	·1	87·3	1·5	·6	1,550
Apricots, candied	—	14·4	·7	·1	83·0	1·1	·7	1,445
Citron, candied	—	18·2	·1	·1	77·6	1·0	3·0	1,380
Ginger-root, candied	—	12·3	·3	·2	86·1	·7	·4	1,520

of which more than 1,500 have been named. Apples were introduced to Britain by the Romans, who highly prized the fruit as an edible of great excellence. The varieties of this fruit, as of many other cultivated vegetables, have a somewhat short duration, and are prone to revert to ancestral forms. Trees grown from the seeds nearly always produce crabs, which are exceedingly sour, but ripen and become sweet and well flavoured if buried in straw in the earth for a few months. Dessert apples are characterized by a firm juicy pulp, a delicious flavour, good colouring, and regular form. A coreless and seedless variety has been produced in Colorado. Cooking apples are characterized by their large size, good keeping qualities, and the property of forming by the aid of heat a pulpy mass of equal consistency. Cider apples must have considerable astringency, firmness, and a rich juice. Among the varieties most cultivated we may name the following home-grown and imported fruit :

1. **British Fruit.**—(*a*) *Dessert Apples* : Blenheim Orange, Cox's Orange Pippin, Golden Pippin, Kempster Pippin, King Pippin, Ribstone Pippin, Russets, Pearmain, Quarrendon, Worcester. (*b*) *Cookers :* Bramley's Seedlings, Codlings, Colvilles, Greenings, Pearmains, Rennets, Potts' Seedling, etc. (*c*) *Cider Apples :* Kingston Black, Fox Whelp, Mandy, Sweet Alfred, Tom Put, Skyrme, Wilding, Yellow Styre, Normandy Beech, Normandy Cider, Dymock Red, White Musk ; a mixture of these is, however, said to produce the finest beverage.

2. **American Fruit.**—Baldwin, Bellflower, Ben Davis, Chenango (Strawberry), Codlin, Fallawater, Gravenstein, Hubbardston's None-Such, Greening, King Pippin, Northern Spy, Newtown Pippin, Norton Melon, Oldenburg, Primate, Rall's Janet, Rambo, Red Astrachan, Roxbury Russet, Smith Cider, Spitzburgen, Talman Sweet, Willow-twig, Winesap.

3. **Australian.**—Blenheim Orange, Cox's Orange, Emperor Alexander, Ribstone Pippin, Sturmer, etc.

A fuller analysis of the fruit by Bertram,[1] and its juice,[2] shows them to have the following composition :

Apples.			Apple-Juice.	
Water		32·12	Water	800·00
Albuminoid		1·06	Sugar capable of fermentation	173·00
Non-nitrogenous extract :			Tannic acid	5·00
Ash	1·96		Pectin and gum	12·00
Free acids	2·68		Free acids	1·07
Starch	5·22		Albumin	5·00
Pectin	4·54		Salts	1·75
Cane-sugar	3·95		Pectic acid, Oil, Colouring matter	2·18
Convertible to glucose	39·71			
		58·97		
Remainder		2·26		
		100·00		1000·00

[1] *Centralb. für Agric. Chem.*, vii. 59.
[2] Thorpe's "Dictionary of Applied Chemistry," i. 561.

THE COMPOSITION OF APPLES—PERCENTAGES.

Variety.	Refuse.	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Ash.	Authority.
All kinds, mean—entire	—	85·18	·41	·57	12·64	1·20	·30	Average of all collected analyses.
Crab apples, entire	—	81·75	·85	·63	9·60	6·50	·67	
Apples, average	—	83·58	·39	—	12·90	—	·31	Bauer.
,, edible part	—	82·50	·40	·50	12·50	—	·40	
,, eating, as purchased ..	25·0	63·30	·30	·30	10·80	·30	·30	Atwater, Bulletin 28, U.S. Department of Agriculture.
,, ,, edible part:								
Minimum ..	—	77·30	·10	·10	8·80	·20	·20	
Maximum ..	—	90·70	·90	·40	21·30	—	·60	
Average ..	—	85·60	·44	·50	14·20	—	·30	
Baldwin's	—	84·72	·50	—	12·70	—	·27	Wiley's "Foods," p. 331.
,, ripe	—	81·30	·40	—	14·68	4·29	·27	
,, very ripe	—	80·30	·40	—	14·07	4·95	·28	
Bell-flower, as purchased ..	16·3	73·28	·53	·54	8·80	—	·24	Bulletin 132.
,, edible part	—	87·50	·64	·65	9·77	—	·53	
Blenheim Orange	—	81·62	—	—	15·56	—	·44	Allen.
Bramley's Seedling	—	83·28	·61	·21	12·25	4·21	·44	Tibbles.
Cox's Orange Pippin	—	84·15	·52	·45	11·75	2·78	·35	
Derby Cooking	—	84·74	·50	·19	12·03	2·10	·54	Allen.

English Russets	—	82·04	·85	—	7·92	—	·36	Fresenius.
,, White Dessert	—	85·04	—	—	12·94	—	·44	
,, Golden Russets	—	81·87	·51	—	14·47[1]	—	—	
Greening, Rhode Island	14·5	74·16	·41	·14	9·87	—	·26	Bulletin 132.
,, ,, ,, edible ..	—	86·74	·48	·16	11·55	—	·30	
Newtown pippins	15·1	72·51	·55	·13	13·29	—	·16	
,, ,, edible	—	88·04	·42	·38	10·02	—	·27	
Pearmains	16·4	73·99	·30	·12	8·47	—	·21	
,, edible	—	85·50	·36	·14	10·14	—	·25	
Spitzbergen	14·0	72·02	·44	·08	12·54	—	·28	
,, edible	—	83·75	·51	·10	14·59	—	·32	
Sweet Alfred	—	80·29	·50	·40	13·38	—	·54	Allen.
Tom Put	—	84·14	·50	·40	11·05	—	·44	
Winesap, as purchased	15·1	77·74	·32	·36	8·51	—	·23	Bulletin 132.
,, edible	—	88·04	·38	·36	8·51	—	·23	
Dried apples : Minimum	—	8·60	1·20	·10	48·60	—	·14	Bulletin 142.
Maximum ..	—	47·40	2·50	5·00	86·90	—	2·90	
Average	—	28·10	1·60	2·20	66·10	—	2·00	
Apple pie	—	42·50	3·10	9·80	42·80	—	1·80	Bulletin 28.
Apple sauce	—	66·10	·20	·80	37·20	—	·70	

[1] Sugars, 10·36 per cent.

The amount of protein and fat in apples is so small as to be negligible in all calculations of dietetics. The carbohydrates are the only important food constituents. They consist of starch, pectose bodies, and sugars. The starch varies from 1 to 5 per cent., and averages about 4 per cent. in green apples, but diminishes to nil in fully ripe fruit. The cellulose varies from 0·2 to 5·0 per cent. The sugars consist of cane-sugar and invert sugar; they average about 11 per cent. in ripe fruit, or, according to Buignet, 5·28 of saccharose and 8·72 of invert sugar; but a very green apple scarcely contains 8 per cent., and a ripe one may have 14 or 15 per cent. Thus the sugars in Blenheim oranges amount to 15·56 per cent., including invert sugar 9·28 and cane-sugar 6·28 per cent. In Winesaps they average 11·95, Northern Spy 11·80, and in Bellflower only 9·0 per cent.[1]

SUGAR IN APPLES—PERCENTAGES.[2]

	Total.	Invert Sugar.	Cane-Sugar.
Tom Put (cider)	10·05	7·21	2·84
Derby (cooking)	11·03	8·74	2·29
Sweet Alfred (cider)	12·38	9·44	2·95

According to Truchon and Martin, a litre of apple-juice usually contains invert sugar 102·8 and saccharose 6·80 grammes.[3]

The changes which occur in the ripening of apples is an indication of the transformation of starch into sugar by a cellular enzyme (*diastase*), as shown in following table:

CHANGES IN BALDWIN APPLES DURING RIPENING—PERCENTAGES.[4]

	Total Solids.	Invert Sugar.	Cane-Sugar.	Starch.	Acidity, as Malic Acid.	Ash.
Very green ..	18·47	6·40	1·63	4·14	1·14	·27
Green	20·19	6·46	4·05	3·67	—	—
Ripe	19·64	7·70	6·81	·17	·65	·27
Very ripe	19·70	8·81	5·26	nil	·48	·28

The *pectose bodies* amount to 4 or 5 per cent. Upon the presence of these the fruit depends for its adaptability for making jelly (see *Pectin*).

The *acids* in apples are chiefly malic and tartaric acids, free and combined. The acidity in apples is reckoned as malic acid, and

[1] Bulletin 132, U.S. Department of Agriculture.
[2] Allen, *The Analyst*, 1902, 184.
[3] *Jour. Pharm. Chem.*, 1901, xiii. 171.
[4] Wiley's "Foods and their Adulteration," p. 333.

varies from 0·09 in Sweet Alfred to 0·70 in Greenings, Northern Spy, and others ; Winesaps contain 0·5 per cent. The proportion, however, varies according to the condition of the fruit ; thus, very green Baldwins contain 1·14 per cent., ripe ones 0·65 per cent., and very ripe ones only 0·48 per cent. The proportion of free acids in crabs is much larger, and the juice of this fruit, owing to its excessive acidity, is called **verjuice.** Apples also contain some tannin, to which in some degree their stomachic properties are due. It also adds to the astringency of the flavour and its palatability. The amount, however, is small, 1,000 parts of juice only containing 5 parts of tannin. The palatability of the fruit depends upon the combination of sugar and acids, together with the ethereal oil (valerianate of amyl). Apples containing much acid are unpleasant, and their excessive consumption is apt to irritate the stomach and intestines, and give rise to diarrhœa. Ordinarily, apples are mildly aperient ; cooked, they are of great value to dyspeptics, to persons whose liver is sluggish from sedentary habits, and to sufferers from constipation. Dyspeptics should not eat too freely of *raw* apples, but the cooked fruit easily passes through the pylorus, and is gratifying to them, and curative by reason of the tannin and other organic acids. By virtue of their malic acid, which is expectorant, they are also serviceable for chronic bronchitis.

Dried Apples consist of the fruit which has been pared, sliced, and dried. Domestically such apples are dried in the sun. Commercially they are dried by artificial heat—*i.e.*, by the hot-air or vacuum process. The sliced fruit is submitted to the action of the fumes from burning sulphur, which bleaches them and protects them from moulds and decomposing organisms. Such bleached fruit, however, is somewhat detrimental to the health of the consumer, as the sulphurous acid is destructive to the red corpuscles of the blood, and has other injurious influences upon metabolism.[1] There is also some slight danger of metallic poisoning from the action of the fruit acids, when they are dried upon zinc or galvanized wire trays. Traces of the metal, dissolved by malic acid, have been discovered by analysis of the dried fruit. It is, however, believed that such contamination is rare, and the danger of zinc-poisoning from this source is very slight.

Pears.

The pear-tree (*Pyrus communis*, genus Pyrus, N.O. Rosaceæ) is a native of the woods of temperate Europe and Asia, and plentiful in Britain. All the cultivated varieties are derived from the wild-pear (*P. communis*), with possibly some admixture of the snow pear (*P. nivalis*), a special variety in Austria and Italy, so called because it is eaten in winter. They are propagated chiefly by budding or grafting on the stock of the wild-pear or on stocks raised from seeds of the cultivated fruit. The varieties are

[1] Wiley's "Foods," p. 333.

numerous, some of the most esteemed being as follows—(*a*) *Dessert Pears:* William, Jargonelle, Duchesse, Marie Louise, Bon Chrétien, Butter Pears (Beurre d'Amanlis), Louise Bonne, Josephine de Malines, Doyenne du Comice, Durondeau. (*b*) *Cooking Pears:* Beurre-Clairgeau, Catillac, Bartell or Bartlett, Kieffer, Uvedales, St. Germain, and Verulam. In addition to the home supply of fruit, the United Kingdom imports a considerable quantity from the Continent, America, Cape Colony, and Australia. (*c*) The American pears are as follows: Angoulême, Anjou, Bartlett, Boussock, Box, Brockworth, Buffum, Clairgeau, Clapp, Columbia, De la Chêne, Doyenne Sieulle, Doyenne d'Alençon, Easter, Flemish Beauty, Gransell's Bergamotte, Gray Doyenne, Heathcote, Howell, Idaho, Jones, Kieffer, Lawrence, La Conte, Louise Bonne, Manning, Elizabeth, Mount Vernon, Pound, Seckel, Sheldon, Souvenir de Congrès, Superfine, Tyson, Colonel Wilder, White Doyenne, Winter Neliss. Dried pears are also imported from Normandy and California. The Chinese or sandy pear (*P. chinensis*) is a distinct species growing wild in China and Japan, and cultivated in both countries.

The fruit is an estimable dessert. Some varieties are well adapted for stewing, baking, or making into marmalade. Good pears are characterized by the aromatic saccharine juice, and a soft pulp of a pearly semiliquid character, almost melting in the mouth, as in the butter pears; or by a firm pulp, as in the bergamot and other winter pears. The fermented juice is known as "perry"; it is made from hard and austere fruit, which is practically uneatable, but, nevertheless, the finest perry is made from it.

Composition.—The constituents are very similar to those of apples. The chief substances are carbohydrates, which average 14·5 per cent., and include sucrose 0·36, dextrose and lævulose 8·42, with a little starch and dextrin. Like all fruits of the N.O. Rosaceæ, they contain a small amount of sorbite,[1] about 0·8 per cent., or 8 grammes per kilogramme, along with the fermentable sugars. The free acids amount to 0·19 per cent., and the mineral salts to 0·4 per cent. An analysis by Church[2] yielded the following:

Composition of Pears.

Albuminoids	·4	per cent.
Sugars	7·0	,,
Pectose and gum	5·2	,,
Cellulose	3·2	,,
Malic acid	1·0	,,
Mineral salts	·4	,,
Water	82·8	,,
	100·0	,,

Siberian Crab, or cherry apple: The fruit of *Pyrus baccata*, genus Pomeæ, N.O. Rosaceæ. The tree is a native of Siberia, grown in Britain as an ornamental tree. The fruit is excellent when preserved. The composition of

[1] Vincent and Delachnel, *Compt. Rend.*, 1889, cix. 181.
[2] *The Analyst*, March, 1891.

COMPOSITION OF PEARS AND VARIETIES—PERCENTAGES.

Variety.	Refuse.	Edible Portion.						Authority.
		Water.	Protein.	Fat.	Carbo-hydrate.	Crude Fibre.	Ash.	
All kinds, as purchased, average..	—	65·30	·79	·38	12·66	—	·40	U.S. Bulletin, No. 132.
,, ,, edible part, average ..	—	80·90	·90	·47	15·75	—	·40	
Minimum	—	83·90	·60	·10	14·10	—	·50	Atwater.
Maximum	—	84·80	·60	·80	14·20	—	·50	
Average	—	84·40	·60	·50	14·10	—	·40	
	—	83·60	·36	—	11·80	—	·09	Bauer.
	—	83·20	·40	·40	15·40	3·20	·40	Church.
English Sweet Red..	—	85·00	—	—	12·58[1]	—	·28	Fresenius.
Easterbury, as purchased ..	21·8	64·86	·89	·56	10·40	1·16	·33	U.S. Bulletin, No. 132.
,, edible portion ..	—	82·83	1·15	·72	13·30	1·48	·42	
Duchess, as purchased	13·6	73·45	·69	·22	11·21	·60	·23	
,, edible portion	—	85·00	·80	·26	12·97	·70	·27	
Glout Morceau, as purchased ..	20·1	64·40	·66	·40	13·26	·88	·30	
,, ,, edible portion ..	—	80·60	·83	·50	16·59	1·10	·38	
Winter Neliss, edible portion ..	—	76·08	1·02	·28	19·17	2·78	·67	
,, ,, as purchased ..	27·0	55·54	·74	·20	14·00	2·03	·49	
Canned pears: Minimum	—	79·60	—	—	15·60	—	·20	Atwater.
Maximum	—	83·60	·50	·90	19·50	—	·30	
Average	—	81·10	·30	·30	18·00	—	·30	
Dried pears	—	16·50	2·80	5·40	72·90	—	2·40	

[1] Sugars, 7·94 per cent.

the canned crabs is as follows: Water 42·4, protein 0·3, fat 2·2, carbohydrate 54·6, ash 0·5, per cent.

Service Fruit.—The name is a corruption of "sorbus"—*Pyrus* (*Sorbus*) *domestica*, genus Pomeæ, N.O. Rosaceæ. This fruit is grown in Italy and other parts of Southern Europe. It is very austere, but when it begins to decay it resembles a medlar, and is then relished. It is esteemed of value in dysentery and chronic diarrhœa. The fruit of the wild service-tree (*P. torminalis*), abundant in Herefordshire, is preferred by many people to the former. It is a small fruit of agreeable acid flavour, not much bigger than a hawthorn, which becomes very pleasant after being stored. It is not unlike a medlar in flavour after being stored and submitted to the frost.

Mountain Ash Berries (*P. aucuparia*), or rowan-tree fruit: The juice contains sorbinose and glucose, and an acid astringent principle. The latter is sorbi-tannic acid, and approximates closely to caffeo-tannic and morin-tannic acids.[1]

Medlar: The fruit of *Mespilus germanica*, genus Pomeæ, N.O. Rosaceæ. A native of Central Europe; cultivated in some gardens in England. The fruit is very austere, but loses its acerbity after being kept for a few weeks; during this period incipient decay sets in (in common parlance they become "bletted"), when the fruit is much relished by some people. The change in them is produced by the action of enzymes in the fruit, including diastase. Their composition is as follows: Water 74·6, protein 0·5, fat 0·3, carbohydrate 16·7, ash 0·6, per cent.[2]

Loquat, or Japanese Medlar: The fruit of *Photinia* or *Eryobotrya japanenis*, genus Cotoneaster, N.O. Rosaceæ. An evergeren shrub indigenous to Japan, grown in Asia, South Africa, etc. It is allied to the medlars. The fruit is of the size of a gooseberry, of yellow colour, downy skin, and taste approaching that of an apple. Composition: Water 77·9, protein 0·2, fat 0·0, carbohydrate 20·2, ash 1·1, per cent.[2]

Hawthorn.—The fruit of the hawthorn, *Crategus oxyacantha*, genus Cydonia, N.O. Rosaceæ—called "scarlet haws"—are sometimes eaten. Their percentage of composition[3] is as follows:

	Refuse.	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.
Entire fruit	20	60·65	1·58	·52	14·85	·66
Edible portion ..	—	75·83	1·98	·65	18·57	·84

Quince: *Cydonia vulgaris*, genus Cydonia, N.O. Rosaceæ. A native of the Isle of Crete, cultivated in England and throughout Southern Europe, Western Asia, and America. It was naturalized at an early period in Persia and in the countries surrounding the Mediterranean. It grows freely wherever apples grow. It was known to the ancient Greeks and Romans, and formed an important element in some of their religious and civil ceremonies, having been naturalized in the East of Europe before the epoch of the Trojan War (*De Candolle*).

[1] *Bull. de Soc. Chim. de Paris*, 1887, No. 7.
[2] Farmers' Bulletin 293, U.S. Department of Agriculture.
[3] Farmers' Bulletin 132, U.S. Department of Agriculture.

There are several varieties of the fruit, which is a handsome yellow pome. It is a hard and austere fruit, having improved but little in this respect from the time of the ancient Greeks. Its nature prevents it being much eaten as a raw fruit; but it is eaten stewed, in pies and puddings, and makes an excellent marmalade. They have a fine flavour, which is communicated to any other fruit with which they are cooked. The juice makes wine having a splendid aroma and delicious bouquet. In England the tree is chiefly an ornamental tree, but it is far more common in the warmer regions of Europe, Asia, and America.

The **Roselle,** or red sorrel, is the *Hibiscus sabdariffa,* N.O. Malvaceæ, grown in the East and West Indies. The leaves and pods are used as a salad. The calyces become fleshy and capsular as they ripen, and develop a pleasantly acid taste. They are used for making tarts, preserves, jellies, and beverages.

Composition of Roselle—Percentage.[1]

	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.
Calyx	86·5	2·1	·3	10·3	·8
Pod	84·0	1·7	1·0	12·2	1·1

Division B: Berries.

A berry is a succulent, pulpy fruit, the flesh of which contains several seeds, and is enclosed in a thin skin. The berry is always crowned with the withered teeth of the calyx, as in the gooseberry and currant. The group includes the grape and tomato, which form is called a *nucularium.* According to Vine's "Botany," the following fruits answer to this description—*Aurantiaceæ:* oranges, lemons, limes, citrons, pomelo, kumquat; *Bromeliaceæ:* pineapple; *Amaryllidaceæ:* agave; *Guttiferæ:* mamey fruit; *Ampelidaceæ:* grapes; *Anacardiaceæ:* mango, cashew; *Cucurbitaceæ:* melons, canteloupes, gourds; *Myrtaceæ:* pomegranate, guava; *Leguminosæ:* tamarind; *Saxifragaceæ:* currants and gooseberries; *Solanaceæ:* tomato; *Vacciniaceæ:* bilberry, blaeberry, huckleberry, whortleberry, and cranberry.

Grapes.

The fruit of *Vitis vinifera* (N.O. Ampelidaceæ), a native of Central Asia, introduced into Europe by the Phœnicians, and now grown in all countries from 55 degrees north latitude to about 40 degrees south latitude; but it is less common from the twenty-first degree to the equator on both north and south.

The vine grows wild in the temperate regions of Western Asia, Southern Europe, Algeria, and Morocco. But it is especially in the Pontus, Armenia, the south of the Caucasus and of the Caspian Sea,

[1] Farmers' Bulletin 293, U.S. Department of Agriculture.

where it grows with the luxuriant wildness of a tropical creeper. The dissemination by birds must have begun very early—before cultivation, before the migration of the most ancient Asiatic peoples, perhaps before the existence of man in Europe or even in Asia. There are proofs of its great antiquity in Europe and Asia. Seeds of the grape have been found in the lake-dwellings of Castione, which date from the Age of Bronze, and in those of Switzerland; and vine leaves have been found in the tufa round Montpellier and of Meyrargue, which is certainly prehistoric, though later than the tertiary epoch of geologists. The records of the cultivation of the grape and the making of wine in Egypt go back five or six thousand years. In the West, the propagation of its culture by the Phœnicians, Greeks, and Romans, is well known; but in the East of Asia it did not take place until a later period: the Chinese did not possess it earlier than the year 122 B.C.[1] It is, however, especially in the middle belt of the zone indicated that the finest grapes are produced —that is, in what are known as the wine-growing countries. Grapes grown out of doors in the northern belt are austere; those in the southern belt are better for making raisins, as wine produced from them has but little odour. Wines having the finest bouquet are those from grapes grown in France and along the Rhine; but wine is also produced in Spain, Italy, the Greek islands, the Canaries, Azores, California, Australia, etc. The fruit ripens out of doors in England in warm summers. Vineyards were once known in England, and an inferior wine produced from the fruit. Although vineyards no longer exist, the grapes grown in English and Scotch hothouses are not excelled by any produced elsewhere; they are grown all over the kingdom. There are a multitude of varieties, the following being among the best: Black Hamburg, Black Alicante, Gros Colmar, Madresfield Court, Muscat, Black Muscat, Canon Hall Muscat, Muscat of Alexandria, Pearsom, Gros Maroc, Gros Guillaume, all of which combine a fine flavour with large size, good appearance, and rich bloom. But Great Britain does not depend solely upon its own resources. A vast amount of fruit is imported from other countries. The out-of-door varieties are particularly abundant and cheap. **Almeria** grapes (Spanish) arrive in England from August to November. They are white, and consist of several varieties. **Lisbon** sweet-water grapes arrive at the same time. **Malaga** and **Denia** grapes also arrive in August. Fine black grapes come from the Cape in February and March.

Wines are said to be made from the following named varieties among others: **Champagne** is made from the Black Cluster or Black Pineau, White Pineau, and Golden Pineau varieties. The best **Burgundy** is made from Black Cluster or Pineau and Miller's Burgundy; other varieties used are Melon Noir, Gibaudst, and Gammé. **Claret,** or red Bordeaux, is made from the Black Prince or Alicante, Black Frontignan, Malaga du Lot, Grand Vidure, Carmenet, Malbeck, Pétuille, Manien, Ciotat, Chasselas, Balauzet le Tarnex. **Hermitage**

[1] De Candolle, "Origin of Cultivated Plants," pp. 191-194.

COMPOSITION OF GRAPES—PERCENTAGES.

	Refuse.	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre and Seeds.	Ash.	Authority.
Average of all collected analyses	—	80·47	·89	·86	14·76	2·53	·49	Author.
,, of numerous analyses ..	—	78·18	·60	—	16·32	—	·50	Bauer.
	—	77·40	1·30	1·60	14·90	4·30	·50	Atwater, Bulletin 28.
,, entire fruit	25·0	58·00	1·00	1·20	14·40	—	·40	
,, edible portion	—	77·40	1·30	1·60	19·20	—	·50	
Variety : Muscat	—	84·80	·81	·36	13·38	—	·20	Bulletin 132.
Tokay	—	87·12	·66	·15	11·36	—	·30	
Verdal	—	85·06	·69	·60	12·68	—	·40	
Cornichon	—	86·78	·66	·21	11·39	—	·40	
Kleinberger	—	84·87	·62	—	11·56	2·52	·37	Fresenius.
White Austrian	—	79·99	·83	—	15·14	2·59	·37	
Grape-juice, unfermented ..	—	92·20	·20	·50	6·90	—	·20	Farmers' Bulletin 293.

wines: red from Ciras, or Siras, grapes; white from Marsane or Roussane. **Sherry** from Pedro Ximenes, Mantuo Castillan, Muscatel Menudo Blanco, Uva del Rey, Mollar, etc. **Malaga** wines from Pedro Ximenes, Muscate de Larmes, and Muscat de Malaga.

Composition.—Grapes contain 10 to 26 per cent. of sugars, about 0·6 to 1·5 per cent. of nitrogenous matters, about 2·0 per cent. of non-nitrogenous matters, including 1·0 per cent. of pectose bodies, 0·5 per cent. of gum, fat, etc., 2·5 to 4·5 per cent. of skin and seeds, 1·2 per cent. of acids, and 0·2 to 0·5 per cent. of inorganic salts. An extended analysis gave the following results—*Soluble:* Dextrose 13·8, tartaric acid 1·12, nitrogenous matters 0·8, fat, gum, etc., 0·5, salts 0·36, per cent. *Insoluble:* Pectose 0·9, skin and seeds 2·6, salts 0·12, water 79·8, per cent.[1]

The sugars consist chiefly of dextrose with some lævulose. The amount varies in different kinds of grapes—*e.g.*, Kleinberger grapes contain 10·59, Oppenheimer 13·5 (very ripe 15·14), white Austrian 13·78, red Asmanhausser 17·39, and Johannisberger 19·24, per cent.[2] The acidity of unripe fruit is due to both tartaric and malic acids; as the fruit ripens the malic acid disappears. The proportion present depends upon the period of development, and good or bad seasons. It averages 0·59 per cent. reckoned as tartaric acid. Ordonneau found that wines from the Vendee in 1890 contained 15 grammes of tartro-malate per litre, and in some white wines the malic acid exceeds the tartaric. The salts are chiefly hydropotassic tartrate or cream of tartar, tartrate of lime, a small amount of phosphates, sulphates and chlorides of potash, soda, lime, and magnesia. An analysis of the ash shows its composition to be as follows: $K_2O = 50·95$, $Na_2O = 6·32$, $CaO = 4·96$, $P_2O_5 = 21·27$, $SO_3 = 4·28$, and $Cl = 1·54$, per cent.[3]

Grapes are delicious fruit. By virtue of their carbohydrates they are nourishing and fattening. In large quantities they are stomachic, aperient, and diuretic. The "grape cure" consists of the consumption of 3 to 12 pounds of the fruit daily, and is especially carried out at the health resorts, such as Meran, Botzen and Gries in Tyrol; also at Wiesbaden and elsewhere. The cure is continued for six or seven weeks, during which the quantity consumed is gradually increased. The rest of the dietary requires consideration, and should be in accordance with medical instruction. The grapes are better swallowed after just cracking them with the tongue, as chewing so many makes the gums sore, and is said to injure the teeth. The "cure" is advised for some forms of dyspepsia and atonic affections of the stomach and bowels; for chronic alcoholic gastritis, bronchitis, pulmonary phthisis, anæmia, chlorosis, and diseases of the kidneys. It is clearly contra-indicated in cancer of the stomach and other organs. In phthisis and other wasting diseases, care is required that they do not cause diarrhœa, which might aggravate the disease and hasten a fatal termination.

[1] Eustace Smith's "Foods," p. 216. [2] *Ibid.*

[3] Bulletin 66, U.S. Bureau of Chemistry.

Raisins (*Uvæ*) are the dried fruit of many varieties of the grape vine. They are principally produced in Southern Europe—France, Spain, Italy, Greece, Turkey, and Persia; and in a smaller proportion in California, South Africa, and Australia. They are usually sold under the following names: (*a*) **Muscatels,** or raisins dried on the vine; they include Malaga, Valencia, and Denia muscatels. (*b*) **Valencias,** or dipped raisins; this kind includes Lexias and Denias from Valencia, which are much valued; Turkey raisins shipped at Smyrna; and California raisins. (*c*) **Sultanas,** or small seedless raisins, grown in and imported from Greece, Turkey, and Persia.

The grapes before drying must have a large proportion of pulpy tissue and sugar; otherwise the product will be of inferior quality. The two following methods of drying the fruit are adopted:

1. *Drying the Fruit on the Vines.*—Muscatels, *pasas de sol,* or sun-dried raisins, are prepared in this manner. They are the fruit of *Muscatel gordo blanco* or white muscatel variety. The finest grapes are grown near Malaga, within six miles of the coast. The vine is denuded of its leaves in order to permit the full rays of the sun to reach the fruit. The fruit is partially separated from the tree by twisting or cutting the stem, the object being to stop the circulation of the sap. They are allowed to hang for two or three weeks, and afterwards collected and packed in boxes without being pulled from the stalks.

2. *Drying the Fruit after Separation from the Vines.*—Lexia and Denia raisins are prepared in the following manner. Though known as Valencia raisins, very few are grown near that city; they are mostly grown in the province of Alicante, and shipped from Denia. The term "lexia" denotes the mode of manufacture: it refers to their being "dipped," and is a corruption of the word meaning *lye.* They are also called *pasas de lejia* (lye raisins) and *pasas de caldadas,* because the lye is used at a boiling temperature. The ripe fruit, gathered from the *gordo blanco* variety of vines, are twisted for *one day* before being pulled, in order to allow some evaporation to occur; they are then plucked, and dried in the sun near the vines for another day. They are afterwards rinsed in water to remove dirt and rubbish, and dipped in boiling potash lye flavoured with rosemary and lavender, and having a layer of olive-oil upon its surface. One object of "dipping" is to hasten their drying. The sun-dried muscatel raisins require three weeks to dry, but dipped raisins dry in four or six days. The high temperature of the lye sterilizes the fruit; they are allowed to remain in it a second or two, until they are somewhat shrivelled. The alkali destroys the natural bloom, which is due to a layer of wax on the fruit; but as they are withdrawn from the lye each raisin gets a thin layer of oil, which gives them an artificial bloom when dry. The outer layer of the skin is also destroyed by dipping, but transpiration is aided thereby, and they evaporate more rapidly. They are dipped in a wire basket upon a long handle. The grapes are then spread evenly on trays, and exposed to the sun in the drying-ground, being turned over by

hand so that fresh portions are exposed now and then. When dry the raisins are carried indoors, and stored in a heap or in large baskets. In this way *sweating* is produced, which improves the fruit, equalizes the moisture, and softens skins which may have been overdried. They are then removed from the stalks by hand, graded, and packed.[1]

Currants.—Zante currants, also called "English currants," are the dried fruit of the small black Corinth grape, grown in the Levant and Morea, and especially in the Greek islands Zante, Ithaca, and Cephalonia. They are exported from Patras in considerable quantities. Several commercial varieties are recognized:[2] (*a*) *Finest quality*—Vostizzas and Panatris; (*b*) *Medium*—Patras, Zante, Amalias, Caidiacafti and Gulf fruit; (*c*) *Ordinary*, called "provincial fruit." The grapes are small, round, thin-skinned, and seedless. They are ripe in July and August, and are plucked when slightly overripe, dried in the sun, afterwards being removed from the stalks, cleaned, and packed.

The important constituents of raisins and currants are sugars (dextrose and lævulose), and potassium acid tartrate in the pulp; tannin and fixed oil in the seeds. According to Harrison,[3] they contain tartaric acid 1·36, citric acid 0·16, and malic acid 0·19, per cent. Raisins and currants are much used in cooking, where they are chiefly of value for the carbohydrates they contain. The salts are practically the same as in grapes. During drying the lævulose increases at the expense of the dextrose, being transformed by means of an enzyme, and some of the remaining dextrose forms an amorphous or crystalline mass.

These fruits are nutritive, demulcent, balsamic, sweetening, and flavouring agents. They are to some extent useful in the same diseases that the "grape cure" is recommended for. Raisins, and especially the expressed juice, save the nitrogenous tissues, reduce the nitrogenous excretion, and lead to a formation of fat. This is in accordance with the protein-sparing property of all carbohydrates. Therefore, while increasing the flow of urine, they diminish the output of urea and uric acid. At the same time they stimulate the hepatic functions, and especially the flow of bile, but diminish or check intestinal fermentation. As a convenient form of food for pedestrians and travellers they have long been held in high estimation, being of small compass, easily carried, and, in addition to being sustaining and nutritious, their demulcent properties are valuable by checking or preventing troublesome thirst.

Mango Fruit.

The fruit of *Magnifica indica*, N.O. Anacardiaceæ; a native of Asia, very much esteemed in tropical climates and cultivated in most Oriental countries. The fruit is flat and oval or kidney-

1 F. de Castella, *Jour. Dep. Agriculture* (Victoria, Australia), 1909, vii. 1-14.
2 "The Practical Grocer," ii. 123.
3 *British Medical Journal*, 1908, i. 1263.

COMPOSITION OF RAISINS AND CURRANTS—PERCENTAGES.

	Water.	Protein.	Fat.	Sugars, etc.	Cellulose, etc.	Ash.	Authority.
Raisins : Mean of seven reports ..	18·61	3·09	2·86	70·49	1·90*	2·70	Bauer, Atwater, Bell, Blyth, Wiley, etc. * Refuse, 10 per cent.
Minimum	7·10	2·50	·50	62·54	—	2·00	
Maximum	32·00	4·50	4·70	78·85	—	5·00	
Edible portion : Minimum ..	7·10	2·30	·50	71·33	—	2·00	Atwater, Bulletin 28.
Maximum	21·00	3·00	7·20	78·80	—	5·00	
Average ..	14·60	2·60	3·30	76·10	—	3·00	
Currants : Mean of seven reports ..	22·60	1·80	2·40	69·30	—	3·35	*Vide supra.*
Edible portion	20·30	1·77†	—	73·00	·89	1·68	Harrison.[1] † Amido compounds, 0·04 per cent.
Minimum	5·30	1·00	·40	60·00	—	2·20	Atwater.
Maximum	35·10	4·70	4·70	85·30	—	9·10	
Average	17·20	2·40	1·70	74·20	—	4·50	

[1] *British Medical Journal*, 1908, i. 1263.

shaped, reddish-brown or like an apricot in colour, specked with black, about the size of a small apple to a goose egg, and with a fine agreeable juice. It cuts like an apple, but is more juicy; the pulp has an agreeable acidity and sweet, aromatic perfume. The fruit is eaten raw, cooked in pies or tarts, in preserves, jelly, and chutney. It is a very grateful addition to the dietary during the tropical summer.

Composition: Water 87·4, protein 0·6, fat 0·4, sugars 9·9, fibre 1·2, ash 0·5, per cent.[1]

Maranon or Cashew-Fruit and Nut.

The fruit of *Anacardium occidentale* (N.O. Anacardiaceæ), a native of tropical America, grown in the East and West Indies and South America. The fruit consists of an enlargement of the stalk of the flower, of pyramidal shape, size of an apple or orange, yellow or red, having an agreeable subacid flavour and astringency. On the outside of the fruit grows the nut, of kidney shape, consisting of two shells which enclose a delicious substance or kernel, abounding in a milky juice. Although used chiefly as a preserve, the ripe fruit and nut are eaten raw, and the fermented juice makes a pleasant wine, which, by distillation, yields a spirit said to be superior to rum or arrack. The composition per cent. is as follows:[2]

	Edible.	Solids.	Protein.	Sugars.	Acidity.	Ash.
Fruit	85·9	12·84	?	6·76	·31	·36
Preserve	—	71·25	·26	66·89	·08	·14

The seed or nut is peculiar in growing outside the fruit. It consists of a tough fibrous substance having a disagreeable odour and astringent taste. The *raw* seed is said to be poisonous owing to the high proportion of prussic acid; but when *roasted*, as they usually are, an agreeable change is produced, a delicious flavour is developed, and they more or less resemble roasted chestnuts.

The Citrus Family.

The natural order of Aurantiaceæ yields, perhaps, the most popular of all fruits; the fruit is a berry having several loculi containing a fleshy pulp in which the seeds are embedded. Their cultivation is very ancient, far more ancient than their cultivation in Europe and America. The citron is indigenous in India, and is of prehistoric antiquity. The cultivation of more or less acid varieties, such as the lemon, spread into Western Asia, at least into Mesopotamia and Media, at an early date. The Greeks obtained the fruit through

[1] Farmers' Bulletin 292, U.S. Department of Agriculture.
[2] Wiley's "Foods and their Adulteration," p. 348.

the Medes, whence the name *Citrus medica*. Theophrastus was the first to speak of it, but probably it was not then cultivated in Greece, for the Romans did not grow it in their gardens at the beginning of the Christian era. It is supposed that this species, after many attempts, was cultivated in Italy in the third or fourth century. The Hebrews probably knew the citron before the Romans, because of their relations with Media and Persia. The Greeks had seen the citron in Media and Persia in the time of Theophrastus, three centuries B.C. ; but it would be strange, says De Candolle, if the Hebrews had not become acquainted with it at the time of the Babylonish captivity. The acid varieties of the fruit—lemon and lime—probably did not attract attention so early as the citron ; nevertheless the strongly aromatic odour mentioned by Theophrastus and Dioscorides appears to indicate them. The Arabs extended the cultivation of the lemon into Africa and Europe. According to Gallesio, they transported it in the tenth century of our era from the gardens of Oman into Palestine and Egypt.

Oranges were unknown to the ancient Greeks and Romans. As they had communication with India and Ceylon, Gallesio supposed their cultivation had not extended into the West of India. The sweet orange came from China, and probably spread into India towards the beginning of the Christian era. It is probable that it was derived from the bitter orange at some remote epoch, and that it came from China or Indo-China. Orange-trees were brought from India by the Arabs into Palestine, Egypt, the east coast of Africa, and the South of Europe. Up to the fifteenth century Arab books or chronicles only mention bitter or sour oranges. However, when the Portuguese arrived in the islands of Southern Asia they found the sweet orange, but apparently it was not unknown to them, as the Florentine who accompanied Vasco da Gama, and published an account of the voyage, says : " There are plenty of oranges, but all sweet." Gallesio infers that the Portuguese were not the first to bring the sweet orange from India, which they reached in 1498, nor from China, whither they went in 1518. Gallesio believes that sweet oranges were introduced into Europe in the fourteenth or fifteenth century. De Candolle thinks that the oranges imported later from China by the Portuguese were only a better quality than those already known, and that the expressions " China " oranges, " Portugal " or " Lisbon " oranges, are due to this circumstance.

Citron.

The citron-tree (*Citrus medica*) is a native of the warm parts of Asia, but has been cultivated in Southern Europe for centuries. The fruit has nine loculi or cells forming a white pulp, which is generally said to be less acid than the lemon. It is, however, seldom eaten without being preserved. The rind is the part most used, preserved and candied in sugar for use in confectionery. The rind is thick and spongy, and has a fragrant aroma. The juice is largely exported from Sicily. There are many varieties grown in France,

Italy, Corsica, and Sicily—*e.g.* : (*a*) The common citron (French *cedratier* or *citronier des juifs*, Italian *petima*), cultivated in Genoa, Taggia, San Remo ; (*b*) the Genoa citron, which is larger, grown chiefly at Mentone, San Remo, and Taggia ; (*c*) the small citron (French *citronier de salò*, Italian *cedrino*), a very fine fruit, grown originally at Salò, but now grown in Nerir, Pegi, and other Italian districts ; (*d*) the Florence citron, grown in Tuscany, is the size of a lemon, has a delicious aroma, and makes some of the finest confections ; (*e*) the large citron, grown in Liguria, has a very irregular exterior, and is seedless ; (*f*) the sweet citron, a hybrid between the citron and orange. The dried candied peel is usually prepared from large fruit with thick spongy peel. The composition per cent. is as follows :[1]

	Water.	Protein.	Fat.	Sugars.	Ash.
Minimum	12·4	·4	·6	72·5	·8
Maximum	25·6	·6	2·5	83·7	·9
Average	19·0	·5	1·5	78·1	·9

Limes.

Citrus medica, var. *Limetta*. The tree is a native of India, but grows in the same region as oranges, and is cultivated for its fruit and juice in Jamaica, Montserrat, Trinidad, and Dominica, Italy, Sicily, etc. The fruit is oval, pale yellow ; it has a sweetish pulp with a slightly bitter flavour. The principal varieties are—(*a*) The small sweet lime cultivated in gardens ; (*b*) the lemon-lime, or sweet lemon, extensively cultivated in Liguria ; (*c*) the bergamot, grown in Calabria (the juice is expressed and exported ; the rind is very fragrant, and yields an oil sold as essence of bergamot) ; (*d*) the mela rosa, or star-like lime.

Lime-juice is obtained by expression and clarification, and is sometimes evaporated to one-tenth its bulk for exportation. Each 100 gallons of ordinary juice is preserved by the addition of 2 ounces of salicylic acid. It contains 6·7 to 10·5 per cent. of citric acid, and from 10·7 to 16·1 ounces, or an average of 12·5 ounces, per gallon. The concentrated juice is standardized to 100 ounces of citric acid per gallon ; such juice is chiefly imported from Montserrat and Dominica. The British Board of Trade established the following standard for ordinary lime-juice—viz., a density of 1·03, and an acidity equal to 30 grains of citric acid per ounce. The *peel* of lime fruit contains an oil similar to that of lemons.

Bergamot-juice has a low acidity, as it contains only about 5·13 ounces of free acid per gallon. It is prepared in Calabria and exported from Messina.

[1] Bulletin 28, U.S. Department of Agriculture.

Lemons.

Citrus medica, var. *Limomum*, is a native of India, but is cultivated in most warm countries, especially Italy, Sicily, and Spain. There are many varieties, the chief being—(*a*) The common or Genoa lemon, the ordinary commercial variety, of oval shape, thick and rough or smooth rind, and an abundant sour juice ; (*b*) the lustrato, or thin-skinned lemon, having a smooth, fragrant rind, delicate pulp, acid juice, but agreeable taste and fragrant aroma only grown in perfection in and around Rome ; (*c*) the sweet lemon ; (*d*) the citron-lemon, having a pulp like an orange and a peel like a lemon, and a rough warty exterior, but it is one of the most delicate limes ; cultivated in Liguria. There are other varieties also, which, however, are never seen in England. The chief sources of British supply are—**Italy,** shipped from Naples from March to October ; **Sicily,** shipped from Palermo and Messina all the year round ; **Spain,** shipped from Malaga from September to December ; and **Australia**, from July to December. Lemon-trees bear two crops a year, flower and fruit appearing together. The fruit, however, is not all suitable for exportation ; *e.g.*, only about one-eighth of the Sicilian crop ripe in November is suitable for shipment, but one-fourth of those ripe in February are of very good quality. They are pulled when green, and ripened in sand or in proper storehouses. Those which ripen on the tree have, of course, the finest flavour, but the skin becomes too thick, and they decay sooner than those ripened after being plucked.

The constitution of the lemon is similar to that of the orange, but the pulp is more acid, and yields an aroma and juice which are used as an ingredient of many refreshing beverages. The rind or peel contains the aromatic oil which is used as a flavouring agent in cooking ; the candied or dried peel being used as a dessert, in cookery, and as an aromatic stomachic. The juice contains citric, malic, and phosphoric acids, free and combined with bases such as potassium. It is cooling, quenches the thirst, and is particularly suitable for people of a bilious or sanguine temperament. Lemon-juice enters the blood in the form of alkaline citrates, which are partly oxidized in the system into carbonic acid and water, and partly transformed to carbonates, which render the urine alkaline. It is used with advantage in the prevention and treatment of scurvy, and was formerly an important part of the equipment required for long voyages.

The *pulp* contains 0·37 per cent. of sugar and 5·39 per cent. of citric acid. The *oil of lemon* contains citral, nonyl-aldehyde, octyl-aldehyde, citronellal, dextro-limonene, cymene, phellandrene, and pinene.[1] The *juice* contains 9·8 per cent. of carbohydrate, including 2·3 per cent. of sugars, with 5·0 to 7·5 per cent. citric acid, besides malic acid and small quantities of formic, acetic, and phosphoric acids. The finest juice contains 11 to 13 ounces of citric

[1] Schimmel's report, October, 1902.

acid per gallon. The British Board of Trade established the following standard: It must have a density of 1·03, and an acidity equal to 30 grains of citric acid in each fluid ounce.

The fruit contains 0·526 per cent. of salts, having the following composition: $K_2O = 48·2$, $Na_2O = 1·76$, $CaO = 24·87$, $P_2O_5 = 11·09$, $SO_3 = 2·84$, and $Cl = 0·39$, per cent.

Composition of Lemons—Percentages.

	Refuse.	Water.	Protein.	Fat.	Sugars, etc.	Ash.
Entire fruit	30	62·5	·7	·5	5·9	·4
Edible portion: Minimum	—	88·4	·8	·1	8·2	·5
Maximum	—	90·2	1·1	1·5	9·0	·5
Average	—	89·3	1·0	·7	8·5	·5
Lemon-juice	—	88·0	—	—	9·8	·5

Oil of lemon is obtained by pressure of the fresh rind of ripe fruit, or by distilling it with water. Essence of lemon is an alcoholic solution of the oil.

Lemon-juice is chiefly imported from Sicily, also from Naples and Sorrento in smaller quantities. It is obtained by pressure and clarification. It has greatest acidity early in the season (November), the finest juice containing 11 to 13 ounces of citric acid per gallon; at the end of the season it contains less acid. The juice of inferior fruit only contains 9 ounces per gallon.

Citric acid is made from the juice of lemons and limes after removing the peel for the purpose of expressing the oil.

Lemon-water is made by expressing the juice from two big lemons; the lemons are then cut or scraped to pieces and boiled with 2 ounces of sugar in 2 pints of water for five minutes; the liquid is strained and the juice added. Made of greater strength, it can be diluted with Salutaris, Apollinaris, soda-water, or other effervescing water. It is useful in febrile diseases, nausea, and vomiting. In some cases of diarrhœa with vomiting, when everything else is rejected, the white of an egg, beaten and mixed with $\frac{1}{4}$ pint of lemon-water, is often retained. Meat essences may also be added to it.

Oranges.

The orange-tree, or *Citrus aurantium*, has its natural home in China and Northern India; but it is cultivated in all the warm countries of Europe, Asia, Africa, America, the tropical and sub-tropical islands and archipelagos. The fruit is a globular yellow berry divided into eight or ten loculi or cells, each filled with pulp consisting of a mass of oblong vesicles, and containing seeds. When ripened on the tree, an orange consists of an extremely juicy pulp, which is sufficiently tender to be eaten with a spoon. Such oranges, however, are rarely seen in England; those which

arrive have not been ripened on the tree, consequently their substance is more fibrous and they contain less juice, some of the latter being lost by evaporation during transit. Nevertheless, the best fruit imported are fragrant and delicious ; although not very nutritious, they possess valuable antiscorbutic and other salutary properties, for which they are highly esteemed. They are as useful in illness and convalescence as they are acceptable in health ; in febrile conditions, when fruit is permissible, their juicy pulp is antipyretic, and has been credited with curative properties in influenza.

The chief varieties of oranges are as follows :

1. **The Sour, Bitter, or Seville Orange** (*Citrus aurantium vulgaris*), also called the Bigarade. It is not much eaten raw, but it is well known in Great Britain for its flavour, acidity, and slight bitterness, which are justly appreciated in orange marmalade and preserve. There are many subvarieties. The chief supply comes from Seville, Denia, Portugal, Palermo, and the Canary Islands.

2. **Sweet Oranges** (*Citrus aurantium sinense*).—These are all technically aclled " China oranges," and have probably arisen from one stock. There are numerous subvarieties, of which the following are a few : (*a*) **China oranges,** which are distinguished by a smooth, thin skin scarcely separable from the fruit. These are the finest oranges, excelling all others by the delicacy of the flavour and perfume and by the abundance of sugary juice. Among the named kinds, of which there are many, the St. Michael's orange, now becoming scarce, is highly esteemed. (*b*) **The Portugal or Lisbon orange** is the most common of all the subvarieties, and is grown in many countries. It is distinguished by the rough, thick skin of a deep orange or reddish-yellow colour, and has a good deal of aroma. Being readily grown from the seeds, these oranges have been transplanted into almost all countries where they will grow, and many named subvarieties have arisen. (*c*) **Brazil or Navel oranges** are large round or oval fruit which received the latter name from their characteristic appearance. They are sweet, delicious fruit, grown in Brazil, Bahia, Majorca, California, etc. The seedless navel orange is a special kind grown in the United States by grafting one tree upon another. (*d*) **The Malta or Blood orange** is the produce of an orange grafted upon a pomegranate-tree, and is characterized by a change in colour during ripening. Flakes of red appear in the flesh, which become broader and deeper in colour as the fruit reaches maturity, until the entire fruit is more or less blood red, even the rind being influenced by the coloration. They are imported from Malta, Egypt, etc. (*e*) **The Tangarine orange** is a small flat, highly-perfumed fruit with agreeably-flavoured flesh. (*f*) **The Egg orange** is a small round or oval golden-yellow fruit grown in Malta, Jaffa, Zanzibar, etc.

3. **The Mandarin Orange** (*Citrus nobilis*), grown in Spain, Italy, Algeria, and Malta, has a sweet juice and edible rind, which is loose and often detached from the interior. It is red without and

within, and has a fine perfume. The **Satsuma,** or Japanese orange, is similar to it.

4. **The Cumquat or Kumquat** (*Citrus japonica*) is a dwarf orange of the size of a plum, about 1 inch by 1½ inches in diameter, and of oval shape. The pulp is agreeably acid and the skin aromatic. It is a native of China, but is grown in other countries.

5. **The Pomelo, Shaddock, or Grape-Fruit** (*Citrus decumana*), a native of Southern China, according to Rumphius, although the number of varieties in the Malay Archipelago indicates an ancient cultivation. It is the largest member of the family. According to some, the grape-fruit and shaddock are two different varieties or species, the shaddock being the larger of the two, grape-fruit the smaller and having the finer flavour. Their size is from that of an orange upwards. They are often as big as a man's head, and some weigh 10 or 12 pounds, or even more. The rind is of a greenish-yellow colour, smooth, thick, spongy, and bitter. The interior consists of ten or twelve loculi or compartments, containing white or reddish pulp and egg-shaped seeds. This fruit is more sour than an orange, but less sour than a lemon. Cuban fruit is less acid, and devoid of the bitterness which to some extent characterizes the Californian and other subvarieties. All kinds, however, make nice preserve and marmalade. They are grown plentifully in Jamaica, Cuba, California, and most Oriental countries. The name Pomelo is from the Dutch name *pompelmoes*, and Shaddock was the name of a captain who brought it to the West Indies.

Sources of the British Supply of Oranges.[1]—1. Sweet oranges: *Naples*, from May to August; *Murcia*, July and August; *Brazil*, July to October; *Australia*, ditto; *Florida*, September and October; *Jaffa*, October to February; *Valencia* and *Denia*, November to July; *Almeria*, November to May; *Palermo* and *Messina*, October and February. They are gathered before they are ripe for exportation, packed tightly in boxes, the best being wrapped in paper, and provided with free ventilation. Oranges shrink and become drier during transit, owing to evaporation. Navel oranges come from Brazil, Bahia, Majorca, and California; seedless navel oranges from California. Blood oranges are from Malta, Egypt, and Provence; egg oranges from Malta, Jaffa, and Zanzibar. 2. Bitter or sour oranges come from Seville, Denia, Lisbon, Palermo, and the Canary Islands. 3. Grape-fruit, pomelos, or shaddocks, come from Jamaica, Cuba, California, etc.

The Composition of Oranges.—Fresh oranges are valuable chiefly for the sugars contained in the refreshing juice, and the anti-scorbutic properties of the salts. Like most kinds of fruit, they assist in overcoming constipation, their acids and cellulose stimulating muscular contraction. Orange-peel is aromatic and stomachic; that of sweet and bitter oranges is preserved, dried, candied, and used for flavouring puddings, cakes, and confectionery. Bitter oranges are chiefly used, in combination with sweet fruit, to make

[1] "The Practical Grocer," vol. ii.

COMPOSITION OF ORANGES—PERCENTAGES.

	Refuse.	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Ash.	Authority.
Sweet oranges: As purchased, average ..	27·0	63·40	·60	·10	8·50	—	·40	Atwater.
Edible part: All analyses, mean ..	—	82·85	·93	·21	10·64	·50	·70	Tibbles.
Fifty analyses	—	89·00	·80	·10	5·15[1]	·50	·49	Bauer.
Minimum	—	80·00	·80	·10	11·60	—	·50	Atwater.
Maximum	—	88·30	1·10	·30	18·50	1·50	·50	
Average	—	86·90	·80	·20	11·60	—	·50	
Varieties: Jaffa	—	85·50	·90	·10	12·60	·40	·40	Tibbles.
Denia	—	87·50	1·00	·20	10·80	·40	·50	
Murcia	—	86·80	1·00	·20	11·40	·50	·50	
Valencia	—	84·60	·90	·15	10·70	·50	·40	
Navel: As purchased	25·6	64·31	·94	·13	8·06	—	·47	Jaffa.
Edible part	—	84·69	1·26	·18	10·84	—	·63	
Orange-juice	—	88·20	—	—	9·65	Acids 1·75	1·28	Tibbles.
Orange marmalade	—	14·50	·60	·10	84·50	—	·30	Atwater.

[1] Sugars only.

marmalade, the fruit being sliced and preserved in boiling syrup. Marmalade is nutritious to the extent of the sugars contained in it, and antiscorbutic by its salts. It is appetizing, and forms an unstimulating addition to our food. It should be made from the finest fruit. Adulteration by substances rich in pectose bodies and by agar-agar is, however, frequent and almost invariable.

The *edible portion* of an orange forms from 65 to 75 per cent. of the whole fruit. As a food they depend upon the content of sugars and the amount of digestible fibre, which vary in proportion to the ripeness. The proportion of sugar varies from 5 to 10 per cent., and averages 5·65 per cent. It consists of cane-sugar and invert sugar; the more cane-sugar there is, the sweeter the orange. According to Buignet, however, the sugar in ripe fruit averages 8·78 per cent., and consists of 4·22 of cane-sugar, or sucrose, and 4·36 per cent. of reducing-sugars (invert sugar, dextrose, and lævulose). The fat is practically nil, and the protein seldom exceeds 1 per cent. The acids vary from 1 to 2·5 per cent., and average 1·5 per cent. The amount is greatest in green fruit, and diminishes as it ripens. It is, however, always more abundant in "sour or bitter" oranges, and less abundant in "sweet" oranges. The acids are chiefly citric and phosphoric, with a little malic and other acids alone and in combination with bases. These acids add to the hygienic value of the fruit, which is greatly superior to their food value. Atwater found the heat of combustion amounted to 240 calories per pound, which is chiefly due to sugars. The *juice* of Valencia oranges contains—Total solids 10·9, sugar 7·6, citric acid 1·7, phosphoric acid 0·027, ash 0·52, per cent.[1] Other orange-juices are similar. Californian *grape-fruit juice* contains 13·2 per cent. of total solids, including 9·5 per cent. of sugars and 2·7 per cent. of acids.

The Oil of Sweet Oranges.—The flavour and aroma of oranges is due to a volatile oil contained chiefly in the oil glands of the peel, the composition of which is as follows : *d*-limonene 90 per cent., citral or decylic aldehyde, $C_{10}H_{16}O$ (224°), *d*-linalool, nonyl-aldehyde, and caprylic acid. The *peel* also contains, according to Tanret, a resinous principle containing aurantiamaric acid ($C_{10}H_{12}O_4$), and aurantiamarin (an uncrystallizable bitter substance).

The *Ash* of oranges is given in the table on p. 623.

The fruit of the orange family is amongst the most popular in the world. Their flavour and aroma justly place them in the front rank of dessert fruits. Their culture is a great industry in all countries where by natural adaptation or art they may be made a source of profit. The softer the pulp, the greater their freedom from acidity, fibre, and seeds, the more valuable they are from both the growers' and consumers' point of view. Like bananas, the fruit ripens when removed from the tree, and such fruit is that seen in the markets of Great Britain and other places distant from the seat of culture. But the fruit ripened on the trees is finer, more juicy

[1] Farnsteiner and Stubner, *The Analyst*, February, 1905.

and tender. Large areas of land are devoted to their culture in all regions where they flourish, and the grower is likely to reap profit from his industry.

Composition of the Ash of Oranges—Percentages.[1]

	China Orange.	Rough Skin.	Sour or Bitter Orange.	Grape Fruit.
Total ash	·52	·55	·57	·39
Composition :				
Potash, K_2O ..	40·66	49·15	45·09	44·19
Lime, CaO ..	10·26	2·62	7·95	7·34
Magnesia, MgO ..	5·27	1·41	2·17	3·92
Ferric oxide, Fe_2O_3	1·09	4·51	2·40	1·28
Phosphoric Acid, P_2O_5	8·56	7·42	8·70	11·09
Sulphuric acid, SO_3	2·84	3·42	2·72	3·29
Chlorine	2·44	1·50	·98	1·38
Silica, SiO_3 ..	1·01	—	—	—

Pineapples.

The fruit of *Ananas sativa*, N.O. Bromeliaceæ. The fruit is a berry, and the berries of each inflorescence coalesce into a large spurious fruit (*sorosis*). The cultivated fruit contains no seeds. The plant is a native of South America, where it is called " nana " (corrupted to " ananas " by the Portuguese), but it is cultivated in all warm countries. It was introduced by Europeans into Asia and Africa after the discovery of America, and into England in the seventeenth century, but at the present time is only grown there in hothouses. It is, however, grown largely for exportation in the Azores, Canaries, Madeira, Natal, Zanzibar, West Indies, Florida and other southern States of America, and in Far Eastern countries. Most pineapples eaten in England are imported from the Azores. In many places, as the Bahamas, they are grown in fields. For exportation they are cut before they are ripe, and packed in well-ventilated boxes.

The green fruit is not edible, it is almost caustic in taste and action ; but the ripe fruit forms one of the most fragrant and delicious desserts, the juice of which is very sweet and grateful. It contains a proteolytic ferment capable of peptonizing albuminoids, for which reason it is used to a considerable extent in the preparation of various artificial foods. This proteolytic ferment renders it a very suitable accompaniment of the repast, and an aid to digestion especially appropriate at the end of a banquet. The juice is also beneficial in certain forms of bronchitis, attended by the expectoration of fibrinous or tenacious mucus.

The following table showing the composition of pineapples

[1] Bulletin 87, Bureau of Chemistry, U.S. Department of Agriculture.

analyzed in the department of the United States Bureau of Chemistry is given by Wiley :[1]

COMPOSITION OF PINEAPPLES—PERCENTAGES.

	Solids.	Sugar.	Protein.	Ash.	Acidity.
FRESH FRUIT :					
All countries : Minimum ..	10·78	8·20	·21	·27	·30
Maximum	18·86	15·20	·57	·55	·85
Average ..	14·17	11·90	·42	·40	·60
Florida fruit—Average ..	13·85	11·69	·40	·42	·52
Cuba fruit ,, ..	14·52	11·85	·40	·35	·56
Porta Rica fruit ,, ..	15·91	15·36	·48	·37	·72
Bahamas fruit ,, ..	14·81	12·22	·48	·40	·77
Singapore fruit ,, ..	13·39	11·73	·48	·38	·39
Nassau fruit ,, ..	13·18	10·86	·40	·41	·59
CANNED FRUIT :					
Singapore fruit ,, ..	20·15	17·90	·46	·28	·30
Bahamas fruit ,, ..	13·78	10·69	·34	·38	·57
Straits Settlements fruit— Average	21·04	18·45	·47	·26	·26

The nutritive value of the fruit depends entirely upon the sugars, which, according to Buignet, averages 13·61 per cent., including 11·63 per cent. of sucrose, or cane-sugar, and 1·98 of invert sugar (dextrose, and lævulose). Wiley found that the sugar consisted of 60 per cent. of sucrose and 40 per cent. of invert sugar. The acids average 0·60 per cent. reckoned as sulphuric acid. The protein is exceedingly small. The flavour is due to essential oils and compound ethers, the special aroma being due to butyrate of ethyl. The amount of sugar depends upon the condition of the fruit, varying from 8 to 17 per cent., and is most abundant in fruit ripened on the plant. Bahama and Porta Rica fruit is sweeter than that of Cuba or Florida, but all have about the same average proportion. *Tinned fruit* has additional sugar; consequently the analyses show it to be richer in carbohydrate. It contains a maximum of 25 per cent. in Singapore fruit, against an average of 12 per cent. in tinned and a maximum of 17 per cent. in fresh fruit. When, however, the proportion of sugar in tinned fruit is unusually low, it is due to its immaturity before being packed.

Bananas.

The fruit of several species of the natural order Musaceæ, especially the following :

1. *Musa sapientum*, or banana, native of the West Indies.
2. *M. paradisiaca*, or plantain, native of the East Indies.
3. *M. ensete*, native of Abyssinia.
4. *M. cavendishii*, native of China.
5. *M. assamica*, of Northern India.
6. *M. troglotydarum*, of the Moluccas.

1 "Foods and their Adulteration," pp. 361-365.

De Candolle[1] says there is only one banana (*M. sapientum*), that it is a native of Southern Asia, and was carried to America by Europeans. The antiquity and wild character of the banana in Asia are incontestable facts. The claims of America, on the other hand, while supported by Humboldt and Boussingault, are much disputed. Botanists who have explored America have no hesitation as to the Asiatic origin. The Greeks, Latins, and Arabs, speak of it as the fruit of a remarkable Indian tree. The Greeks saw it in India at the time of Alexander's expedition. Sages ate the fruit, hence the name *M. sapientum*. *Musa* is from the Arabic *mouz*, or *mamoz*, and occurs as early as the thirteenth century. The specific name *paradisiaca* comes from a legend that it figured in the story of Eve and Paradise. It is a curious fact that the Hebrews and ancient Egyptians did not know it. It is a sign, says De Candolle, that it did not exist in India from a very remote epoch, but was first a native of the Malay Archipelago.

The nomenclature of bananas is very indistinct. In some countries the names of banana for *M. sapientum* and plantain for *M. paradisiaca* are adhered to; in India both are plantains; in Zanzibar both are bananas; in other countries a still greater distinction is made for the varieties. The *Journal of Agriculture* for Zanzibar says there are nineteen named varieties. According to other authorities there are known 176 varieties, that most cultivated for the market being the large yellow variety of Jamaica or Martinique.

Bananas are natives of the Old World, and are cultivated throughout Eastern countries, the West Indies, Central and Southern America, many of the smaller tropical countries, and practically all regions adapted to their growth. The plants are herbaceous perennials or biennials, which die down when they have produced their fruit. The fruit is a berry which has no endosperm, but a large perisperm, and is always cut before it is ripe. When they are to be consumed locally, Jamaica bananas are cut at a time when it is deemed that the stalk has sufficient vitality to provide for the sustenance of the fruit during the final stages of ripening. They are still green, but the proper moment for cutting is well known to an experienced grower. For exportation they are cut earlier than for local consumption, and are stored in a moderately warm room or the hold of a vessel where the temperature is maintained between 60° and 70° F., and protected from draught. The fact that the fruit will ripen after separation from the plant, and loses little of its real value by being separated, has led to its being transported long distances from the place of cultivation, most of that consumed in Great Britain coming from Jamaica and other West Indian places, the Canaries, Southern and Central America.

The ordinary banana is yellow when ripe, but some of the smaller species are of a red colour. They are largely used for food wherever they grow, and in some regions they constitute one of the principal foodstuffs of the native population. They are very prolific, and

[1] "Origin of Cultivated Plants," pp. 304-308.

an acre of land set with bananas will produce more food than the same area set with potatoes or wheat. Humboldt calculated that 100 square yards set with bananas would produce 4,000 pounds of fruit; the same area set with potatoes would produce 1,000 pounds of tubers, and with wheat only 30 pounds.

The fruit contains a soft and luscious pulp of delicious flavour. They are eaten raw, fried in slices, or roasted in ashes; the green fruit is boiled and eaten as a vegetable. Flour is made from the unripe or green fruit, gathered before the starch is converted to sugar, dried in the sun or by artificial heat, reduced to a powder, and sifted. This flour is used in the form of "damper," cake, porridge, biscuits, etc. Dried bananas are also prepared by exposing the perfectly ripe fruit to the sun; when they begin to shrivel the skin is peeled off, and they are then completely dried. When finished they are white and mealy, have a coating of sugar upon them, and are pressed into masses between banana leaves; they have a flavour between that of a date and a fig, are very sweet, but without acidity.

Composition.—They are among the most nutritious fruits, but consist chiefly of carbohydrates, and especially sugars. The starch consists of long, narrow granules with indistinct striæ and hilum. The proportion varies according to their condition. Ricciardi[1] found that green bananas contain 12 per cent. of starch, which mostly disappears during ripening, along with the tannin and organic acids. Doherty[2] found 6 per cent. of starch in ripe fruit; but other observers find less than this, most of it being converted into sugars and other soluble carbohydrates. The woody fibre does not exceed 2 per cent. The sugars in *ripe* fruit average about 20 per cent. of the edible portion, but Doherty found as low as 3 per cent. sugar and 11 per cent. of other carbohydrates. The proteins are small; in ripe fruit they average 1 per cent. of the edible portion, and consist of albumin and gluten. The acidity = 0·3 per cent., reckoned as sulphuric acid. The ash varies from 0·5 to 1·0 per cent., as shown in the following table,[3] being 0·70 per cent. in Niño, 1·08 in Orinoco, and 0·83 in Colorado bananas.

Composition of the Ash—Percentages.

	Niño.	Orinoco.	Colorado.
K_2O	46·46	52·41	51·47
CaO	·95	1·02	·37
MgO	·42	1·90	·65
P_2O_5	10·36	5·16	3·25
SO_3	2·36	3·32	2·77
Cl	6·59	8·48	7·63

[1] Biedermann's *Centralb. f. Agrik. Chem.*, xiv. 18.
[2] *Chemical News*, 1892, lxxiv. 187.
[3] Bureau of Chemistry, Bulletin 87, U.S. Department of Agriculture.

COMPOSITION OF BANANAS—PERCENTAGES.

	Water.	Protein.	Fat.	Carbo-hydrate.	Fibre.	Ash.	Authority.
Fresh fruit: As purchased (refuse 35 per cent.)	48·67	1·01	·15	12·41	—	·60	Bulletin 132, U.S. Department of Agriculture.
Entire fruit	48·90	·80	·40	14·30	—	·50	Bulletin 142, U.S. Department of Agriculture.
Edible portion: All analyses ..	75·50	1·26	·50	21·70	·81	·76	Tibbles.
Minimum ..	66·30	1·00	·00	16·30	—	·50	Atwater and Bryant.
Maximum ..	81·60	1·60	1·40	29·80	—	1·10	Atwater and Bryant.
Average ..	75·30	1·30	·60	22·00	—	·80	
	73·85	1·13	—	21·71	—	·84	Wiley's "Foods."
	72·75	1·21	—	21·76	—	·86	Wiley's "Foods."
	73·10	1·87	·63	23·05	·29	1·06	König.
Jamaica fruit, average	73·30	1·30	·60	22·00	—	·80	Doherty.[1]
Fiji fruit, average	75·77	1·71	—	20·13	—	2·45	Doherty.[1]
Musa paradisiaca	73·90	4·80	·63	19·66	·20	—	Corenwinder.
Dried fruit	29·20	5·30	2·30	55·80	—	5·30	Farmers' Bulletin 293.
Fiji, water-free	—	7·05	—	84·88	7·26	2·92	Doherty.[2]
Banana flour: All analyses ..	11·10	3·55	·83	81·70	1·50	2·23	Tibbles.
Average	9·70	3·10	·50	83·40	—	5·30	Farmers' Bulletin 293.
	13·00	4·00	·50	80·00	—	2·50	Hutchison.[3]
	10·62	3·55	1·50	81·60	1·60	1·60	Coppock.[4]

[1] *Chem. News*, 1892, lxxiv. 187. [2] *Ibid.* [3] "Food and Dietetics," p. 244. [4] *Chem. News*, 1897, 78.

In some countries the banana is a far more important article of food than it is in Europe. To an immense portion of the human race it occupies the place of wheat, rye, barley, and potatoes, used by inhabitants of temperate regions.

A reference to the analyses given above, however, show that the banana is deficient in protein and fat. It contains less of these elements than the cereals do. The proportion of protein and fat places it on a par with the potato, but with the advantage that it is unnecessary to cook it. The fresh fruit is too bulky, however, to form a satisfactory ration, for one must consume 1,400 grammes (nearly 50 ounces) in order to obtain 300 grammes of carbohydrate, which, moreover, would contain but 21 grammes of protein and very little fat, and would yield only 1,400 calories. It is true the protein and fat deficiency could be made up by drinking milk, whereby more carbohydrate would also be taken. Weight for weight, it is somewhat inferior in nutriment to potato ; but it is more productive than any other plant cultivated for food, and a larger number of persons can be fed from a given space of ground planted with bananas than an equal space planted with potatoes or any cereal.

A comparison of banana flour and wheaten flour or oatmeal is also to the disadvantage of the fruit, and shows it to be deficient in protein and fat as compared with the cereal products, but it is a more valuable source of carbohydrate.

NUTRITIVE VALUE OF BANANA AND OTHER FOODS COMPARED.

	Banana.	Banana Flour.	Wheat Flour.	Oatmeal.	Potatoes.
Moisture	75·50	11·10	14·0	8·9	78·3
Protein	1·26	3·55	11·4	15·5	2·2
Fat	·50	·83	1·0	10·1	·1
Carbohydrate	21·70	81·70	75·0	54·8	18·4
Mineral matters	·76	2·23	1·7	4·0	1·0

Banana flour can be made into cakes. An ordinary ration for natives working on an estate consists of 2 pounds of banana meal and $\frac{1}{4}$ pound of salt pork. This contains, roughly, protein 35 grammes, fat 96 grammes, carbohydrate 735 grammes, and is manifestly deficient in protein. It could be improved by the addition of milk. Europeans should consider bananas as a dessert to follow a meal containing meat, fish, eggs, peas, beans, or nuts. The fruitarian should beware of consuming a one-sided diet. The extreme productivity of the plant renders the fruit a cheap source of food wherever it grows, and one which promises to become important to those parts of the world where it is exported.

Agave.

The American aloe, *Agava americana*, N.O. Amaryllidaceæ, of Mexico and the West Indies, which has been cultivated from time immemorial, yields a sugary juice or sap which, when fermented, forms **pulque,** a native wine resembling cider. The fruit is sometimes a berry, and at other times a trilocular capsule. The sap is obtained just when the flower is ready to burst forth. It has the following composition, according to Boussingault :[1]

JUICE OF AGAVA AMERICANA.

Lævulose	26·45
Saccharose	61·71
Malic acid	3·53
Gum	5·45
Albumin	10·13
Ammonia	·06
Mineral salts	6·21
Water	886·46
	1000·00

Mamey Fruit.

The **Mammee Apple,** or abricot de St. Dominique (*Mammea americana*, N.O. Guttiferæ), is grown extensively in South America, the West Indies, Cuba, and other tropical countries, where it is highly esteemed as well as in the United States. It is a large fruit of a baccate character, may be round or have three or four angles, is 2 to 9 inches in diameter, and weighs from 8 to 20 ounces. It is covered with a brownish-yellow external rind of leathery consistence, and a thinner internal rind which adheres closely to the flesh. The flesh is firm, bright yellow, has a sweet, aromatic perfume, an acidulous, saccharine, but peculiar taste, it contains much juice, and seeds about 2 or 3 inches in size in a large fruit. Although eaten raw, the fruit is mostly used for preserves and marmalade.

COMPOSITION—PERCENTAGES.[2]

	Edible.	Solids.	Ash.	Acids.	Protein.	Sugars.
Fresh raw fruit	60·7	14·12	·310	·420	·490	9·47
Preserve, or Mamey en Almibar	—	60·05	·154	·194	·363	57·45
Marmalade de Mamey	—	69·74	·149	·123	·269	62·68

The **Mamey Colorado** is a fruit having some resemblance to the former, but does not belong to the same genus. It is a large round chocolate-coloured fruit with a yellow dry mealy pulp, of a subacid, sweetish taste. The edible portion contains 34 per cent. of solids, including 22 per cent. of sugars, 0·1 of acids, and 0·8 of ash.[3]

Mangosteen.—The fruit of *Garcinia mangostana*, a genus of Clusiaceæ, grown in India, China, and the Malay Archipelago. It is the size of an orange, and is accounted the most delicious and wholesome fruit in the world.

Durian, the fruit of *Durio zibethenus*, N.O. Malvaceæ, a lofty tree of the

[1] *Anal. de Chim. et de Phys.* (4), xi. 447.
[2] Wiley's "Foods," p. 355.
[3] *Ibid.*

Malayan Archipelago. It is the size of a man's head, and a favourite of the natives, who consider it a most delicious and enticing fruit, being in season in May and June, and again in November. The odour of the fruit is offensive, like that of putrid animal matter ; but it is associated with a most delicious flavour, which, in the opinion of most authorities, places it in the front rank of tropical fruits. The kernels of the seeds, which are surrounded by an aril like that of nutmeg, resemble blancmange.

Melons.

Melons are the fruit of varieties of *Cucumis melo*, N.O. Cucurbitaceæ, which have been cultivated from time immemorial in Eastern countries, but probably for not more than two thousand years. Naudin finds the species includes an enormous number of varieties and strains, which he divides into ten groups, and calls them *canteloups, melons brodés, sucrins, melons d'hiver, serpents, forme de concombre, chito, dudaim, rouge de Perse,* and *sauvages.* He divides the wild varieties into Indian and African forms. Those of India have a fruit which is sweet, insipid, or slightly acid, striped or all of one colour, differences which are common to the cultivated canteloupe. The African forms appear to have been derived from those which grow wild in Guinea, whose fruit smells like a fresh green melon. The dudaim, among cultivated varieties, is allied to it. The majority of the species are found in Africa, a minority in Asia and America.

De Candolle says the culture of the melon may have begun separately in India and Africa. Its introduction into China appears to date from the eighth century of our era. It is not proved that the ancient Egyptians cultivated it. It is probable that it was introduced into the Græco-Roman world in the time of the Empire, at the beginning of the Christian era. Since the Renaissance an improved mode of cultivation and closer relations with the East have been the means of introducing better varieties into our gardens.

The **Common Melon**, or musk melon, originally from India, Beluchistan, and Guinea, has been grown in hot Eastern countries from time immemorial. It is well known as a large yellow or yellowish-green oval fruit, with a highly-flavoured sweet pulp. The subvarieties include—(*a*) the Citron, (*b*) the Canteloupe, (*c*) the Nutmeg, and (*d*) the Pineapple melons, so called from their various characteristics. The canteloupe, named after its place of origin, is a small round or globular variety, of pale green or yellow colour, fragrant odour and flavour. The Egyptian melon, or shamman (*C. melo chate*), is a fruit similar to the musk melon. Many people consider it the finest fruit grown in Egypt and Arabia. The Persian or Queen Anne's melon, *C. dudaim*, native of Persia, has a variegated colour, green and orange, but becomes yellowish or white when fully ripe. It has a fragrant vinous or musk-like odour and somewhat insipid pulp. Melons are grown to some extent in England and the Channel Islands, where they require a covernig of glass or artificial heat to bring them to perfection. They are largely imported from warmer climates.

The **Water Melon,** or batikh (*Citrullus vulgaris*), a native of tropical Africa, was cultivated by the ancient Egyptians. Its cultivation early spread into Asia, and it was introduced to America by Europeans. It is a smooth round fruit of green colour, having a hard green rind and a rose-coloured interior, a rich, delicious flavour, a pulp which nearly melts in the mouth, and an abundant watery juice of sweetish taste, for which it is highly prized. They are imported from the South of France, Spain, and Mediterranean ports. The water melon is a very important part of the food of the natives in Egypt during the hot months of the year. It is much esteemed in India, and grows in America from Chili to the United States.

These and other varieties of melon are grown in nearly all hot countries, where they are esteemed for their cool, juicy, and succulent pulp, which is sweet, highly flavoured, but of little nutritive value. They are grown throughout northern Africa, Egypt, Arabia, India, China, Japan, Persia, the West Indies, the southern States of North America, and South Europe.

Composition of Melons—Percentages.

	Refuse.	Water.	Protein.	Fat.	Carbohydrate.	Fibre.	Ash.	Authority.
Melons :								
As purchased	50·0	44·80	·30	—	4·60	—	·30	Bulletin 28, U.S. Department of Agriculture.
Edible part	—	89·50	·60	·30	9·30		·60	
	—	88·90	·70	·30	7·60	1·0	·60	Hutchison.
Canteloupe, edible part	—	89·50	·60	—	7·20	2·1	·60	Bulletin 132.
Water melons :								
As purchased	59·4	37·50	·20	·10	2·70	—	·10	Bulletin 142.
	62·0	35·05	·33	·03	2·44	—	·10	Bulletin 132.
Edible part	—	92·90	·30	·10	6·50	—	·20	Hutchison.
	—	92·40	·40	·20	6·70	—	·30	Bulletin 28.
	—	92·17	·87	·10	6·41	—	·27	Bulletin 132.

Pomegranate.

The fruit of *Punica granatum*, N.O. Myrtaceæ, is a berry or capsule grown on a spiny shrub in Spain, Portugal, East and West Indies, China, etc.; indigenous to Persia, Afghanistan, and adjacent countries. Cultivated from time immemorial. It was well known to the Greeks of Homeric times, and entered into the ceremonies of the ancient Romans. The edible pulp consists of reddish globules having a sweet but subacid taste. Mixed with water and sweetened with honey or sugar, it makes a delicious beverage. The Persians make a wine of them, and the South Americans a beverage called "aguardiente." The rind is highly astringent. Both fruit and

rind have medicinal properties. The expressed juice of the ripe fruit contains 10 to 13·6 per cent. of sugars, and 0·51 per cent. of organic acids.[1]

COMPOSITION—PERCENTAGES.[2]

	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.
Edible part: Minimum	75·4	1·3	1·2	18·5	·5
Maximum ..	78·2	1·6	2·1	20·4	·8
Average	76·8	1·5	1·6	19·5	·6

Guava.

The fruit of *Psidium guajava*, N.O. Myrtaceæ. According to De Candolle, it is of American origin, being wild in the whole of Central America and the West Indies. Species were found wild in the Malay Archipelago as early as the sixteenth century, but they were the result of naturalization, the common names in Malay being derived from the American *guiava*. There are several varieties, but the two principal have an apple- or pear-shape berry. The common or white guava, *P. pyriferum*, is a pear-shaped fruit of the size of a tennis-ball, with a russet-coloured rind, tinged in places with red. The pulp is pink or white, of a sweet, agreeable aromatic flavour, interspersed with numerous white seeds. The red guava, *P. pomiferum*, is apple-shaped. The pulp is yellowish-red, very acid, and much inferior to the former. There is also a small round variety, *P. cattleianum*, of about the size of a walnut, deep purple colour, pulp of consistence of a fig, but juicy, and resembling a strawberry in flavour. There are sixty or more species grown in South America, West Indies, China, and other Oriental countries, etc. They are eaten raw, in jelly and marmalade. The latter has a unique flavour. The fruit contains about 20 per cent. of solid material, including 1 per cent. of protein, the remainder being sugar, chiefly invert sugar, and organic acids. The preserve is made with 50 or 60 per cent. of added sugar. The jelly is obtained from fruit which is not quite ripe. They are sliced and heated to draw out the juice, which is then expressed and boiled with sugar until it gelatinizes. The composition of the edible portion of the fresh fruit is—Water 80, protein 1·13, fat 0·57, carbohydrates 16·60, crude fibre, 1·31, ash 0·2, per cent.[3]

Tamarind.

The fruit of *Tamarindus indica*, N.O. Leguminosæ, is a berry, or, more properly, a legume, of from 1 to 6 inches long, dark brown colour, a thin and brittle exterior when dry, and containing a dark

[1] *Jour. Chem. Soc.*, Abstracts, 1898, 16.
[2] Atwater and Bryant, Bulletin 28, U.S. Department of Agriculture.
[3] Bulletin 132, U.S. Department of Agriculture.

fleshy pulp which is used both for food and medicine. The composition, according to Wiley,[1] is as follows: Water 47·7, protein 1·36, **sugars 31·43,** acids 6·03, ash 1·56, per cent. The sugar is chiefly invert sugar. The acidity, according to other authorities,[2] is 11 to 16 per cent., due to cream of tartar (8 per cent.), tartaro-acetic and citric acids, and various aromatic acids, which may reach 10 per cent. The fruit is imported from the East and West Indies. Tamarinds from the East Indies are about 6 inches long, dark, dry, but containing much pulp. They are preserved by the addition of salt and drying in the sun. As they contain no added sugar, they are esteemed for medicinal uses. The West Indian fruits are shorter but much redder than the former, and, being preserved in sugar, are much more palatable. They are preserved by putting them in jars, with layers of sugar between them, or by pouring boiling syrup over the ripe fruit. Preserved tamarinds should be fresh and juicy, free from musty odour, and have an agreeable smell and taste. They are laxative and refrigerant. An infusion is highly grateful to those suffering from fevers and inflammations. The pulp is an agreeable addition to the diet of convalescents.

Tamarind Whey is made by mixing 1 ounce of the pulp with 1½ pints of warm milk, and is a nourishing acid beverage esteemed by sick persons.

Tomatoes.

The tomato (*Lycopersicum esculentum*, N.O. Solanaceæ) is a native of Southern and Central America, being first cultivated in Peru; but it is also found wild in the East Indies, where it is said to have been introduced by the Spaniards. It is cultivated in all warm and temperate climates, and was brought to Europe in the sixteenth century. A large quantity is grown in England, especially in hothouses, and they are imported from the Canaries (*February*), Malta (*March and April*), and the Channel Islands from May throughout the year.

Composition.—They contain about 1 per cent. of protein, 0·4 per cent. of fat, 4·0 per cent. of saccharine matter, carrotin (colouring matter, a brown resinous substance), an acrid volatile oil, an alkaloid, and salts. They do not contain oxalic acid, as frequently stated, but citric acid. As a fruit they are estimable either raw or cooked; they are also used largely in sauces, soups, ketchup, preserves, and confectionery. The ketchup is usually preserved by the addition of sodium benzoate.

The **Egg-Plant,** or aubergine (*Solanum melongena v. esculentum*), is a native of the East Indies, but is grown in South Europe, America, and West Indies. It produces a large oval fruit which resembles a hen's egg in size, shape, and colour; eaten like tomatoes.

Composition.—Water 93·0, protein 1·13, fat 0·3, carbohydrates 4·27, fibre 0·69, ash 0·6, per cent.

Other fruits belonging to N.O. Solanaceæ are also consumed—

[1] "Foods and their Adulteration," p. 367. [2] Brit. Pharm. Codex.

e.g., *S. quitoense*, called by Spaniards the Quito orange, from its size, appearance, and flavour ; *S. ethiopica*, grown in Africa ; *S. muricata*, which grows in Peru, and has the flavour of a melon ; and *S. vulgare*, an oval yellow fruit, called the " Kangaroo apple " in Australia.

Currants and Gooseberries.

These berries, being the fruit of the same genus (*Ribes*, N.O. Saxifragaceæ), may be treated together. The fruit is a berry containing a sweet mucilaginous substance mixed with malates, nitrates, *free* organic acids, and an astringent substance.

AVERAGE COMPOSITION OF CURRANTS AND GOOSEBERRIES—PERCENTAGES.

	Water.	Protein.	Fat.	Carbohydrate.	Fibre and Seeds.	Free Acids.	Ash.	Authority.
Currants ..	84·77	·51	—	7·28	4·59	—	·72	Bauer.
	85·00	1·50	—	12·80	—	—	·70	Atwater.
Red and white ..	85·20	·40	—	7·90	—	—	·50	Hutchison.
White ..	83·42	·68	—	7·12	4·85	2·53	·70	Fresenius.
Red ..	85·27	·49	—	6·44	4·48	1·83	·57	
Large red	85·35	·35	—	5·64	3·94	1·69	·62	
Black ..	79·00	·50	·3	13·10	6·10	—	·72	Farmers' Bulletin 293.
Gooseberries	85·74	·07	—	8·43	3·52	—	·42	Bauer.
American	85·60	1·00	—	10·10	3·50	—	·30	Farmers' Bulletin 293.
Yellow ..	85·36	·36	—	7·50	—	1·33	·27	Fresenius.
Small red	84·83	·44	—	6·23	—	1·59	·50	
Large red	85·35	·44	—	8·06	2·99	1·35	·31	

Gooseberries (*Ribes grossularia*) are the fruit of a spinous shrub growing wild in parts of Britain and Europe, and from which all the cultivated varieties are derived. The cultivation of the fruit in England, Holland, and Germany, was begun in the sixteenth century. The varieties and subvarieties differ from one another only in size, colour, and hairiness of the fruit, the American variety being smooth. Analyses show that they contain very little protein and fat. The sugars average 7·5 per cent., and consist chiefly of invert sugar. This varies, however, according to ripeness and whether raw or cooked. One analysis shows that *raw* gooseberries contain cane-sugar 1·16 and invert sugar 5·84 per cent. ; the same fruit *boiled* contained, cane-sugar 0·00 and invert sugar 6·91 per cent. The other non-nitrogenous contents are pectose, cellulose, seeds, etc., 3·5, and ash 0·4, per cent. The *free* acids average 1·0 to 1·5 per cent. in ripe fruit ; but 2·66 per cent. has been obtained from the skins, and 1·80 per cent. from the pulp, reckoned as tartaric acid. Gooseberries are wholesome, agreeable fruit, and come into season when other fruits are scarce. They are of especial benefit to plethoric individuals and those of bilious tendency.

Red Currants (*Ribes rubrum*) : the fruit of a tree native in the North of England, Scotland, and temperate Europe, cultivated from the Middle Ages ; used for puddings, pies, wine, and jelly. The jelly and a beverage made from it or the fresh juice form a refreshing and agreeable beverage useful in fevers and inflammations. The *white currant* is a variety of the red tree, the fruit differing only in colour and flavour. **Black Currant** (*R. nigrum*) also grows wild in the woods of Scotland, England, and northern Europe. The fruit is used for the same purposes as the red variety. The berries of *R. sanguinum* are the fruit of an ornamental flowering shrub. They are deficient in the fine qualities of black and red currants, and are particularly destitute of pulp. They are sometimes erroneously considered to be poisonous. *R. fragrans* and *R. lacustre*, natives of North America, are sometimes eaten. The former has a sweet taste and fragrant odour ; the latter is much like the ordinary black currant in size, colour, and taste. Black and red currants contain about 6·5 per cent. of sugars, 0·9 per cent. of other non-nitrogenous extractives, 2·25 per cent. of free acids, 4·5 per cent. of pectose, cellulose, and seeds, and 0·75 per cent. of salts. They have a diaphoretic action, are soothing to an irritable throat, quench the thirst, and refrigerate the system.

Bilberries, Whortleberries, and Cranberries.

The berries of various plants of N.O. Vacciniaceæ are much appreciated as fruit. Whortleberry is the common name for several of these. The most common are—

Vaccinium vitis-idæa : Huckleberry, red bilberry, red whortleberry.
V. myrtilus : Bilberry, blueberry, blaeberry or whortleberry.
V. uliginosum : Great bilberry or bog-whortleberry.
Oxycoccus palustris : The cranberry or moorberry of Great Britain.
O. macrocarpus : The American cranberry.

The fruits are subacid, moderately astringent, and contain mucilage, sugar, malic and citric acids, and an astringent substance which exercises a tonic effect.

The common *Bilberry*, *Blaeberry*, or *Blueberry*, grows abundantly on the moors of England, Scotland, and other countries. The fruit is the size of a currant, of a bluish-black colour, covered with a mealy bloom. They are eaten raw, in tarts or jelly. They contain 5·0 per cent. of sugars, which are chiefly glucoses, pentoses, and inosital,[1] with 1·66 per cent. of free malic and citric acids, but no oxalic or tartaric acid. The juice of bilberries is used for colouring wine, and is difficult of detection, because the colouring matter gives the same reactions as that of grapes.[2]

The *Red Whortleberry*, *Red Bilberry*, or *Huckleberry*, also grows on moors and barren land. It is a dark red berry, acid and austere,

[1] *Year-Book of Pharmacy*, 1897, 65.
[2] Andrée, *Archiv Pharm.*, xiii. 90.

not nearly so agreeable as the former. It makes an excellent jelly, which is eaten with meat and dissolved in water forms a refrigerant beverage. The composition is similar to the former, but they contain more acid and less sugar. The *great whortleberry*, or bog-whortleberry, is large and black, less juicy, and neither so agreeable nor wholesome as either of the former. When eaten in a great quantity, it is apt to produce headache or vertigo.

COMPOSITION OF BILBERRIES AND ALLIED FRUIT—PERCENTAGES.

	Water.	Protein.	Fat.	Carbohydrate.	Fibre and Seeds.	Free Acid.	Ash.	Authority.
Bilberry, average	77·55	·79	—	5·78	12·86	1·34	·85	Fresenius.
Bilberry or blaeberry, average	85·60	·60	·6	12·80[1]	—	—	·40	Atwater.
Blaeberry, average	76·30	·70	3·0	5·80	12·20	1·60	·40	Hutchison.
Huckleberry, average	81·90	·60	·6	16·60[1]	—	—	·30	Atwater.
Red whortleberry, average	78·36	·70	—	5·90	—	—	1·00	Bauer.
	89·60	·10	·3	3·80	6·00	—	·20	Atwater and Farm. Bull. 293.
Whortleberry, average	82·40	·70	3·0	10·20	3·50	—	·40	
Cranberry : Average	86·50	·50	·7	3·90	6·20	1·40	·20	Hutchison.
	88·90	·40	·6	9·90	—	2·34	·20	Atwater and Farm. Bull. 293.
Minimum ..	87·60	·40	·4	9·30	—	—	·20	
Maximum ..	89·50	·50	·9	10·90	—	—	·20	

The *Cranberry* grows in mountainous districts, peat bogs, and swampy areas, in Europe and America. They are found in many parts of Great Britain, but the fruit is inferior to that imported from Russia. The fruit is of the size of a currant, crimson colour, and contains a very acid juice. The American fruit is larger than the English. Analyses show that they contain 2·34 per cent. of free acids, reckoned as sulphuric, and including 0·05 per cent. of benzoic acid ; the sugars average only 1·52 per cent.[2] The fruit is very austere, but is consumed in tarts, jam, jelly, and as a sauce to various meats. Like the previous berries, they are reputed to be of special benefit to persons suffering from chronic rheumatism and gout, presumably from the excess of organic acids, which, by their reduction to alkaline carbonates, stimulate the kidneys and render the blood and urine more alkaline. On the other hand, the presence of an appreciable quantity of benzoic acid is against their consumption by persons suffering from Bright's disease or other organic pathological condition of the structure of the kidneys.

[1] Including fibre and seeds.
[2] Wiley's "Foods and their Adulteration," p. 369.

Division C : Drupes, Drupels, etc.

The drupe is a stone fruit, in which the outer part of the *pericarp* becomes fleshy or softens like a berry, while the inner part hardens like a nut, forming a stone with a kernel. The stone is called the *endocarp*, the pulpy or succulent portion the *mesocarp*. The following fruits answer to this description — **Rosaceæ :** Peach, sloe, plum, prune, apricot, damson, cherry ; **Palmaceæ :** Dates ; **Oleaceæ :** Olive, persimmon. A drupel is a little drupe—*e.g.*, elderberries, with which is also included blackberries, dewberries, raspberries. Various drupels form a *syconus*—*e.g.*, strawberry, fig, custard apple ; others a *sorosis*—*e.g.*, bread-fruit.

The Prune Family.

The generic or tribal name of **Prunæ** (N.O. Rosaceæ) includes the following drupaceous fruits :

The **Peach** (*Prunus persica*), which is allied to the almond, and belongs to subgenus *Amygdalus*, was formerly supposed to have come from Persia.

It is found wild in Persia, the Crimea, and south of the Caucasus. The expedition of Alexander was probably the means of making it known to Theophrastus (332 B.C.), who speaks of it as a Persian fruit. Xenophon (401 B.C.) does not mention it, neither do the Hebrew writings. The Greeks and Romans received it shortly after the beginning of the Christian era. But in China its cultivation dates from the remotest antiquity—at least 2,000 years before its introduction to the Græco-Roman world—and a number of superstitious legends and ideas about it exist in that country. After most careful consideration of all the data, De Candolle concludes that its natural home is in China, and that it is very probable that stones of the fruit were carried over the mountains from the centre of Asia into Kashmir, Bokhara, and Persia, by the Chinese, who early discovered this route.[1] The group of peaches is composed of five forms: (1) *Persica vulgaris*, the common peach, with a downy skin ; (2) *P. læve*, the nectarine, having a smooth skin ; (3) *P. platycarpa*, or flattened peach, in which the top of the stone is not covered with flesh ; (4) *P. simonii ;* (5) *P. davidii*—the last three are indigenous to and cultivated chiefly in China. The trees spread easily in the country where they are cultivated.

Peaches are grown largely in France, especially in the district of Montreuil, and other European countries, and still more largely in the United States, Canada, and South Africa. Thousands of acres are planted with the trees in New Jersey, Maryland, California, and other States. Fresh fruit is exported from America and Africa in refrigerating chambers. There are many varieties of the tree and two kinds of fruit—free-stones and cling-stones. *Free-stones* are so called because of the easy separation of the stone from the surrounding pulp, which is left dry and clean ; *cling-stones* are characterized by the pulp adhering firmly to the stone, and when the latter is removed part of the pulp comes away with it.

This delicious fruit is a large downy drupe with a kernel which contains a large proportion of amygdalin, and produces prussic acid to the extent of 2·85 per cent. The pulp contains 4·5 to 7·5 per cent. of sugar, which is 60 per cent. invert sugar and 40 per cent.

[1] De Candolle's " Origin of Cultivated Plants," pp. 221-227.

cane-sugar ; the rest of the non-nitrogenous extract amounts to 7·7 per cent.—0·56 to 0·75 per cent. of free acid reckoned as sulphuric ; the protein only averages 0·7 and the ash 0·4 per cent. The composition and especially the flavour of the fruit depend upon the variety of the tree and its environment, fruit grown in warm climates having a larger proportion of sugar, essential oil, and ethers ; that grown in cooler regions, and especially the fruit of wild uncultivated trees, being more acid and containing less sugar and flavour than the average. Peaches are mildly laxative, diuretic, and sedative. Poisonous effects have followed the excessive consumption of the fruit, owing to the presence of amygdalin. They are eaten raw as a dessert, in puddings and pies. A good deal of the fruit is canned or dried in the sun or by evaporation.

The **Nectarine** (*P. persica lævе*) is a variety of peach having a smooth skin and rather firm pulp. The fruit is regarded by some authorities as being merely a "sport," and not a separate variety, because smooth-skinned fruit sometimes appears on peach-trees. There are free-stone and cling-stone kinds.

The **Apricot** (*Prunus armeniaca*) was believed to be a native of Armenia, hence the name. M. Reynier says it is a native of Africa, where it flourishes in a wild state ; but De Candolle considers these to have sprung from cultivated trees.

The apricot grows wild in the mountains of Pekin. The Chinese knew it 2,000 or 3,000 years before the Christian era. It is not found wild in India or Japan, and, as the result of numerous investigations, De Candolle believes its native home to be in China. Its culture spread into the West very late ; it was not until shortly before the Christian era that it spread towards the Græco-Roman world. A century before this period Changkien travelled from China into the West, and it was then, perhaps, that the apricot was introduced into Western Asia and became naturalized. Had it formerly existed in Africa, it would have been known to the Hebrews and Romans ; but there is no Hebrew name for it, and Pliny says it was introduced to Rome about thirty years before he wrote.

It is now grown in nearly all warm and temperate climates, and was introduced into England in the sixteenth century. It flourishes abundantly in the oases of Africa, where the fruit is dried and carried to Egypt as an article of commerce. Analyses show that fresh fruit contains 5·0 to 8·78 per cent. of sugar ; the maximum was observed by Buiqnet, who found that the sugars consisted of 6·04 per cent. cane-sugar (sucrose or saccharose) and 2·74 per cent. invert sugar (dextrose and lævulose). Desmoulière found 3·8 per cent. cane-sugar, 2·25 lævulose, and 0·35 dextrose—total 6·4 per cent. The free acids, reckoned as malic acid, 0·70 per cent. ; but Bauer found 1·16 per cent., and larger quantities have been observed. Fruit grown in a wild state is more acid than the cultivated varieties. Dried fruit contains 30 per cent. of sugars and 2·5 per cent. of free acids. Candied fruit comes mostly from the South of France. Further analyses are given in the following table (p. 642). The fresh fruit is soft and mealy, has a downy skin,

but is delicious and very agreeable ; an excessive consumption readily causes diarrhœa.

Plums.—All the cultivated varieties of plums have been derived from *Prunus domestica,* which is said to be a native of Anatolia, Persia, and Asia Minor, was introduced into Europe through Greece to Italy, and thence all over the temperate regions of the earth. It is found wild in Great Britain and all over Europe, but it is doubtful if it is indigenous. De Candolle thinks it dates from 2,000 years at most. The fruit needs no special description. They are used as a dessert, in tarts, pies, preserves, and other confections. They are nutritive by their sugars, and laxative by some special property ; when taken too freely they cause flatulence, pains in the bowels, or diarrhœa.

Classification of Plums.

	Dark Fruit.	Pale Fruit.
(*a*) Round fruit	Nectarines.	Greengages.
	Orleans.	Apricot plums.
(*b*) Oval fruit	Prunes.	Imperials.
	Perdrigons.	Mirabelles.

The above classification is from a well-known authority. Each kind is a plum, no matter what fancy name is given to it, and each variety has two kinds—free-stones and cling-stones (*vide ante*). The following are named varieties : Burbank, Bradshaw, De Soto, Coe's Golden Drop, Greengage, French Prune, Italian Prune, Lombard, Marianna, Miner, Ogon, Peach, Robinson, Damson, Satsuma, Wild Goose, and many others. Analyses show that they contain from 10 to 20 per cent. of sugar and 1·0 per cent. of acids (see Table of Composition, p. 642).

The bullace (*P. insititia*) and sloe, or blackthorn (*P. communis vel spinosa*), grow wild in our hedges and thickets. The bullace, a native of southern Europe, is used by country people for pies, puddings, and jam. The fruit is acid, but when tempered by exposure to a mild frost it is not at all disagreeable in flavour. The sloe is a very sour and astringent fruit, grown on a spinous shrub. The astringency gives tonic properties to a wine made from them, which is valued as a remedy for chronic diarrhœa, enteric catarrh, sprue, etc.

Damson.—A small variety of plum. According to some authorities the tree is *Prunus communis,* var. *damascena;* according to others it is *Prunus mahaleb,* and belongs to the subgenus *Laurocerasus.* It was introduced from Damascus, and the name is a corruption of Damascene. The tree is bushy and not unlike the sloe (*P. communis*). The fruit is small and oval, of finer quality than the ordinary plum, and has more astringency. There are numerous subvarieties, as black, bluish, dark purple, yellow, etc. The finest fruit is the Shropshire variety, which is multiplied by grafting.

Prunes consist of several sorts of plums, which are of firmer texture than the average fruit, dried whole. They are chiefly

imported from France, Bosnia, Servia, and California. The most important varieties of plums used in France for drying are—(*a*) **Pruneaux d'Agen,** the famous Prune du Roy grown in the departments of Lot and Garonne. The fruit is a medium-sized plum, with free stone, pulp of firm texture, and skin covered with a blue bloom. (*b*) **Pruneaux de Brignole,** called after the town of that name, and grown largely in Provence. They provide the finest French-dried plums. There are several varieties—the *Perdrigon violette, Perdrigon Blanc,* and *Prune d'Ast.* They are fine fleshy oval plums, with a reddish-purple skin, firm and sugary pulp clinging to the stone, and well flavoured. (*c*) **Petit Damas,** grown in the Loire district; they have a sour taste and are distinctly laxative. In Germany, long egg-shaped plums, called *Quetsche,* are dried extensively, and also other varieties similar to those of France. Prunes are also exported from Spain, Portugal, and Italy, but to a less extent. Bosnian prunes come from Bosnia, Servia, and Herzegovina, chiefly exported from Breka. Californian prunes are finer than those grown in any other State of America. Japan plums introduced into California produce a larger and handsomer fruit than the native varieties, and therefore yield a finer prune.

Preparation of Prunes.—The fruit has been dried for centuries. The old method was to allow the fruit to dry upon the trees, or to gather the ripe fruit and dry them in the sun. Sun-dried prunes are the most delicious, and some of the finest are still prepared in that way. The process adopted in Provence is simple, and is as follows: The fresh-gathered fruit is plunged into boiling water; the temperature of the water is reduced by contact with the fruit, and the latter is kept in it until it boils again. It is thereby sterilized. It is then placed in baskets and gently shaken until it is cool, when it is put upon trays and exposed to the heat of the sun until desiccation is complete. The modern methods of drying the fruit on a commercial scale are by (*a*) baking and (*b*) evaporating.

(*a*) The baking process is the ordinary French method of preserving prunes. The fruit is exposed to the sun for a few days until they are partly desiccated, being turned over several times. They are then submitted to the action of heat in a special apparatus somewhat like a baker's oven. In this they are first exposed to a temperature of 45° or 50° C. for five or six hours; all apertures are carefully closed, and therefore they are exposed to the action of their own steam. They are now taken out of the oven, cooled and turned over, and put in again. They are baked a second time for six hours at a temperature of 65° to 70° C., with all apertures into the oven closed. After this time they are taken out and cooled. They are then baked for a third time for six hours in a temperature of 80° or 90° C., all the apertures of the oven being open, in order to dry them perfectly. The temperature of the oven is never allowed to reach 100° C., for in that case the skins would burst and the plums be burnt. When finished they should have a firm, shining, black exterior consisting of the wrinkled skin, and an elastic interior

consisting of a reddish-brown pulp. Bosnian prunes are prepared in a similar manner.

(*b*) The evaporation process is the system in vogue in America as well as in some parts of France and other countries. This method is more rapid and cheaper than the former, and it is claimed that fruit so prepared remains lighter and more like fresh plums than after being baked. The ripe fruit is gathered, put upon wicker trays, and exposed to a current of hot air in an evaporator for twelve to fifteen hours, care being exercised that the temperature never reaches 100° C. When removed from the evaporator the moisture and consistence of the fruit is unequal. To remedy this defect the evaporated fruit, previously cooled, is piled in a heap in a lofty room for twelve to fourteen days; during this time a species of "sweating" goes on, the moisture becomes evenly distributed, the skins pliable, and the pulp elastic.

Fresh prunes contain 75 to 80 per cent. of moisture, but properly dried fruit only contains 18 or 20 per cent., which is necessary to give it the softness and elasticity which characterize the first qualities. The chief constituents of dried prunes are 40 to 50 per cent. of sugars and 2 per cent. of vegetable acids. When dried prunes are being used, a little art is required to restore them to the condition of fresh fruit. They should first be washed in water to remove grit and other adherent particles, and then covered with cold water and allowed to stand for twelve hours, afterwards being cooked gently in a slow oven. All kinds of dried fruit should be cooked in the same way.

Cherries.—The fruit of *Prunus cerasus* and its varieties, *C. vulgaris* and *C. avium*, both of which are found growing wild in Great Britain and Europe. Their place of origin, however, appears to be Asia, from the Caucasus to Western Anatolia. The red-hearts, white-hearts, and bigarreaus, are subvarieties of the **Gean**, or *C. avium*; the Dukes, Montmorencies, Griotte, Morellos, and Kentish fruit, are varieties of *C. vulgaris*. They are used for dessert, pies, puddings, brandied cherries, and cherry-brandy. The German *kirschwasser* is distilled from this fruit, and *maraschino* is made in Italy from a small black gean.

Cherries are cultivated in most countries; their chief value lies in their being the earliest fruit of the season. They contain cellulose, pectose, sugars, protein, acids, ethereal oils, and salts. *Tinned* cherries are usually artificially coloured, because the galvanic action which takes place between the metal and the acid of the fruit destroys the natural colour. This, however, can be avoided by coating the interior of the tin with gum or some similar protective substance. Wiley[1] says it is a common practice to bleach cherries with sulphurous acid and brine to destroy the natural colour; they are then washed. Such treatment, however, removes the juice of the fruit, and what remains is little more than a mass of cellulose. After the bleaching and washing, the fruit is saturated with glucose

[1] "Foods and their Adulteration."

COMPOSITION OF APRICOTS, PLUMS, CHERRIES, ETC.—PERCENTAGES.

	Refuse.	Water.	Protein.	Fat.	Carbohydrate.		Acids.	Ash.	Authority.
					Sugar.	Pectose.			
Apricots: As purchased	6·00	79·90	1·00	—	12·60		—	·50	Atwater and Bryant.
	—	85·00	1·10	—	13·40		—	·50	
Edible part	6·27	81·20	·50	—	4·69	6·35	1·16	·82	Bauer.
Small, edible part ..	5·76	83·55	·41	—	2·73	5·56	1·60	·71	Fresenius.
Fine, ,, ..	5·26	84·96	·83	—	1·14	5·92	·89	·82	
Large, ,, ..	4·16	82·11	·38	—	1·53	9·28	·76	·38	
Canned	—	81·40	·90	—	17·30		—	·40	Atwater and Bryant.
Dried: Minimum ..	—	26·40	2·90	1·0	62·70		—	1·40	
Maximum ..	—	32·40	6·40	1·1	63·30		—	3·40	
Average ..	—	29·40	4·70	1·0	62·50		—	2·40	
Sauce	—	45·20	1·90	1·3	48·80		—	2·80	
Candied	—	12·10	·50	·2	86·10		—	·60	Farmers' Bull. 293.
Cherries: Average ..	6·07	80·26	·62	—	10·24	1·17	·91	·73	Bauer.
	—	79·87	1·42	—	11·10	—	·43	·44	Wiley, p. 336.
Sour	5·90	80·49	·82	—	8·77	2·65	1·27	·56	Fresenius.
Light-heart, rather sour	3·60	81·99	·90	—	8·56	3·52	·96	·83	
Sweet black	6·10	79·90	1·01	—	10·70	1·68	·56	·60	
Sweet red	5·90	73·37	·93	—	13·11	3·18	·36	·60	
Surinam	—	85·00	·40	—	13·90		—	·70	Farmers' Bull. 293.
All analyses, average	—	82·04	·90	·8	11·53	2·75	·75	·63	Tibbles.
As purchased, sixteen analyses	5·00	76·80	·90	·8	15·90		—	·60	Atwater and Bryant.
Edible: Minimum ..	—	76·90	·70	·7	11·40		—	·50	
Maximum ..	—	86·10	1·11	·8	20·60		—	1·00	
Average ..	—	80·90	1·00	·8	16·70		—	·50	
Canned	—	77·20	1·10	·1	21·10		—	·50	
Dried	—	49·90	2·00	·3	45·50		—	1·60	Bauer.
Cherry jelly	—	21·00	1·10	—	77·20		—	·70	Farmers' Bull. 293.
	—	38·40	1·20	—	59·80		—	·60	Atwater.

	6·06	80·03	·65	—	4·48 | 7·17	·92	·69	Bauer.
	—	88·80	·50	·2	5·80 | 3·40	·70	·60	Hutchison.
Peaches : Average ..	5·62	84·90	·63	—	2·59 | 6·31	·61	·42	Fresenius.
	9·18	76·50	1·05	—	1·56 | 10·00	·73	·91	
	—	88·10	·70	·1	10·80	—	·70	Wiley, p. 341.
As purchased	18·00	73·30	·50	·1	7·70	—	·30	
Edible : Minimum ..	—	89·30	·40	·1	9·30	—	·40	
Maximum ..	—	89·60	·90	·1	9·40	—	·50	
Average ..	—	89·40	·70	·1	6·00 | 3·40	—	·40	
Canned : Minimum ..	—	81·40	·50	—	5·30	—	·30	
Maximum ..	—	93·70	·90	·2	17·30	—	·40	Atwater and Bryant.
Average ..	—	88·10	·70	·1	10·80	—	·30	
Nectarines : As purchased	6·60	77·40	·60	—	14·80	—	·60	
Edible	—	82·90	·60	—	15·90	—	·60	
Plums : As purchased ..	5·00	74·50	·90	—	19·10	—	·50	
Edible	—	78·40	1·00	—	20·10	—	·50	
	—	78·40	1·00	—	14·80 | 4·30	—	·50	Hutchison.
Average	5·41	81·18	·78	—	6·15 | 4·92	·85	·71	Bauer.
	—	—	·65	—	5·00 | 7·71	·92	·50	Fresenius.
Californian	—	80·40	·40	—	13·25 | 5·50	1·00	·50	Wiley, p. 341.
	—	80·80	·50	·2	5·80 | 4·30	—	·30	Hutchison.
Greengage	—	80·90	·47	—	2·96 | —	·96	·31	
,, large ..	3·98	79·70	·40	—	3·43 | 11·07	·87	·39	
Black-red	4·32	85·23	·42	—	2·25 | 5·85	1·33	·55	Fresenius.
Mirabelle (yellow) ..	5·65	82·25	·19	—	3·58 | 5·77	·58	·57	
Mussel	5·53	81·93	·78	—	5·79 | 3·64	·95	·73	
Prunes—Fresh : Average	4·34	84·86	·40	—	3·56 | 4·68	1·50	·66	Bauer.
As purchased	5·80	75·60	·70	—	17·40	—	·50	
Edible, twenty-four analyses	—	79·60	·90	—	16·10 | 2·80	—	·60	
Dried : As purchased ..	15·00	19·00	1·80	—	62·20	—	2·00	Atwater and Bryant.
Edible : Minimum	—	16·90	1·40	—	68·10	—	1·50	
Maximum	—	27·50	3·20	—	78·60	—	3·00	
Average	—	22·30	2·10	—	25·30 | 48·00	—	2·30	
Stewed ..	—	76·60	·50	·1	22·30	—	·50	Farmers' Bull. 293.

or other syrup, which has been flavoured and artificially coloured. The use of cochineal is not detrimental to the consumer, but aniline dyes are dangerous to health, and their use should not be permitted. However, such fruits are tinned or bottled in alcohol, and sold as maraschino cherries to be used for beverages and in culinary art. They are by no means a natural fruit, and should not be regarded as such.

Composition.—Plums, peaches, apricots, and cherries, are of value as food chiefly for their **sugars.** *Apricots* contain according to Wiley 11·01 per cent. of sugars, but according to Buignet only 8·78 per cent., including 6·04 per cent. of sucrose and 2·74 per cent. of dextrose and lævulose. In *plums* the sugars range up to 14·7 per cent. according to Wiley, and in fresh prunes up to 16·11 per cent.; in *peaches* the sugars only reach 7·88 per cent.; while in *cherries* the sugar averages 10·0 per cent., and, according to Buignet, consists entirely of invert sugar (dextrose and lævulose). In *dried* fruit the sugars are 30·0 per cent. in apricots, 60·0 in prunes, and about 40·0 in cherries. All these fruits contain a small amount of sorbite, an unfermentable sugar, cherries yielding 7 grammes per kilogramme.[1] The *acids*, reckoned as malic acid, vary, being 0·5 in peaches, 1·0 in plums, 1·0 to 1·5 in cherries, and 0·7 in apricots. It should be noted that the acids include a small amount of benzoic acid. The *salts* have the following composition per cent.:[2]

	Percentage of Total Ash.	K_2O.	Na_2O.	CaO.	P_2O_5.	SO_3.	Cl.
Apricots ..	·508	59·36	10·26	3·17	13·09	2·62	·45
Prunes ..	·486	63·83	2·65	4·66	14·08	2·68	·34
Cherries ..	·440	57·67	6·80	4·20	15·11	5·83	1·83

Dates.

The fruit of the date-palm, *Phœnix dactylifera*, N.O. Palmaceæ, which grows spontaneously throughout the whole of the East, also in the greater part of Northern Africa—Arabia, Egypt, Morocco, etc.—and is cultivated in Italy, Sicily, Spain, Portugal, and Brazil. The wild-date, *P. sylvestris*, is said to be the normal form of the date-palm, from which *P. dactylifera* and subvarieties have been derived by cultivation; but the change in the characters of the fruit must have been very great, as that of the wild date-palm is not eatable.

The date-palm has existed from prehistoric times in the warm, dry zone which extends from Senegal to the Indus, between parallels 15 and 30. Egyptian and Assyrian remains show that it early grew in abundance in the region between the Euphrates and the Nile. Egyptian monuments contain

[1] Vincent and Delachnel, *Compt. Rend.*, 1889, cix. 181.
[2] Bulletin 66, U.S. Department of Agriculture.

the fruit and drawings of the tree. But David, about 1000 B.C., or 700 years after Moses, does not mention it among the trees to be planted in his gardens. Herodotus, in the fifth century B.C. mentions the dates of Babylon and Libya. Pliny mentions the date-palm in the Canaries. The date-palm had existed for thousands of years in Egypt and the West when Herodotus wrote of it, and probably inhabited Northern Africa long before the earliest Egyptian dynasty. In the East, however, it remained long unknown. The Chinese received it from Persia in the third century of our era. It was planted here and there along trade routes in the latitudes above mentioned, or was disseminated by wandering tribes, the stones germinating easily in damp soil near rivers, oases in the deserts, or fissures in the rocks. The name *Phœnix* refers to Phœnicia or the Phœnicians who possessed it; *dactylus* and *date* are of Hebrew origin.

The distribution of the date-palm remained the same for about 5,000 years; but it is now grown in China, Brazil, and California, and (under glass) even in Great Britain. The date-palm is of great value to the Hindoos, for the sap of *P. sylvestris* is one of the chief sources of palm-wine and jaggery-sugar. Each tree, according to Roxburgh, yields 180 pints of sap, 12 pints of which form 1 pint of jaggery, and 4 pints of jaggery yield 1 pound of good powder sugar. A tree produces an average of 7 or 8 pounds of sugar annually. The wine yields the spirit called "toddy," and is also converted into vinegar. The fruit is also a source of sugar, "honey," spirits, and vinegar; and the unopened leaf-buds are a tender succulent vegetable, which may be eaten as cabbage.

There are many subvarieties of the date-palm. The tree is diœcious—*i.e.*, the male and female flowers grow on different trees, and fertilization is performed by insects or currents of air carrying the pollen. In some districts the growers plant one male tree amongst thirty female trees; in others the natives gather the male flowers, from *wild* date-trees of the deserts, and shake them over the mature female flowers, the pollen thus distributed fertilizing them and making them fruitful. In times of war the Arabs sometimes punish their adversaries by cutting down all the male date-trees, thereby rendering the female trees barren, and causing a famine amongst the inhabitants. All the varieties of dates grown in any country ripen about the same time; in Africa and Oriental countries the harvest is about the end of August, but in European countries—Spain and Sicily—they do not ripen until December, and in Italy the fruit does not ripen. The fruit is gathered just before it is ripe, dried in the sun or in ovens, and carefully packed. "Squashed" dates are not gathered until they are quite ripe, when they are pressed into baskets.

The fruit forms an important article of food in the countries where it is cultivated, and is a considerable source of income to the growers. The fruit imported into Great Britain, however, is eaten as a sweetmeat rather than a food. Those known as "Tafilat dates" are the best. In Africa a thick black solid cake is made by kneading or pounding the fruit, for the use of the caravans in their journeys across the desert. These cakes are very hard and keep well. Before use they are soaked in water, thereby softening

the cake and affording a cooling and nutritious beverage. Dates are wholesome and nutritious. When used alone as an everyday food, they are considered heating and a cause of thirst, owing to the large percentage of sugar in them; hence they are made into a paste with durra or barley-meal. The dates imported into Great Britain are thus classified:[1] **Tafilat dates**—these are esteemed the best, especially those of Degla. They are grown in the interior of Morocco, and exported from Tunis. **Algeria dates** are also very fine, but are not so good as the former. **Majhol dates** are grown in the Trans-Atlas regions, and exported from Fez. The fruit is large and sweet, having a greenish-brown skin, an agreeable pulp, and large stone. They are esteemed more highly by Europeans than the natives, the latter preferring a smaller and drier fruit. **Egyptian dates** come from Alexandria. They are larger than Tafilat dates, but do not keep so well. The *white dates* of Egypt are only about the size of an acorn. **Persian dates** arrive via Smyrna. They are called Bagdad or Bassora dates, from being grown in the regions along the Persian Gulf. There are several varieties. The best are the **Hallowie dates**, known by their golden-yellow colour and honey-like flavour; and **Khadrowie dates**, which have a reddish-brown colour and fleshy pulp. Dates are subject to the attacks of various fungi, the chief one being the *date-smut*, which transforms the fruit into a powdery mass, consisting chiefly of the spores of the fungus, and rendering the fruit uneatable.

The nitrogenous matters in dried dates are chiefly albuminous, and average 3·45 per cent. The carbohydrates have the high average of 69 per cent., and consist chiefly of dextrose, lævulose, and some sucrose. When such a fruit is consumed with milk, as it is by native races, it forms an admirable diet of a standard character.

Persimmon.

The persimmon, or date-plum, is the fruit of *Diospyros virginiana*, N.O. Ebenaceæ, a tree of North America, especially of the south-eastern States, and Japan. The fruit is a succulent reddish-yellow drupe, about the size of a small plum, containing eight or ten seeds. The green fruit is very astringent, but when fully ripened it has a soft glutinous pulp which is very sweet and palatable. It is eaten raw and cooked. Sometimes they are pounded, dried, and made into cakes with bran. A wine is made by fermentation of the juice, and it yields an ardent spirit. The persimmon grown in Mexico (*D. texana*) is a larger and darker fruit, but very delicious. The Japanese persimmon (*D. kaki*) is like a yellow plum in appearance, and is the most highly esteemed fruit of the Japanese Empire. There are many varieties of it grown throughout Japan, China, India, and the Malay States. Various other species of *Diospyros* also yield edible fruits.

[1] "The Practical Grocer," vol. ii., p. 127.

COMPOSITION OF DRIED DATES—PERCENTAGES.

	Water.	Protein.	Fat.	Carbo-hydrate.	Cellulose.	Ash.	Authority.
Dried dates: Average	20·0	4 to 5	—	54 to 66	20·00	1·50	Wiley.
	10 to 20	2 to 2·2	·6 to 5	70 to 86	—	1·30	Atwater.
All analyses: Minimum	15·0	2·00	·50	55·0	4·00	1·00	Tibbles.
Maximum	35·0	5·00	5·00	86·0	5·00	1·50	
Average	20·0	3·45	2·32	69·1	3·77	1·36	

COMPOSITION OF PERSIMMON—PERCENTAGES.

	Refuse.	Water.	Protein.	Fat.	Carbohydrate.		Ash.
					Starch, Sugar, etc.	Fibre.	
American, edible portion	—	66·10	·80	·70	29·70	1·80	·90
Japanese Seedling, edible portion	—	77·04	1·61	·31	19·39	·93	·72
Tane Nashi, edible portion	—	81·93	1·16	·55	12·81	2·93	·62
Yemon, edible portion	—	81·66	1·32	·85	13·19	2·37	·61
Average, edible portion	—	80·21	1·36	·57	15·13	2·08	·65
,, as purchased	23·97	60·96	1·04	·43	11·53	1·58	·49

The proportion of sugars in the edible portion of American persimmons is, according to Atwater, 14·5 per cent., including 13·5 per cent. glucose and 1 per cent. cane-sugar. The fruit also contains tannic and malic acids, colouring matter, and lignin, the acids being most abundant in unripe fruit. The fruit is eaten to a considerable extent in China and Japan, both fresh and dried like figs. The latter are imported into England.

Rose Apple or **Malabar Plum** (*Eugenia jambolana*, N.O. Myrtaceæ) is a tree cultivated in the East Indies and all tropical countries for its fruit, which is of the size and shape of a small pear, rose-scented, and tasting like an apricot.

The **Malay Apple** (*E. malaccensis*), of same family, is a fleshy fruit, about 1½ inches in diameter, also scented like a rose, and of agreeable taste. It is common in the islands of the Southern Seas and the Malay Archipelago, where it is indigenous. There are many varieties.

Star Apple or **Cainito,** the fruit of *Chrysophyllum cainito*, N.O. Sapotaceæ, grown in the West Indies, tropical America, and Cuba. There are two varieties—purple and white. The purple star apple, *C. cainito*, is a large purple or rose-coloured drupe when fully ripe, but mixed with green and yellow. The interior consists of an outer purple portion, which is fibrous and uneatable. The inner portion is white and gelatinous, and divided into ten compartments, each containing a seed surrounded by the gelatinous pulp of characteristic flavour and odour. It is eaten raw, and the edible portion forms 40 per cent. of entire fruit, and contains—Total solids 14·23, protein 0·67, sugars 7·9, acidity 0·05, ash 0·35, per cent.[1] The white star apple, *C. roxburghii*, is of the size of a crab, and when ripe has a smooth yellow skin, a firm pulp of glutinous character and insipid flavour. There are also other varieties, all of which are much valued in tropical America, though Europeans do not care for them.

The **Sapodilla** or **Naseberry** (*Sapota zapotilla*, N.O. Sapotaceæ) is another drupaceous fruit, grown in the West Indies, Central America, and Cuba. It is the most esteemed of the order of Sapotaceæ, and one of the best tropical fruits. It is a small brown or greenish-brown fruit, resembling a bergamot pear in shape and size, and looks like a dark potato, or one which has been exposed to the light on the surface of the soil. It weighs about 2 ounces, has a sweet taste, characteristic odour, a soft core, and contains five or six brown or black seeds. Descourtalz says a fully ripe sapodilla "is melting, and has the sweet perfumes of honey, jasmine, and lily of the valley." There are round and oval varieties, whose percentage of composition is as follows :[2]

	Solids.	Protein.	Sugars.	Ash.	Acids.
Round sapota, edible portion	23·07	·35	10·85	·38	·13
Long sapota, edible portion . .	21·01	·65	12·75	·55	·16

European analyses show that they contain—Water 77·9, protein 0·5, fat 1·6, carbohydrate 16·0, fibre 2·8, ash 0·6, per cent. They are eaten raw or preserved. This fruit is sweeter than the custard apple (*q.v.*), and is regarded by many people as being more agreeable. The **Mammee Sapota** (*Lucuma mammosa*), also called the "Malabar plum," is a native of the West Indies and South America. It contains a thick agreeable pulp, having the flavour and appearance of quince marmalade, surrounding a single seed. The fruit is about 5 inches long, and has a rusty-coloured skin. The **Mimusops**, or bully-tree (*Mimusops elengi* and other varieties), produces a small delicious fruit, eaten in Guiana, Ceylon, etc.

[1] Wiley's "Foods," p. 366

[2] *Ibid.*

Olives.

The olive (*Olea europæa*) is believed to have originally come from Asia. It grows wild in Syria, Southern Anatolia, and neighbouring islands, and has been naturalized in Spain, Italy, France, Tunis, Greece, California, Southern and Central America, and other sub-tropical regions.

The cultivation of the olive is prehistoric. It is mentioned in the earliest Hebrew books as being brought to Noah's ark by the dove, and as one of the trees of the land of Canaan. The ancient Egyptians cultivated it. Babylonia, however, had no olives. The ancient Greeks cultivated it. The planting of the olive in Attica is attributed to Minerva. Aristæus introduced or perfected the manner of pressing the fruit. It was probably introduced from the North of Greece into Sicily and Sardinia by the Phœnicians. The Romans knew it later than the Greeks. According to Pliny, the cultivated variety was introduced in the time of Tarquin the elder, 627 B.C. It thrives in dry climates such as Syria and Assyria, and succeeds at the Cape, in parts of America and Australia.

The cultivation of olives is an important source of income in Spain, Italy, and some of the other countries in the South of Europe. The tree is an evergreen shrub, and there are numerous varieties, the long-leaved variety being generally grown in Italy and France, the broad-leaved mostly in Spain. The fruit is an oval or globular drupe, of white, greenish, or violet colour, having a stone in the centre. The finest oil is obtained from fruit of the long-leaved variety (see Olive Oil).

Edible olives are usually plucked before they are ripe or while young. There are several kinds. Those mostly imported into England are the dark green or violet fruit, like a small plum in size and shape. They are first pickled in a stong lye of quicklime or some other alkali, being afterwards washed, soaked in pure water, washed again, then boiled in salt and water with or without spices, and finally bottled in brine seasoned with spices. Among the named varieties are "Queens," which are the best edible fruit from Cadiz; "Manzanillas," which are somewhat larger; Californian fruit consist of a large kind known as "Mission" fruit, and "Picholine," of the size of a damson and very must esteemed. *Olea fragrans vel osmanthus* is a native of China and Japan, the leaves and flowers of which are used to flavour some kinds of tea.

As a fruit, olives contain one of the chief principles which the average vegetarian diet lacks—fat, for which they are extremely valuable. They are wholesome, easily digested, nutritive, and laxative. They are consumed largely as a ripe or pickled fruit wherever they are grown. The composition is given on p. 651.

Mulberries.

The fruit of several varieties of *Morus*, N.O. Moraceæ. The fruit is a drupel, and the "berry" consists of a collection of the small drupes into a spurious fruit. They were introduced into England about the sixteenth century.

The mulberry (*Morus nigra*) is a native of Persia and Armenia, cultivated in most countries of Europe, Asia, and America, for its agreeable and succulent fruit, which has a characteristic flavour, is cooling and laxative. Wine is made from the juice, and vinegar from the wine. In Siberia a spirit is distilled from it. The white mulberry (*Morus alba*), the cultivation of which has spread westward through India, Persia, and Greece, to Southern Europe, is a native of China. It is cultivated chiefly as a food for silkworms. The fruit is white or reddish, and has an insipid taste. The red mulberry (*Morus rubra*) is one of the most valuable trees in the United States. The fruit is a deep red colour, of sweet flavour and slight acidity. Other species are peculiar to Tartary and Peru. The fruit of all kinds is eaten raw, preserved or dried to make a sweetmeat. Mulberry and apple juice combined make a cider of port-wine colour.

The composition of mulberries is, according to Fresenius—Water 84·71, protein 0·39, free acids 1·86, sugars 9·19, pectose bodies 2·31, fibre 0·91, ash 0·56, per cent.

Elderberries : The fruit of *Sambucus nigra*, a drupel. They are used chiefly for making spiced cordials and wine, and for the adulteration of port-wine.

Blackberries : The fruit of *Rubus fructicosus*, tribe Potentillidæ, N.O. Rosaceæ. The common bramble or blackberry of the hedgerows of Great Britain, eaten in puddings, tarts, jam, etc. They are astringent and tonic, but, owing to the large proportion of seeds, are not very nutritious.

Raspberries : The fruit of *Rubus idæus*, N.O. Rosaceæ, and cultivated varieties of the wild form native in Great Britain. This fragrant, subacid, and cooling fruit is too well known to require description. It is recommended as particularly suitable for rheumatic and gouty persons.

Loganberries : Various hybrids of the blackberry and raspberry are now cultivated. Some of these are very fine fruit, superior to the blackberry, and also considered by some people superior to the raspberry. These hybrids are known by the names of Loganberry, Lowberry, Laxtonberry, Phenomenalberry, etc.

Dewberries : The fruit of *Rubus cæsius*, a large berry or succulent drupel, of black colour, and covered with a bluish bloom of dew-like appearance. It is sweet, but more acid than the blackberry, and has astringent and tonic properties. Several species are cultivated in America. The fruit makes an excellent wine.

The **Cloudberry,** or mountain bramble (*Rubus chamæmorus*), is a subacid orange-yellow fruit or drupel, moderately acid and mucilaginous, somewhat like tamarinds in flavour. They are eaten raw, in tarts and preserves. The Laplanders eat them bruised and mixed with reindeer's milk. They grow in mountainous districts in the North of England, Scotland, Sweden, Norway, Lapland, etc. They are exported from Norway in casks, and may be gathered in the Highlands of Scotland for several months in succession.

COMPOSITION OF PICKLED OLIVES—PERCENTAGES.

	Refuse.	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.	Authority.
Green : As purchased	27·00	42·30	·80	20·20	8·50	1·20	Atwater and Bryant.
Edible portion	—	58·00	1·10	27·60	11·60	1·70	
Ripe : As purchased	19·00	52·40	1·40	21·00	3·50	2·70	
Edible part	—	64·70	1·70	25·90	4·30	3·40	
"Mission" : As purchased	17·85	55·08	2·04	13·96	7·44	3·63	Bulletin 132, U.S. Department of Agriculture.
Edible portion : Minimum ..	—	70·33	2·44	11·13	5·57	3·65	
Maximum ..	—	63·68	2·52	23·01	12·45	5·22	
Average	—	67·00	2·48	17·07	9·02	4·43	

COMPOSITION OF BLACKBERRIES—PERCENTAGES.

	Water.	Protein.	Fat.	Sugar.	Starch, etc.	Fibre and Seeds.	Free Acid.	Ash.	Authority.
Fresh fruit : Average	86·41	·51	—	4·44	1·76	5·21	1·19	·48	Bauer.
Minimum	78·84	·90	·5	7·50		2·50	—	·40	Atwater.
Maximum	81·86	1·50	2·9	16·70		—	—	·90	
Canned fruit	40·00	·80	2·1	56·40		—	—	·70	

The fruit of other species of *Rubus* is also esteemed—*e.g.*, *R. villosus* and *trivialis* in America; *R. saxitilis*, or roebuck-berry, is also an edible fruit which grows in parts of Great Britain, but more abundantly in Russia and other Northern countries, where the inhabitants consume the fruit, make a wine, and distil a spirit from it. *R. arcticus* is another species, little known in Britain, excepting the Isle of Mull, but is an important fruit in Norway, where it is held to be of the highest rank among wild fruits, and is considered in Stockholm a dainty of the rarest and most delicious kind.

Strawberries.

The fruit of several species of *Fragaria*, tribe Potentillidæ, N.O. Rosaceæ. The "fruit" is a syconus, or receptacle which bears the achenes, or true fruit, upon its surface. As it ripens the "fruit" becomes succulent, and of a variety of colours from a scarcely perceptible pink to a dark red.

The **Common Strawberry** grows wild in Europe from Lapland and the Shetland Isles to as far south as Spain, Sicily, and Greece. It is also found in Asia from Armenia to the Himalayas. The Greeks and Romans did not cultivate strawberries, but their cultivation began in the fifteenth or sixteenth century, when the fruit was already known in England, but was a novelty in France. It was transported to the colonies, and became naturalized far from dwellings. The finest fruit now grown is the result of crossing the species with those of Virginia and Chili. There are numerous species, all natives of temperate climates. The following species have given rise to the numerous cultivated varieties: (1) The **Wood strawberry** (*F. vesca*), growing wild in the woods and on the sides of hills in Great Britain and throughout Europe; yielding small coral-red berries, which, however, are fragrant and delicious. Its cultivated varieties are red and white, the red and white wood strawberries, the American and Danish Alpine strawberries, and the red and white Alpine bush-strawberries. (2) The **Alpine strawberry** (*F. collina*), a native of Switzerland and Germany, is the origin of the green strawberries. (3) The **Hautbois strawberry** (*F. elatior*), native of North America, but sometimes found wild in the South of England, is the parent of the common hautbois, muscatel, red, black, and brown varieties, and a large number of named kinds which are much prized. (4) The **Virginian** (*F. virginiana*), a native of Virginia or Carolina, introduced into English gardens in 1629, is the original of the rose-berry, scarlets, globe, cone, pine, and other garden varieties. (5) The **Surinam** (*F. grandiflora*) is a large-flowered plant, which is the origin of the British Queen, Carolina, Pine, and other large varieties of fruit. (6) The **Chilian** (*F. chilensis*), native of Chili and Peru, has a large berry, and takes part in the production of many varieties —*e.g.*, Ananas, Victoria, Trollope, Rubis, etc. Many strains of strawberries have been produced by cultivation and hybridization, which, however, soon degenerate and revert to the original type. The fruit, which has been cultivated in England since the fifteenth century, is too well-known to need description. They are used as a dessert, for cooking and preserving. They are especially

COMPOSITION OF RASPBERRIES—PERCENTAGES.

	Water.	Protein.	Fat.	Sugars.	Pectose, etc.	Fibre and Seeds.	Acids.	Ash.	Authority.
Wild red	83·86	·54	—	3·59	1·10	—	1·98	·27	Fresenius.
	86·55	·54	—	4·70	1·74	—	1·35	·48	
Cultivated red	86·21	·53	—	3·95	1·54	5·9	1·38	·49	Bauer.
	84·10	1·70	1·0	5·33[1]	2·00	5·5	1·48	·60	Wiley.
	85·80	1·00	—	—	9·70	2·5	1·47	·60	Bulletin 293.
,, black	84·10	1·60	1·0	—	12·70	—	—	·60	
Dried fruit	8·10	7·30	1·8	—	80·20[2]	—	—	2·60	Atwater.
Fresh juice	49·30	·50	—	—	49·90	—	—	·30	

[1] Buignet found sucrose 2·0, dextrose and lævulose 5·2, per cent.

[2] Candied and sweetened.

COMPOSITION OF STRAWBERRIES—PERCENTAGES.

	Water.	Protein.	Fat.	Sugars.	Pectose, etc.	Fibre and Seeds.	Acids.	Ash.	Authority.
Wild fruit	87·01	·56	—	5·50	—	1·05	1·33	·60	Fresenius.
	87·47	·35	—	7·57	·37	2·32	1·13	·49	
Cultivated fruit	87·66	1·07	—	6·28	·48	2·35	·93	·81	Bauer.
	85·90	·90	·6	7·00	—	—	—	·60	Wiley.
As purchased, 22 analyses	85·90	·90	·6	7·00	—	5·00	—	·60	
Edible portion : Minimum	85·40	·60	·4	4·40	·70	—	—	·40	Atwater and Bryant.
Maximum	94·00	1·20	1·2	12·30	2·30	—	—	·90	
Average	90·40	1·00	·6	7·40	1·40	—	1·40	·60	

grateful to invalids and convalescents, being cooling, diuretic, and laxative; are esteemed good for persons suffering from gouty and rheumatic affections; and have been adopted as a "cure" for sprue.

Wiley found the sugar consists of 6·24 per cent. of dextrose; Atwater 5·5 of dextrose; but Buignet found 6·33 of sucrose and 4·99 per cent. of dextrose and lævulose. The fibre and seeds vary from 2 to 5 per cent. The acid is chiefly malic acid. They also contain a small amount of methyl-salicylic acid.

Figs.

The fruit of *Ficus carica*, N.O. Moraceæ. It is a syconus consisting of a large receptacle formed by the deeply concave axis of inflorescence, upon the inner surface of which are the true fruits in the form of the ripe carpels or hard grains embedded in a saccharine pulp, the receptacle being closed above by bracts. They are eaten green—*i.e.*, fresh—or dried, and are very nutritious.

The fig has been cultivated from remotest antiquity, as shown by ancient historical and sacred writings. Its origin and geographical limits have a close analogy with those of the olive. It grows wild over a vast area, having Syria as a centre—namely, from Persia or Afghanistan to the countries around the Mediterranean Sea and as far as the Canaries. The earliest Egyptian and Hebrew writings mention it. It is mentioned in the "Iliad" as growing near Troy, and the sweet fig is mentioned in the "Odyssey." Romulus and Remus, according to tradition, were nursed at the foot of a fig-tree. From these references De Candolle concludes it was wild in Greece in those times, and was early cultivated. Theophrastus and Dioscorides mention both wild and cultivated figs. As the result of his investigations, De Candolle concludes that the prehistoric area of the fig covered the middle and southern parts of the Mediterranean basin from Syria to the Canaries.

There are numerous species. The most noted is the common fig (*Ficus carica*), a native of Persia and the surrounding countries, and cultivated extensively in all Oriental countries. The property of being easily dried and preserved early revealed the importance of the "fruit" as a storage food of great value, for which purpose it has been used from time immemorial, especially by nomadic tribes and great armies upon the march. There are two chief varieties used for drying and exportation: the Smyrna and the Adriatic fig. The former grows well in the Western States of America, but especially in Southern California and Arizona. The male and female flowers grow upon separate trees, and fertilization is brought about by means of insects, notably by the fig-wasp (*Blastophaga grossorum*). The process of **caprification,** as it is termed, has been studied as much in the interests of entomology as botany. It has been the custom in the East from prehistoirc times to hang upon the cultivated fig-trees branches of the wild-fig, bearing fruit, or **caprifigs,** as it was observed that only by doing so did the cultivated fruit obtain the development and flavour which characterizes them. As a matter of fact, it is only by doing so that they were fertilized. Investigation has shown that the **caprifigs** contain the male flowers, and the cultivated figs only female flowers. How, then,

is fertilization brought about, seeing they are in a closed sac ? The fruit of the wild tree contains a great number of eggs of the minute insect *B. grossorum*, the larvæ of which, as soon as they are hatched, crawl over the cultivated tree, pierce the flower-bearing receptacle, and, passing over the flowers in the interior, carry the pollen from the male to the female flowers, and thus secure fertilization.

Preservation of Figs.—The ripened figs are either gathered by hand (*elemé* figs) or shaken from the trees. There are various methods of curing them—(1) *Sun-drying :* The best figs, especially Turkish *elemé* figs, are simply dried in the sun. The interior of the fruit is full of syrup, which evaporates and condenses. Some of the sugar crystallizes on the external surface, and acts as a preservative. When sufficiently dry, they are pressed flat and packed between laurel leaves in boxes. (2) *Sulphur-drying :* In many districts of Southern Europe the figs are first exposed to the fumes of sulphur in order to sterilize the exterior, to destroy the larvæ of insects and spores of fungi. They are then dried in the sun until they have lost about 60 per cent. of their weight, and afterwards packed in boxes, pressed sufficiently, and care being taken not to split them. (3) *Lye-drying :* In other districts they are sterilized by being plunged for a minute or two in a boiling lye of wood ashes (*potashes*) ; they are afterwards washed in water to remove the alkali, drained, and dried in the sun or in ovens. The best are packed in boxes for sale as dessert figs, and inferior fruit in mats as cooking figs.

The best Turkish *elemé* figs are imported from Smyrna. They are soft, thin-skinned, and packed in boxes. Greek figs are smaller, thick-skinned, packed in baskets or barrels, and upon strings. Spanish figs, from Valencia or Malaga, are not so good. They are frequently packed in mats. Figs are also classified as—" Natural figs," which are packed loose and allowed to retain their shape as far as possible ; " pulled figs," which are kneaded and pulled to make them supple, and afterwards packed in small boxes ; " pressed figs," which are closely packed in boxes, and are usually flattened into thin discs.

Composition of Figs—Percentages.

	Water.	Protein.	Fat.	Sugars.	Other Carbo-hydrates.	Fibre and Seeds.	Ash.	Authority.
Fresh or green figs	79·11	1·50	—	15·53	3·30	—	·58	Atwater.
Dried figs	28·78	3·58	1·27	51·43	5·29	6·19	2·75	Wiley p. 349.
	31·20	4·01	1·44	49·79	4·51	4·98	2·86	Bauer.
Edible portion	22·70	4·30	·70	62·50		8·50	1·30	Jaffa.
As purchased :								
Minimum ..	11·60	2·60	·30	68·30		—	2·20	Atwater.
Maximum ..	25·00	5·70	·30	83·10		—	2·50	
Average ..	18·80	4·30	·30	74·20		—	2·40	
Stewed figs	56·50	1·20	·30	40·90		—	1·10	

Fresh or green figs are a wholesome and agreeable fruit. Dried figs are nutritive by virtue of their sugars ; they are pectoral, demulcent, and laxative ; eaten to excess they cause pain, flatulence, and diarrhœa. As a food they are a valuable source of heat and energy, 1 pound having a fuel value equivalent to 1,475 calories. Buignet found that the sugars in fresh figs consist entirely of dextrose and lævulose, and average 11·55 per cent. In dried figs these sugars vary from 50 to 62 per cent., with an average of 52 per cent. The acidity, according to Wiley, amounts to 0·71 per cent. of malic acid ; other analysts have found as little as 0·4 and as much as 1·1 per cent. The salts are 0·682 per cent., and have the following percentage composition : K_2O, 57·16 ; Na_2O, 2·38 ; CaO, 10·90 ; P_2O_5, 12·76 ; SO_3, 3·90 ; Cl, 2·05. Being deficient in protein and fat, the fruit does not form a complete ration, but the defect may be remedied by the consumption of milk or cheese.

The latex, or milky juice, of the fig-tree contains various enzymes. One is a peptonizing agent, which acts upon fibrin in the same way as pepsin, and also coagulates milk ; another transforms starch and glycogen into sugar. Hansen found that a syrup made from dried figs possessed similar properties to the latex, whence it is inferred that figs form a suitable adjunct to amylaceous foods.

The Custard Apples.

The fruit of various tropical evergreen trees belonging to N.O Anonaceæ, all the species of which belong to America, excepting *Anona senegalensis*, and none to Asia. The fruit is imported into temperate regions, and much esteemed. They are grown in a few English hothouses. There are ten or twelve kinds, the principal being as follows :

The **Custard Apple** (*Anona reticutala*) is a native of the West Indies, and grown in all tropical countries. It is called " bullock's heart " in the East Indies. It is a spurious fruit or syconus, the size of a tennis-ball or larger, round, and of a greenish to dark brown colour. The edible pulp, which forms almost the entire mass of the fruit, is of the consistence of a custard, sweet, tastes like clotted cream and sugar, and has an odour of rose-water. It surrounds a black seed, and is enclosed by a tough skin. It is eaten raw or as a preserve.

The **Cherimoyer** (*A. cherimolia*) is one of the finest fruits of Peru, bears a great resemblance to the custard apple, and is often called by that name. It is a heart-shaped fruit (*syconus*), with a scaly exterior, of greyish-brown to nearly black colour when ripe, containing numerous seeds embedded in the delicious pulp. It is much esteemed throughout South America.

The **Anona, Sweet-Sop,** or **Sugar Apple** (*A. squamosa*), is a West Indian fruit allied to the custard apple, heart-shaped or oval, of greenish-yellow colour, covered with scales like a pineapple, and having a thick, sweet, luscious pulp. It is also called the " custard apple " in British India.

The **Guanabana** or **Sour-Sop** (*A. muricata*), grown abundantly in Jamaica, is a large conical or pod-like fruit, from 3 to 12 inches long, about two-thirds as broad at top, and tapering to a rounded point. It often weighs about 2 pounds. The skin is thick, greenish-yellow, and covered with hooks (*sorosis*). A fibrous core runs through it, surrounded by a white pulp which is pleasantly acid. It is used for making preserves and beverages. This tree, introduced into all tropical countries, is found wild in the West Indies and South America.

The **Alligator Apple** (*A. palustris*), a somewhat apple-shaped fruit growing wild in Jamaica. It possesses narcotic properties, and is not generally eaten.

The **Papaw,** of North America (*Asimina triloba*), is a sweet edible fruit allied to the custard apples. It must be distinguished from the fruit of *Carica papaya*, which is likewise called the **papaw.**

Composition of Sour-Sop and Sweet-Sop—Percentages.[1]

	Edible Portion.	Solids.	Sugars.	Protein.	Ash.	Acidity
Sour-sop	72·3	19·03	13·07	1·65	·41	·51
Sweet-sop ..	30·0	28·10	10·07	2·13	·92	·20
Preserves ..	—	54·33	49·66	·73	·43	·19

The Avocado.

The avocado, or alligator pear, is the fruit of *Persea gratissima*, N.O. Lauraceæ, a native of Mexico, and grown in the West Indies and tropical America. It is a pear-shaped fruit of green or brownish colour, weighing 1 or 2 pounds. The pulp is sweet, firm, like that of a squash or vegetable marrow, but becomes soft as that of a melon when ripe. It is eaten with salt as a salad or in soup, to which it gives an agreeable flavour. It contains much oil and a moderate amount of starch and sugar.

Composition.—Water 81·0, protein 1·0, fat 10·2, starch and sugar 6·8, ash 0·9, per cent.[2]

Cactus Fruit or Prickly Pear.

This is the fruit of *Opuntia vulgaris* and other varieties (N.O. Cactaceæ). The prickly pear, or Indian fig, is said to be a native of North America, but it is grown also in Italy, Sicily, etc. It is a purplish fruit having a succulent, juicy pulp.

Composition.—Water 79·2, protein 1·4, fat 1·3, sugars 11·7, fibre 3·7, ash 2·7, per cent.[3]

[1] Wiley's "Foods and their Adulteration," pp. 344, 345. [2] *Ibid.*
[3] Farmers' Bulletin 293, U.S. Department of Agriculture.

The Papaw.

The fruit of *Carica papaya*, N.O. Papayaceæ, native of West Indies and Central America, is grown all over the East and West Indies, South America, and all other tropical countries. It is not the same as the North American papaw. The trees are male and female. The fruit is the size of a small melon, of a deep green colour, becoming red as it ripens. The interior consists of a soft, yellow, sweet pulp, which contains numerous black seeds. The ripe fruit has a flavour peculiar to itself. It is eaten raw with salt or boiled as a vegetable. Mixed with lime-juice the flavour resembles that of apples, and it is used as a substitute for them. The unripe fruit is eaten in curries and pickles in India. The juice of unripe fruit is acrid and milky, and acts as an efficient vermifuge. A powder of the seeds has a similar action. The juice is also a galactagogue, but neither the fruit nor juice can safely be taken by pregnant women. The juice of the leaves and fruit contain **fibrin,** which is elsewhere only found in the animal kingdom and some fungi. Moreover, it contains an active proteolytic enzyme (**papain**), which has a powerful influence upon proteins. An infusion of the fruit or leaves will render the toughest meat tender. A piece of fresh-killed beef boiled in water with some of the infusion or juice becomes quite tender in a few minutes. This change is also effected by hanging fresh meat or birds in a papaw-tree, or by dipping the flesh in water and wrapping it in papaw leaves. For these reasons the fruit and its juice have a wide sphere of usefulness. The dried juice, called **papayotin,** is used industrially in the preparation of extracts of meat and other prepared foods. The reports upon its activity, however, are conflicting. Emmerling in particular has investigated it. He found that its action on meat is slow, fresh additions of papayotin being necessary from time to time, but the resulting mixture contained a large proportion of peptone and albumose, which showed that it has very pronounced proteolytic action. The enzyme **papain** is a white granular powder, 0·5 gramme of which will digest 1 pint of milk in thirty minutes. It is valuable in therapeutics, where it is deemed advisable to administer artificial digestants. It especially acts upon the sarcolemma of muscular fibres, and exposes the sarcous elements to the action of the pepsin of the gastric juice. Papayotin, the dried juice, is useful as a sedative to the stomach in gastralgia, ulcer of the stomach and duodenum, vomiting, flatulence, acid eructations, atony, and other diseases of the stomach where artificial aid is desirable.

Bread-Fruit.

The fruit of *Artocarpus incisa*, N.O. Moraceæ, is a large spurious fruit, or sorosis, like the pineapple, consisting of a somewhat round fleshy mass, 6 inches or more in diameter, of a greenish colour, covered with fibrous papillæ, and containing a white fibrous pulp, which becomes yellow and succulent during maturation. The taste of the pulp is not unlike cabbage. It is roasted before being

eaten, or is made into bread. The inhabitants of Ceylon also make numerous savoury dishes of it. It is a native of Java, Amboyna, and the neighbouring islands; has been cultivated from great antiquity, giving rise to many varieties, and forms one of the principal foodstuffs of the Cingalese, Malay, and South Sea Islanders.

Composition.—Water 63·0, albumin 3·0, starch 14·0, gluten and woody fibre 19·0, ash 1·0, per cent.[1]

The **Jack-Fruit** (*A. integrifolia*) is much larger than bread-fruit, but contains seeds like chestnuts, which are used in the same way. It is cultivated in Asia from the Punjab to China, and from the Himalayas to the Moluccas. The bread-nut (*Brosimum alicastrum*) of the West Indies tastes like hazelnuts when roasted, and is eaten as bread.

Rhubarb, or Pie-Plant.

Rhubarb is not a fruit, but the leaf-stalk of *Rheum rhaponticum et undulatum*, N.O. Polygonaceæ. It is a valuable article of diet, rich in vegetable salts, and is in season when fruit is scarce. It occupies the same position as fruits in the dietary, but it is uneatable in its raw state. Wine and other beverages are made from it. Its use is contra-indicated for persons of the gouty diathesis, and those with oxalate of lime gravel, and some cases of rheumatism, owing to the presence of oxalate of lime in the stalks.

Composition.—Water 92·67, protein 0·83, fat 1·19, carbohydrates 3·36, salts 0·94, per cent.

Various Unclassified Fruits.

N.O. Berberidaceæ.—The fruit or berry of the common barberry (*Berberis vulgaris*) of our woods and hedges is acid and astringent, grateful and refreshing to the palate; used as a preserve or dried and eaten as a sweetmeat. The juice is used to flavour comfits or to make a refrigerant beverage. The fruit has refrigerant, antiscorbutic, and astringent properties. The leaves are subject to the attacks of *Æcidium berberis*, which becomes in a further stage of development *Puccinia graminis*, the rust or smut of wheat. *Mahonia aquifolia*, closely allied to the barberry, produces a purple fruit which makes an excellent preserve.

N.O. Bixaceæ.—*Flacourtia ramoutshi*, of Madagascar, yields an edible fruit of the size and shape of a small plum, with transparent pulp having a sweet taste, but leaving a sharpness in the mouth. *F. sapida* and *F. inermis*, several species of which are cultivated, yield fruit of the size of a currant, called "pedda canrew" in the Moluccas.

N.O. Dilleniaceæ.—The fruit of *Dillenia speciosa* is a very acid fruit, made palatable by the addition of sugar, the juice also being used as a beverage in India. The young calyces of *D. speciosa*, *D. scrabella*, and *D. elliptica*, are used in curries, and the ripe fruit as a sauce for fish.

N.O. Bombaceæ.—The Ethiopian sour gourd, the fruit of *Adansonia digitata*, contains a white spongy pulp which envelops seeds of a kidney-bean shape. The pulp has a taste like gingerbread, but is slightly acid, and is eaten by the natives of Northern Africa, with or without sugar. The juice is used as a beverage.

N.O. Tiliaceæ.—*Grewia asiatica*, *G. sapida*, and other species, produce berries which are highly esteemed for their agreeable acid flavour, and are much used in the East for making sherbet. The berries of *Aristotelia maqui*, black when ripe, which are agreeably acid, are much esteemed, and used for making wine in Chili.

[1] E. Smith's "Foods," p. 206.

N.O. Clusiaceæ.—Besides mangosteen (*q.v.*), other fruits of this order are used—*e.g.*, *Xanthochymus pictorius*, which is like an orange in appearance and an apple in flavour; *Garcinia cochinchinensis*, which bears a reddish fruit, of size and shape of a small pear, having a juicy pulp and an odour of apples. It is eaten raw when ripe. The fruit of *Cambogia gutta*, 2 inches in diameter, is sweet and succulent, and eaten at meals as an appetizer and an ingredient of sauces in Malabar, Siam, Cambodia, etc.

N.O. Hippocrateaceæ.—The edible fruit of *Salacia cochinchinensis* is covered with imbricated scales, and is of the size and shape of a pear. That of *S. pyriformis*, of Sierra Leone, is similar, but sweeter and more agreeable. Several species of *Tontella* yield sweet, mucilaginous, and wholesome fruit. The seeds of *Hippocratea comosa*, which are oily and sweet, are used in the West Indies like almonds.

N.O. Malpighiaceæ.—The cowhage cherry, cometimes called the "Barbadoes cherry," is the fruit of *Malpighia urens*, of South Africa, Central America, etc.; is an acid, mucilaginous, and astringent fruit. The Surinam cherry, also called the "true Barbadoes cherry," is the fruit of *M. glabra*; it is red, of the size of a cherry, and has an abundant sweet and agreeable juice (for composition, see Cherries). Another cherry-like fruit is that of *M. setosa*, which is much used in Martinique. The sugar plum of Sierra Leone (*M. saccharina*) is of the size of a damson, has a sweet, agreeable juice, but a warty and uneven surface. It is grown abundantly, and sold in great quantities in the markets.

N.O. Sapindaceæ.—Some of the most delicious fruits in the world belong to this order. The akee, or fruit of *Blighia sapida*, is much esteemed in the West Indies and South America. It is of an orange-red colour, ribbed, and contains several large seeds embedded in a white, succulent, and slightly acid aril, which is the part eaten. The leechee or litchi (*Nephelium litchi*) is a Chinese fruit of the size of a date, red on one side, green on the other, covered with a hard scaly rind, but having a delicious white sweet pulp of subacid flavour. The fruit is eaten fresh, or dried like prunes; they are also preserved in honey or spirit, and are imported into Europe and America. The Chinese use this fruit in their tea, to which it gives a subacid flavour, preferred by them to the sweetness of sugar (see Litchi Nuts). The longan (*N. longana*) is considered to be even superior to the litchi, being more fragrant, sweeter, and wholesomer. Like the former, it is a native of China, but is cultivated as far west as Bengal. It is imported in a dried state into Britain, and is grown there in some hothouses. The rambutan (*N. lappaceum*), cultivated over the whole of the East Indies, is also much esteemed. The fruit is round or oblong, of the size of a plum, has a downy exterior, and grows in clusters. The rind is easily removed, and discloses a white pulpy interior, which is somewhat tough, but contains a viscid, acid, but sweetish juice, something like lemon-juice and sugar. The honey-berry (*Melicocca bijuga*) of the West Indies is a black fruit of the size of a damson, with sweet, agreeable taste. The seed is roasted and eaten like chestnuts. The wild-prunes of South Africa are the fruit or berries of *Sapindus senegalensis*. Guarana bread consists of the seeds of *Paullina sorbilis*, of Brazil, which are made into cakes as a medicine.

N.O. Meliaceæ.—The aril which surrounds the seeds of *Melia edulis* is thick, lucid, and edible, like that of the litchi. The bead-tree (*M. azedarach*), of India, Persia, South Europe, and America, bears a pale yellow, cherry-like fruit with a sweetish edible pulp.

N.O. Rhizobalaceæ.—The suwarrow or butternut (*Caryocar nuciferum*) of South America and the West Indies is highly esteemed. The kernels are pure white, soft, and fleshy, have a fine milky or bland flavour, like that of a sweet almond, but are softer in texture. *C. butyrosum* has a flavour like Brazil nuts; *C. tomentosum* is also much esteemed in Guiana; and other similar nuts are *C. glabrum*—the suwarrow of Cayenne—*C. amygdaliferum*, and *C. amygdaliforme*.

N.O. Oxalidaceæ.—The carambola (*C. averrhoa*) of East India bears a fruit of the size of a duck's egg, of yellow colour, agreeable acidulous flavour, used

in tarts, preserves, and sherbet. They are also called the "Coromandel gooseberry," and are grown in almost every garden in India. The leaves and flowers are eaten as a salad and pickled in vinegar. The cucumber-tree (*C. bilimbi*) of the East Indies and South America bears a beautiful smooth, green, fleshy fruit of the size of a small cucumber. The unripe fruit is extremely acid, and is preserved with sugar or pickled in brine or vinegar. The ripe fruit contains a grateful acid juice, and is eaten raw.

N.O. Rhamnaceæ.—The fruit of *Zizyphus vulgaris* is known as the "jujube" in France, Spain, and Italy. It is a drupe of the size of a small plum, at first green, but becoming red outside, and having a yellow, tender, fleshy pulp of acidulous taste, and a stone in the centre. They are gathered when ripe and dried for dessert. The jujube originally consisted of the juice of this fruit mingled with sugar and gum arabic, but as now made the fruit forms no part of that confection. The jujube-tree of India, China, etc., is *Z. jujuba*, which bears a small edible fruit, which is sweet but mealy, and as large as a hen's egg. The fruit of *Z. lotus* is said to be the lotos of the Lotophagi celebrated by Homer. The tree is a native of Northern Africa and Southern Europe, and its fruit is a drupe of the size of a small plum, of purplish colour, downy covering, and farinaceous pulp, having a flavour of fig or date. The fruit is much used by the Arabs and other African races, who dry them in the sun, pound them to remove the stones, and make the pulp into a cake which has the colour and flavour of gingerbread. Some authorities, however, refer the lotos to the deliciously-flavoured but intoxicating berry of the *Nitraria tridentata*, which is still highly prized by the Berbers.

N.O. Anacardiaceæ.—The name "hog-plum" is the popular name of fruits of various species of *Spondias* in the West Indies. *S. purpurea* and *S. lutea* in particular are known by this name. *S. purpurea* is a purple plum with an agreeably acid yellow pulp of aromatic flavour, which is highly esteemed, and also called the "Spanish plum." *S. lutea*, also called the "golden apple," is a yellow fruit of the size of a plum and agreeable but delicate aromatic flavour. *S. tuberosa* is much esteemed in Brazil, where a dish is prepared of the juice mixed with milk or curds and sugar. The Otaheite apple (*S. dulcis*) is a large smooth fruit of golden-yellow colour, having a sweet, aromatic pulp of a nauseous odour. The flavour somewhat resembles that of a pineapple. Custom evidently induces a great relish for the fruit, as the trees are cultivated all over the Moluccas, Java, the Friendly and Society Islands.

N.O. Amyridaceæ.—The fruit of *Canarium commune*, of the East Indies and Moluccas, is an important article of food to the natives. It is eaten in the same way as almonds in Europe, both raw and roasted. In Amboyne they are made into bread and marmalade. The fruit of *C. pimela* and *C. album* are pickled and eaten like olives, which they are considered to resemble.

N.O. Rosaceæ, genus *Chrysobolanæ*.—The fruit of *Parinarium exelsum*, of Sierra Leone, etc., called the "grey plum," is of the size of an ordinary plum, grey colour, coarse skin, dry mealy pulp, and large stone. They are grown abundantly and sold in the markets.

N.O. Passifloræ.—The fruit of the sweet calabash, or apple-fruited granadilla (*Passiflora maliformis*), has an agreeable pulp, which is eaten with wine and sugar. The common granadilla (*P. quadrangularis*) contains an edible succulent pulp of purple colour which is very agreeable.

N.O. Cornaceæ.—The cornelian cherry is a shrub (*Cornus mas*) which grows over all Europe except England. The unripe fruit, which is of the size of a horsebean, is pickled in brine or vinegar, and eaten like olives. The ripe fruit is sweet, and eaten raw or preserved.

N.O. Rubiaceæ.—There are several edible fruits of the gardenias. *Genipa marianæ*, of Cayenne, and Surinam, has an edible fruit of the size of an orange, and of agreeable acid flavour. *G. esculenta*, of Indo-China, is only about the size of a cherry, but is edible. The genipap, or fruit of *G. americana*, a native of the Caribbee Islands, is as large as an orange, and has a greenish-white colour, a dark violet juice, and vinous pulp, for which it is much esteemed in Guiana and Brazil.

CHAPTER XXIV

THE PRESERVATION OF FRUIT

THE decay of fruit, like that of all other foodstuffs, is brought about by the activity of vegetable organisms. Fruits are, for various reasons, a favourable medium for the growth of micro-organisms. Fungi growing thereon, by reason of their enzymes, produce sugar and peptones, yeasts ferment the sugars, and various other bacteria participating in these changes, finally cause the fruit to putrefy. The object of the preservation of fruit is to destroy such organisms or check their development, and to prevent the access of others. These objects are gained by various means.

1. Cold Storage.

Fresh fruit is readily preserved for an indefinite period by keeping it in a temperature below that which is necessary for the development of the spores of fungi or the growth of bacterial organisms. The temperature must not be low enough to freeze the fruit, which is usually maintained at 34° F. The following temperatures are found most suitable for storing various fruits, etc., by the Genessee Fruit Company, Rochester, New York :[1]

Apples	30 to 33° F.	Lemons	36° F.
Berries	40° F.	Maple syrup	35° F.
Canned goods	35° F.	Nuts	35° F.
Celery	35° F.	Oranges	36° F.
Cherries	40° F.	Pears	35° F.
Cranberries	33° F.	Peaches and plums	35° F.
Dried berries	35° F.	Prunes	35° F.
Dried apples	35° F.	Quinces	35° F.
Dried corn	35° F.	Raisins	35° F.
Dates	35° F.	Vegetables	35° F.
Evaporated apples	35° F.	Wine	40° F.
Figs	35° F.	Water-melons	35° F.
Grapes	36° F.		

2. Chemicals.

Fruit can also be preserved in a fresh condition by placing it in a solution of borax and boracic acid, salicylic acid, or formalin. The micro-organisms gaining access to the solution are destroyed, and the fruit is preserved without change.

[1] *Cf.* Bailey's "Principles of Fruit-Growing," p. 444.

3. Evaporation.

Many fruits, such as apples, pears, peaches, apricots, prunes, cherries, strawberries, raspberries, and blackberries, are preserved by being evaporated.

Dried Fruit.

There are various methods of evaporating fruit :

1. *Sun-drying*, as in the preparation of dried figs, dates, and raisins (*q.v.*).

2. *Baking* them in an oven—*e.g.*, prunes (*q.v.*).

3. *Hot-Air Process.*—This is the most common mode of drying apples, pears, peaches, etc. The evaporator consists of a box-like apparatus with shelves which move upward on an endless chain. The fruit, properly prepared, is put in at the bottom, and slowly ascends to the top, where it is taken out. A current of air, heated to 240° F., enters at the bottom, and, ascending through the apparatus, passes out at the top, carrying with it the moisture absorbed from the fruit. The effect of this method of treatment is as follows : The albumin is coagulated, instead of being slowly dried, as it is when fruit is exposed to the sun ; some of the starch is converted by heat into " glucose," which helps to preserve the fruit ; pectose bodies remain unchanged or converted to pectin, instead of passing with the starch through the saccharine into acetous fermentation ; the diastase, or saccharifying enzyme, whose action produces the primary change leading to the fermentation of the fruit, is rendered inactive ; all bacteria, fungi, and their spores, are destroyed. Fruit evaporated by the hot-air process, or even by baking, is not the same as sun-dried. Apples are boiled at 212° F., and baked at 225° F., but they neither bake nor boil in the evaporator when the air is sent in at 240° F., *providing the air circulates through the drier rapidly*. Indeed, the fruit never attains the temperature of the air, for evaporation is a cooling process, the vapour rising from the fruit carrying away the heat.

4. *Cold-Air Process.*—Some manufacturers use what is known as the " cold-blast system," in which the fruit is dried, without heat, by means of a current of dry compressed air, which absorbs the moisture from the fruit. At the same time the chamber is surrounded by calcium chloride, which absorbs moisture from the air with great avidity. The process is slower than the former, no chemical changes are produced, and its advocates maintain that fruit so dried retains its *natural* flavour while being quite as well preserved.

5. *The Vacuum Process.*—In this method the fruit is dried in a vacuum pan, which combines the advantages of the former processes. The fruit is raised to a temperature of 175° F., which is regarded as sufficient to destroy moulds, ordinary bacteria, and putrefactive organisms. At the same time air, previously dried by passing it through calcium chloride, is alternately let into the

pan and withdrawn. By this means nearly all the moisture is extracted from the fruit in twenty minutes. Fruit so dried usually contains about 12 per cent. of water.

4. Sterilization.

Bottled and Canned Fruit.—In the early part of the nineteenth century François Appert made the first practical application of the methods of preserving fruit by sterilization—*i.e.*, by putting them into bottles or cans, hermetically sealing them, and boiling them for a long time. This method of preservation has come to be known as "Appert's process." About the same time Gay Lussac made extended observations upon similar methods, and arrived at the same conclusions.

In Appert's time, and until more recently, it was generally thought that the decomposition of food was induced by the action of the oxygen of the air. Hence he concluded that for the preservation of such substances the exclusion of air was essential, and the application of gentle heat in a water-bath caused a fusion of the principal constituents of the food in such a manner that putrefaction was impossible. It is, however, to Pasteur and subsequent scientists that we are indebted for the knowledge that it is not the oxygen of the air which produces the changes in fermenting or decomposing food, but bacteria and other micro-organisms.

But if Appert's theory of the causation of putrefaction was wrong, his method of preserving foods from decomposition was correct; and it was shown by Gay Lussac, and confirmed by Pasteur, that if food is properly sterilized and hermetically sealed it will keep indefinitely.

Under ordinary circumstances food is spoiled by bacteria, yeasts, and moulds. Bacteria grow luxuriantly in foods rich in nitrogenous substances, such as meat, fish, eggs, milk, and cheese; hence it is difficult to keep these foods fresh unless proper precautions are taken. Bacteria do not grow rapidly in substances containing a large proportion of sugar, such as jam or preserves, but they grow rapidly in a moist substance containing a small percentage of sugar, such as fresh fruit. Yeasts also grow rapidly in dilute sugary solutions containing a small amount of nitrogenous and mineral matters, such as the fruit juices. In general, however, acid fruits do not favour bacterial growth; some vegetables contain so much acid and so little nitrogen—*e.g.*, rhubarb, lemons, and cranberries—that very few bacteria and yeasts will attack them. Moulds develop from spores which constantly float in the atmosphere, their development being favoured by warmth and moisture. This is especially seen in warm damp weather, when various foods—*e.g.*, boiled potatoes, blancmange, bread, starch-paste, as well as fruits—become rapidly mouldy. Such moulds are a common cause of the decay of fruit, preserves, jellies, etc.

The principles of sterilization therefore consist in the destruction

of bacteria, yeasts, moulds, and their spores. Most of these organisms are destroyed by exposure to a temperature of 212° F. for ten or fifteen minutes, and some of them at a degree of heat as low as 125° F.; but a few bacteria and the spores of many others resist a temperature of 212° F., unless exposed to it for two hours or longer. Yeasts and their spores are more readily destroyed than bacteria. Mould spores are destroyed by a temperature varying from 150° to 212° F. It is, however, usually considered that fruit may be pasteurized; that is, the ordinary micro-organisms are destroyed by exposure to a temperature of 170° F. But if so low a degree of heat were used, every particle would have to be raised to that temperature, to insure which the application must be prolonged, owing to the size and nature of the fruit. Hence it is customary in practice to submit the fruit for a shorter time to a higher temperature. The soft fruits, when bottled or canned, are usually boiled in an open water-bath at 212° F., and all fruits sterilized on a small scale are done in the same way. Large fruits, such as peaches, pears, tomatoes, pineapple chunks, are boiled for a short time in a closed vessel, or "autoclave," where the temperature reaches 220° to 240° F. This apparatus consists of a vessel which is kept close and steam-tight by the steam proceeding from the contents of the pan, or by a lid which is screwed down. It is fitted with a pressure-gauge, thermometer, and a safety-valve. Modern autoclaves are heated by steam, and the action is called **processing.**

The fruit may be sterilized in their own juice, in water, syrup, or alcohol and syrup. When boiled in syrup, they are allowed to soak in it for a few days before being sterilized. The syrup may be "light"—*i.e.*, having a density of 18° Beaumé—or "heavy" —*i.e.*, having a density of 28° or 30° Beaumé. The following proportions of fruit, sugar, and water, are given by Maria Parloa :[1]

	Fruit by Measure.	Sugar.	Water.
Raspberries	12	2	—
Raspberries 10, currants 3	13	2½	—
Blackberries	12	2	—
Currants	12	4	—
Gooseberries	6	1½	½
Blaeberries	12	1	½
Cherries	6	1½	½
Grapes	6	1	¼
Peaches	8	1	3
Plums	8	2	½
Pears	8	1	3
Quinces	4	1½	2
Crab apples	6	1½	2

[1] Farmers' Bulletin 203, U.S. Department of Agriculture, 1904.

Brandied Fruit.—Cherries and other fruit are sometimes bottled in brandy, or brandy and syrup, after previously sterilizing the fruit. The chief point requiring notice is that such fruit contains alcohol, varying from 15 to 25 per cent. of the entire substance; therefore the unrestrained consumption of it might lead to various dangers arising from alcohol. Such fruit is by no means a proper food or dessert for children or young persons. With respect to the form of alcohol used, it should be noted that an inferior brandy is the customary liquor, and it is sometimes not a genuine but a manufactured brandy, which adds to the dangerous nature of the substance. Brandy of a good quality ought to be used in this mode of preserving fruit, instead of impure brandy or that made of grain spirit.

Tinned Peaches and Apricots are sent out in enormous quantities from the districts where they grow abundantly, especially the Californian orchards. In their normal state these fruits are very perishable, and could not be delivered in a fresh condition at a distance of thousands of miles from their source; neither are they so well adapted for preservation by refrigeration as other articles of food. But the operation of canning them affords to the consumers of temperate climes the opportunity of purchasing at a reasonable price the finest produce of remote regions. For *tinned and bottled cherries*, see Cherries.

The Action of Fruit Juices upon Tin.—Tinned fruit is sometimes poisonous owing to the action of the juice upon the tin, and especially upon the solder used for sealing them. Solder is usually an amalgam of tin and zinc, and is more easily acted upon than tin itself. The action of the juice is of an electrolytic character, ions being produced which lead to the destruction of the colour of the fruit and to the formation of chlorides of the metals zinc and tin. The ash of cherries, for instance, contains 1·8 per cent. of chlorine, which, being liberated by hydrolysis, leads to the formation of chlorides of the metals. Chloride of tin is distinctly poisonous, and is sometimes found in sufficient quantity to form a deposit in the juice or upon the surface of the fruit. It is found, however, that when a due proportion of resin is used with the solder this substance forms a protection for the metal against the acids of the juice and chlorine ions. A tin of fruit in which the line of resin outside the solder is not visible ought to be rejected. With fish and meat a lining of parchment paper is a sufficient protection against the formation of the metallic chlorides.

5. Preservation of Fruit by Sugar.

Preserves and Jam.—The domestic preservation of fruit usually consists in boiling the fruit with ordinary sugar until the combination has sufficient consistency to "set" on cooling. The fruit thus thoroughly sterilized, when properly protected from the entrance of germs by being covered *while hot* with parchment paper, will keep good for years. There is no more wholesome food than good "home-made" perserve or jam. It is valuable as a food by reason

of the sugars, organic acids, and salts. It is a ready means of providing carbohydrate material. Its use encourages the consumption of a substantial meal of bread and butter by young children, who require a large amount of carbohydrate in proportion to their size. It is also of great value in tarts and boiled puddings for the same purpose, the fat or suet used in these confections being an additional source of heat and energy. The only distinction between jam and preserve appears to be as follows : In preserves an endeavour is made to keep the fruit in its unbroken condition ; in jam no such effort is made—on the contrary, the fruit is frequently broken up while boiling, in order to remove the stones, thereby reducing the fruit to a pulp.

The manufacture of jam on a large scale is an industry in many places. The pans then consist of large iron or copper vessels, the best firms having them lined with silver. Care must be taken that such jam is composed of sound fruit and sugar only, and that foreign vegetable substances, glucose, and aniline dyes, are not used. The selection of the fruit is a matter of importance. It should be mature, but not overripe ; immature or deformed fruit should be rejected. In the domestic preservation the fruit comes under the supervision of the housewife, and is likely to be carefully overhauled ; but in the commercial manufacture of jam such careful inspection is impossible. Care, however, should be taken to remove leaves, stalks, dirt, insects, and other obnoxious substances. The stones are usually removed from peaches, apricots, and large plums ; apples, pears, and oranges, etc., are peeled, and the pit or core and seeds removed.

The proportion of sugar used in making jams or preserves varies with the kind of fruit, cane-sugar being the proper material. More sugar is required for acid fruits, because the inversion is greater, less sugar being required for small berries, and especially sweet fruit. Scientifically speaking, every kind of fruit should be boiled in a syrup of known density. When the proportion of sugar to water is greater, the density is higher, and a " heavy " syrup is produced ; when less sugar is used, the density is lower, and we have a " light " syrup. It is difficult to say what proportion of sugar and water will produce a syrup of definite density, because the density varies with the altitude above the earth's surface—*i.e.*, if a syrup were made of the same proportion of sugar and water at sea-level and at 1,000 feet above sea-level, the syrup made at sea-level would be thicker than that produced at the higher altitude. A syrup-gauge should therefore be used, by which means the density of the syrup can be ascertained at any stage of the boiling process, and the syrup can be made heavier or lighter, as the case demands, by the addition of sugar, more fruit-juice, or water. The following is given by Maria Parloa [1] as the amount of sugar and water required to produce a syrup of a particular density, after boiling the mixture for one minute ; and also the kind of syrup suitable for preserving various kinds of fruit :

[1] Farmers' Bulletin 203, U.S. Department of Agriculture.

SYRUP FOR PRESERVING FRUIT.

Density of Syrup.	Proportions.		Fruit.
	Sugar.	Water.	
40° Beaumé	1 pint	1 gill	To preserve strawberries or cherries.
32° ,,	,,	2 gills	To preserve peaches, plums, quinces, currants, etc.
28° ,,	,,	3 ,,	
24° ,,	,,	1 pint	For canning acid fruits.
17° ,,	,,	1½ pints	For canning pears, peaches, sweet plums, raspberries, cherries, blackberries, and blueberries.
14° ,,	,,	2 ,,	

The Changes which occur during Preserving.—All bacteria, yeasts, moulds, and their spores, are destroyed; all portions of the fruit become saturated with the syrup; the free acids of the fruit, aided by the heat, transform a considerable proportion of the sucrose or cane-sugar into invert sugar, a mixture of dextrose and lævulose. The amount of cane-sugar in "home-made" jam, according to Aitchison Robertson,[1] is about 20 per cent., but in commercial jam it varies from 15 to 50 per cent. He also found that the inversion of sugar varies in the following manner:

Kind of Jam.	Sugar inverted.
Strawberry jam	Two-fifths.
Raspberry jam	Three-fifths.
Blackberry jam	Four-fifths.
Marmalade	Five-sixths.
Plum jam	Six-sevenths.

When fruit is very ripe it contains less free acid, and consequently the inversion of sugar is less, for which reason acid fruits make better jam than sweet fruits. Again, the inversion of sugar is not so great if the fruit is not boiled long enough. In either case the proportion of cane-sugar remains high, and has a tendency to crystallize in the jam, and when such crystallization occurs the consumption of the jam is neither so desirable nor agreeable. Many manufacturers, aware of the possible crystallization of cane-sugar in the jam, add "glucose" in order to prevent it. But when genuine fruit of good quality only is used, the inversion of cane-sugar is so great that there is little risk of its crystallization, which does away with the manufacturers' plea of the necessity to add "glucose" in order to prevent it.

Among other changes which take place is the conversion of the "pectose" bodies of the fruit into **pectin**, or vegetable jelly, which causes the jam to set when it is cold. Some fruits, such as apples and gooseberries, contain more pectose than strawberries, cherries, etc. The deficiency in pectose bodies has led manufacturers to use other substances than fruit in order to gelatinize the jam.

[1] "Saccharine Foods as Articles of Diet," the *Scottish Medical Journal*, July, 1898.

These are, Japanese gelatin (agar-agar), which is used in the proportion of 1 per cent.; ordinary gelatin in the proportion of 5 per cent.; turnips, beetroot, vegetable marrow, boiled sago, boiled figs, etc. Turnips contain 5 per cent. of carbohydrate, the bulk of which consists of pectose bodies, and some of the other vegetables contain a like proportion, hence their value to the maker in compounding or adulterating jam. Apple pulp and gooseberry pulp are frequently combined with other fruits, because they are rich in pectin and supply that deficiency. The following are given by "The Practical Grocer," vol. ii., p. 206, as the proportions used in making commercial jams :

COMMERCIAL JAM—PROPORTION OF SUBSTANCES USED.

	Fruit.	Water.	Cane-Sugar.	Glucose.	Other Material.
Apricots (*a*)	20	2	15	8	
,, (*b*)	20	2	15	16	Apple pulp, 12.
Black currants ..	14	6	16	—	
Orange marmalade	25	nil	22	—	
Plums	60	nil	60	7	Apple juice, 10.
Raspberries (*a*) ..	20	nil	20	nil	
,, (*b*) ..	14	nil	20	nil	Apple pulp, 6.
,, (*c*) ..	10	nil	30	7	Apple pulp, 14; gooseberry pulp, 12.
Strawberries ..	18	nil	20	nil	
Mixed fruit	100	nil	30	70	Agar-agar, 1¼.

Composition of Jam or Preserve.—It consists of the substance of the fruit—cellulose, pectin, fruit-sugar, organic acids, and seeds or stones, together with the natural ethers or essential flavourings, and the added sugar or "glucose." The composition of the jams in the table on p. 670 is given by Wiley; they are free from commercial glucose, and apparently pure :

The following table[1] of the composition of home-made and commercial jam was made after an analysis of seven samples of home-made black currant, strawberry, gooseberry, raspberry, quince, plum, and damson jam; and eleven commercial samples of black currant, raspberry, damson, apricot, strawberry, and plum jam :

		Water.	Invert Sugar.	Cane-Sugar.	Other Solid Matter.	Skins and Seeds.	Ash.
Home-made jam :	Minimum	24·76	40·98	2·27	1·11	2·56	·35
	Maximum	33·93	60·42	16·14	7·35	8·44	·81
	Average	30·47	53·11	6·71	4·84	4·34	·52
Commercial jam :	Minimum	23·09	20·00	12·11	·40	1·26	·22
	Maximum	34·56	51·88	41·45	6·39	11·45	·53
	Average	29·52	35·67	27·85	3·09	3·49	·37

[1] *The Analyst*, ix. 100.

Many factory-made jams are formed of the pulp of fruit from which some of the juice has been removed, whereby it is deprived of the natural sugars, acids, and pectose bodies. As a portion of the pectose bodies has been removed with the juice, such jam does not gelatinize in a normal manner, but remains of a syrupy consistence. In order to obviate this, however, it is the custom to add about 1 per cent. of Japanese gelatin (agar-agar), dissolved in water, just before bottling the jam, or to combine with the fruit pulp some other substance containing pectose bodies—*e.g.*, turnip, beetroot, mangold, carrot, or in some instances apple or gooseberry pulp. Jam made from pulped fruit is frequently inferior in colour, inasmuch as some of the colouring matter is removed with the juice; but this defect is also rectified by colouring the mixture with **cudbear** or **cochineal,** and some other substances, according to the kind of fruit.

COMPOSITION OF JAM—PERCENTAGES.[1]

	Total Solids.	Acidity.	Reducing-Sugars.	Cane-Sugar.	Total Sugars.
Average composition	65·89	·536	36·41	22·15	58·56
Minimum	50·43	·163	13·20	·30	—
Maximum	82·46	1·356	61·02	54·23	—
(*a*) Home-made jams:					
Apple jam ..	63·22	·282	25·22	29·11	54·63
Blackberry jam	55·42	·851	18·77	29·00	47·77
Grape jam ..	56·64	·744	33·44	11·33	44·77
Orange marmalade	80·52	·433	13·61	54·23	67·84
Pear jam ..	61·52	·163	13·20	33·74	46·94
Peach jam ..	65·65	·500	36·48	23·16	59·64
Pineapple jam ..	73·92	·314	14·05	46·40	60·45
Plum jam ..	50·43	1·012	28·29	9·70	37·99
(*b*) Shop jams:					
Apricot jam ..	70·15	·407	38·96	26·00	64·96
Currant jam ..	66·32	1·117	52·45	1·64	54·09
Grape-fruit jam	69·20	·387	27·00	35·51	62·51
Guava jam ..	82·46	·299	25·14	52·73	77·87
Peach jam ..	65·65	·500	36·48	23·16	59·64
Strawberry jam	75·83	·480	37·15	31·43	68·58

What is Jam ?—Correctly speaking, jam is a fruit preserved by boiling it with sugar. If, therefore, a substance is sold for black-currant jam which contains other substances than black currants and sugar, or their chemical products, the additional substance should be regarded as an adulteration, whether or not the substance be injurious to the human system. It is therefore an adulteration to combine apple pulp with apricot jam, or gooseberry pulp with raspberry jam. In general terms it may be stated that the addition of rhubarb, vegetable marrow, turnip, carrot, beetroot, figs, boiled sago, gelatin, or agar-agar, to fruit jam is fraudulent, unless the

[1] Wiley's "Foods and their Adulteration," pp. 377, 378.

fact is distinctly stated on the label, or the material is sold as a compound of fruit, vegetables, and gelatin. Commercial "glucose" has been found in jam in the proportion of 50 or 60 per cent. It can be detected by chemical tests, and especially by polarization—"glucose" turning the plane of polarized light strongly to the right. The addition of "glucose" must be an adulteration, although it has been held in a High Court of Justice that the addition of 13 per cent. of "glucose" to orange marmalade was not an adulteration. The proportion of water in jam varies from 20 to 50 per cent.; it would therefore be difficult to fix a standard for water. Preservatives are absolutely unnecessary in properly-prepared jam, but salicylic, benzoic, and boric acids and borax are frequently put in as a safeguard against moulds and fermentation. The composition of jam is determined by chemical analysis, especially for cane-sugar, invert sugar, and "glucose." The nature of the organic constituents is ascertained by diluting a little jam with water, and inspecting the residue with a lens. The presence of apple pulp is determined by tests for starch, which it contains—*i.e.*, by boiling a little jam in water and adding some iodine to the liquid; the presence of starch—*e.g.*, sago—is also revealed by the characteristic blue reaction with iodine, and the nature of the starch is determined by the microscope.

Fruit Jelly.

Fruit jelly consists of a transparent or translucent substance, which is fluid or semifluid when warm, but becomes stiff on cooling. Such a jelly is made from the juice of a fruit, to which it owes its flavour, colour, and consistency, and ordinary cane-sugar. The property of gelatinization is due to **pectin** derived from the fruit. Pectin, however, only occurs in ripe fruit, and not at all in unripe fruit; but growing and partially ripened fruit contains a large amount of insoluble **pectose bodies** and an enzyme, **pectase.** As the fruit ripens the pectase acts upon the pectose, converting it into the soluble pectin, a carbohydrate having properties similar to those of starch. There is most pectin in the fruit when it is just ripe or a little before; this is therefore the best time to make the jelly. When equal quantities of fruit juice and sugar are heated together for a short time at a temperature of 212° F., the pectin gelatinizes the mass on cooling. If the juice is boiled too long, the pectin undergoes a change and loses its power of gelatinizing; it becomes transformed into pectic, parapectic, and metapectic acids But even the pectose bodies become converted to pectin by the due application of heat, and therefore the juice of unripe fruits will gelatinize after being cooked.

The manufacture of such jellies is done on a small scale domestically, and on a large scale commercially. Soft fruits are boiled with a small amount of water until reduced to a pulp; the juice is then separated by pressure, and strained through a felt jelly-bag to separate suspended matters and pulp. Large quantities are manu-

factured from the juice of unboiled soft fruit obtained by pressure. Hard fruits are softened by boiling them, in order to obtain the juice by pressure. In all cases the juice is boiled with an equal quantity of cane-sugar for about half an hour, or until it will gelatinize. Maria Parloa says the juice and sugar should be put in a pan over a fire, and stirred until the sugar is dissolved; when it boils, draw it back and skim it, boil again and skim it, and again a third time; pour it into hot glasses, and cover it up as soon as the jelly sets. "The Practical Grocer" (vol. ii., p. 209), however, says the following is one of the best modes: "Put the sugar into a pan, with enough water to dissolve it; boil, and skim it until it is free from scum, and a little of the syrup poured upon a cold plate sets into a brittle sugar. Now add the fruit juice, and boil it again until a little poured upon a cold plate will gelatinize."

Jelly made of equal parts of juice and sugar is sometimes considered too sweet; it is, moreover, a common practice in the commercial manufacture of fruit jelly to use equal quantities of "glucose" and sugar to make the syrup, which, when boiled with fruit juice, results in the formation of a jelly which is less sweet, but very palatable. All fruits do not contain the same amount of pectin or pectose bodies, and therefore do not make an equally stiff jelly; this has led to the use of other substances to stiffen them, especially those made from the juice of berries. Apple juice makes an excellent jelly, and it has become a custom to add this liquid in the proportion of 1 part to 2 or 3 parts of the other fruit juice—*white* apple juice being combined with that of oranges, lemons, and pineapples, and *pink* apple juice to that of red fruit. Japanese vegetable gelatin (agar-agar) is added by some makers in the proportion of 1 per cent.

Composition of Fruit Jellies—Percentages.[1]

	Total Solids.	Ash.	Acids.	Protein.	Reducing Sugars.	Cane-Sugar.
Apple jelly	59·18	·22	·279	·175	20·78	33·04
Blackberry jelly	59·63	·33	·475	·243	12·51	44·90
Cherry jelly (*a*)	61·60	·60	—	1·100	59·80	
,, ,, (*b*)	79·00	·70	—	1·200	77·20	
Crab apple jelly	63·29	·11	·171	·137	34·93	23·69
Damson jelly	45·56	·68	1·127	·350	19·18	22·67
Huckleberry jelly	63·02	·28	·245	·069	24·27	32·74
Peach jelly	69·98	·21	·245	·175	8·75	56·59
Pear jelly	69·12	·34	·181	·156	6·59	58·46
Pineapple jelly	80·28	·43	·328	·387	22·13	56·70
Plum jelly	54·49	·40	1·029	·138	24·00	25·48

Jelly is a compound of the pectose materials of the fruit, fruit-sugar, organic acids, natural flavour and colouring, *plus* the added

[1] *Cf.* Wiley, Report of Bureau of Chemistry, U.S. Department of Agriculture; (*a*) and (*b*), Atwater and Bryant, Bulletin 28, U.S. Department of Agriculture.

sugar. *Commercial jellies*, however, frequently contain gelatin, agar-agar, and the juice from other pectose-containing substances. Apple juice is largely used as a basis for all kinds of jellies; various colouring agents and flavouring essences are used, and the substance is frequently preserved by benzoate of soda, benzoic, boric or salicylic acids. Apple juice and "glucose" do not alone form a very stiff jelly, but the addition of a little alum, sulphuric, phosphoric, or tartaric acid, causes it to gelatinize.[1] The cheapest jellies are nearly always compounds in which pectin is replaced by agar-agar, the fruit-sugars by "glucose," the natural acidity by citric or tartaric acid, and the aroma and flavour of the fruit by artificial essences. The following commercial recipe for making such jellies is given by "The Practical Grocer":[2] "In one vessel 26 pounds of ordinary sugar and 54 pounds of glucose are dissolved by the aid of a little water and gentle heat. In another vessel 17½ ounces of Japanese gelatin (agar-agar) is dissolved in water, and mixed with 18 pounds of glucose and gently heated. The surface of both liquids is skimmed to remove impurities, and the contents of the latter added to the former vessel. Now 18 quarts of **fruit juice** are separately heated, and mixed white hot in the foregoing syrup. Finally 9½ ounces of tartaric acid is dissolved in 30 ounces of water and mixed with it, and it is coloured by the addition of cochineal for strawberry jelly, or cudbear for other red jellies. The mixture is not allowed to boil after the addition of the fruit juice and acid, because acids aided by heat produce a change in agar-agar which prevents it setting into a jelly." Orange and lemon jellies are frequently made with no other juice than that of apples, some makers adding gelatin, agar-agar, or even starch; they are usually flavoured with citric or tartaric acid, or both of them, and essence of orange or lemon.

Artificial Jellies.—Some of the commercial jellies are made entirely without fruit. Girard, the Director of the Paris Municipal Laboratory, found **gooseberry jelly** which was made entirely of seaweed, coloured with aniline dye, and flavoured with a compound containing acetic ether 5 parts, succinic acid 1 part, tartaric acid 4 parts, aldehyde 1 part, and œnanthic acid 1 part. Strawberry, cherry, plum, apple, pineapple, and other fruit jellies, are made in the same way, and flavoured with mixtures such as those used in flavouring fruit syrups, jelly tablets, etc.

The presence of starch in a jelly is detected in the following manner: An aqueous solution of the sample is heated to nearly boiling-point, and decolorized by dilute sulphuric acid and permanganate of potash. The liquid is then cooled, filtered, and tested for starch by iodine. Apple juice normally contains only enough starch to just give a reaction with iodine.

The presence of aniline colouring is detected in the following manner: Strips of woollen cloth, such as "nun's veiling," are boiled with soap and thoroughly washed. A strip is afterwards boiled for fifteen minutes in a solution of the jelly or jam, to which a little bisulphate of potassium has been added. It is then boiled again in a soapy water, and if it has been at all coloured by the

[1] Leach, "Food Inspection and Analysis," p. 716. [2] Vol. ii., p. 210.

dye it is digested with dilute ammonia, which will dissolve the colours ; the fabric is then removed. The jelly or jam solution is now slightly acidified, and a fresh piece of the fabric boiled in it. This second dyeing will fix the aniline colours, but will not fix the natural fruit colours. There are, however, a few vegetable colouring matters used—*e.g.*, archil and cudbear—which cannot be distinguished from aniline dyes.[1]

It is convenient to mention here that **jelly tablets** and **powders** are made of gelatin, agar-agar, and other vegetable substances, acidified with citric or tartaric acid, and flavoured with essence of orange and lemon, or artificial flavourings. **Wine jellies** are also made in a similar manner ; they were originally made from cow-heel, like calf's-foot jelly, but they are now usually made by adding 5 per cent. of gelatin to liquids containing port-wine, sherry, madeira, noyau, champagne, or punch. The gelatin is dissolved in water by gentle heat, clarified by the white of egg, strained, and mixed with the wine (whose name they bear) and sugar, etc. But some of the jellies bearing the names of various wines contain no wine whatever, but are a combination of gelatin, agar-agar, apple pulp, or other vegetable substance, sweetened, coloured, and flavoured by artificial agents.

Fruit Juices and Syrups.

Most fruits in their mature condition contain an abundant juice which, when expressed and properly prepared, forms a pleasant addition to our supply of unfermented beverages.

Fruit Juices are bottled for drinking and culinary purposes. The juice of the grape makes a particularly good unfermented beverage. Grape juice is prepared on a large scale by some firms by the Kühn process, which consists of sterilization by a combination of heat and pressure. At the time of vintage the skins of the grapes contain so many spores that alcoholic fermentation begins in the juice immediately after it is expressed. These spores, or some of them, are proof against boiling ; hence fermentation in some commercial juices is checked by the addition of chemicals, which are nearly as injurious as alcohol itself. But they can be preserved by the Kühn process without the addition of preservatives, such as sulphides, salicylic or boric acid. The method consists in sterilizing the juice under strong pressure at a temperature of 230° F. (110° C.). The apparatus consists of a long, narrow metal cylinder, having a silver lining, and closed by a lid, to which is attached a bundle of silver-lined tubes. The fruit juice is put in the cylinder, which is made to revolve, and is heated by the circulation of hot water through the tubes, and through an outer casing which surrounds the cylinder. The liquid is thus raised to the temperature indicated, which causes a tremendous pressure owing to the expansion induced ; sterilization is thus effected by a combination of heat and pressure. It is then cooled and received into bottles or other vessels previously sterilized.

[1] Winton, *Jour. Amer. Chem. Soc.*, 1900, p. 582.

Maria Parloa[1] gives the following mode of the preparation of **grape juice** as an example of the manner in which all fruit juices should be prepared domestically: The grapes are washed, picked from the stems, put into a preserving-pan, slightly crushed, and boiled for half an hour. The juice is then obtained by straining and expression. It is boiled again and skimmed; sugar is afterwards added in the proportion of *1 pint* to each gallon of juice, being stirred until it is dissolved, boiled and skimmed again. It is boiled three times, poured into *hot* sterilized bottles, and put into an oven in a pan of boiling water for ten minutes; after which the bottles are filled up with sterilized juice, corked, and sealed down. All other juices are prepared in a similar manner. The proportion of sugar which should be added, according to M. Parloa, is 1 pint to each quart of currant juice, and ½ pint to each quart of raspberry, blackberry, or strawberry juice. The juice of plums, peaches, cherries, and stone fruit generally, is obtained after boiling the fruit in the same way as for making jelly.

Fruit juices make an admirable beverage of a non-intoxicating character, containing the organic acids of the fruit either free or in combination with bases, the fruit-sugars, and natural flavour. The most important from this point of view are grape juice and apple juice, although the juices of currants, gooseberries, and rhubarb, make a very pleasant beverage. Grape juice contains as much as 20 per cent. of carbohydrates (glucose, dulcite, and mannite), some albuminoid and gummy matters, mineral salts (phosphates and carbonates), organic salts (tartrates, malates, citrates), free acids, tannin, and a notable amount of iron. It is useful in health and in various acute infections, dyspepsia, liver and kidney diseases—in fact, for the same diseases as the "grape cure" is recommended.

Fruit Syrups.—The only difference between preserved fruit juice and fruit syrups is in the proportion of sugar, the added sugar amounting to 50 per cent. Like fruit juice, they make a delicious beverage when two or three tablespoonfuls of the syrup are added to a tumblerful of water; and they are equally useful for making jelly, ice-cream, or water-ices. Commercial enterprise and the introduction of the soda-fountain has led to the consumption of a large amount of such syrups. In their manufacture the expressed juice is sterilized, usually at boiling temperature, clarified, and filtered. Fifty per cent. of sugar is then added, and it is boiled, skimmed, boiled and skimmed again, until scum ceases to rise. Finally it is put into sterilized bottles, hermetically sealed, and kept at a low temperature.

The composition of such syrups is the same as fruit juice, with 50 per cent. of added sugar. Preservatives, such as benzoate of soda, benzoic, boric or salicylic acid, are frequently added, the argument for this proceeding being that a syrup which does not contain them soon goes wrong after a bottle has been opened. It should, however, not be forgotten that the use of preservatives is

[1] *Loc. cit.*

deleterious to the health of the consumer, and the small quantity which is added to the many articles consumed regularly may quite easily bring the total daily quantity up to a dangerous dose.

Fruit syrups are sometimes imitated by a combination of glucose, colouring matters, and artificial essences. An account of these ethereal flavourings is given elsewhere. The flavour, aroma, and colour, of the juice can be accurately copied, but such substances ought never to be sold as genuine products of the fruit. Many manufacturers of syrups also use an indefinite proportion of genuine fruit juice, and make up the deficiency by artificial products.

Fruit Vinegar.

Raspberry, blackberry, and strawberry vinegars are used for making an acidulous beverage by adding two or three tablespoonfuls to a tumblerful of cold water. Such vinegars are all made in a similar manner. Maria Parloa gives the following directions for making **raspberry vinegar**: Put 2 quarts of raspberries and 2 quarts of vinegar in a bowl, cover, and let them stand for two days in a cool place. Strain the vinegar through cloth, pour it over 4 quarts of raspberries again, and allow it to stand for two days. Strain the vinegar off, put it into a preserving-pan with 3 quarts of sugar, heat slowly, skim carefully, boil twenty minutes, put it into sterilized bottles, and seal it down.

The Colouring Matters used in the Manufacture of Jam and Other Foods.

Many foodstuffs besides jam and jellies are artificially coloured with various substances. It is therefore deemed advisable to give a short account of the materials used for this purpose. These are either aniline dyes or animal and vegetable colourings. The **aniline** colours used are chiefly those of the "azo" class, especially the following: *Dinitro-cresol*, called "saffron substitute," "Victoria yellow," "Victoria orange," "aurantia," and other names, and used for colouring cakes, liquors, etc. *Dinitro-naphthol*, called "Martius' yellow," "Manchester yellow," "naphthol yellow," and "saffron yellow," is used for colouring mustard and other articles requiring a yellow colour, and for combining with other colouring matters. *Trinitro-phenol*, or picric acid, is used for giving a yellow colour and bitterness to beer and other substances. *Aniline-azo-β-naphthol*, sold as Soudan I., gives an orange-red colour to liqueurs and sweets. *β-Naphthol* also gives orange to green colours. Saffoline, called "acid-red"; oroline, called "acid-yellow"; metanil, another yellow; eosin, fuchsin, magenta, blue, violet, and every other shade of colouring, can be produced by aniline dyes in jams, jellies, fruit syrups, artificial wines, confectionery, etc. "A critical review of the existing literature," says Dr. Weyl,[1] "shows that trustworthy

[1] "Sanitary Relations of the Coal-Tar Colours," p. 27. Translated by H. Leffmann.

evidence of poisoning by *pure* aniline colours is not at hand ;" and he expresses the opinion that the poisonous effects on man attributed to them is often due to impurities, such as arsenic ; nevertheless he states that the foregoing articles have all a more or less poisonous action on dogs, and therefore they are presumably poisonous to man.

It has been shown by Weber[1] that **oroline** (acid yellow), diluted to 1 in 160, will retard the action of pepsin in artificial digestion experiments ; and methyl orange, saffoline, and magenta, seriously interfere with pancreatic digestion ; and although most of the " azo " class are not directly poisonous to human beings, they will cause vomiting, diarrhœa, and albuminuria, which effects are seen after the excessive consumption of substances—*e.g.*, sweets—coloured by them.

Mineral Colouring Matters usually consist of Prussian blue, yellow ochre, chalk, salts of copper, arsenic, zinc, and barium, but their use is not so common as it was formerly.

Animal and Vegetable Colouring Matters.—Numerous vegetable colouring matters, and some of animal origin, are used to give a particular tint to many foodstuffs. They are quite unnecessary. A pale-coloured cheese or butter is just as nutritious as that in which the colour is artificially heightened. But it has become an established custom to colour such materials. Fruits contain an abundance of colouring matter, and when fruit only is used there is no occasion to add any other colouring matter to jam, jelly, syrup, or wine. But many jams and jellies are compounds of various fruits, gelatin, agar-agar, or pectose-containing substances, artificially coloured. Wines, syrups, confectionery, sweets, etc., are also artificially coloured. The vegetable colouring matters are for the most part perfectly innocuous. Most of the following substances are non-poisonous.

The Juice of Fruits, such as currants, cherries, mulberries, elderberries, whortleberries, blueberries, privet-berries, Portugal-berries, holly-berries, etc., are used for colouring jams, jellies, syrups, wines, and sweets. A red colour is produced by several of the above-named berries, but especially currants and mulberries, and also by cudbear, carmine, and cochineal ; a yellow colour is due to saffron, safflower, marigold, or turmeric ; blue, to litmus or indigo ; green, to a mixture of those yielding blue and yellow colours ; and black, to Spanish juice or Chinese ink.

Alkanet : a brownish-red colouring matter obtained from various roots of N.O. Boraginaceæ, especially *Anchusa tinctoria, A. virginiana, Echium rubrum, Lethospermum tinctorium,* and *L. anchusoides.* The greatest amount is, however, obtained from the epidermis of *A. tinctoria,* a native of the Levant, but grown largely in Southern Europe and Asia.

Annatto, Annotta, or Onotto : a colouring agent obtained from the seeds of *Bixa orellana,* N.O. Bixaceæ, an evergreen shrub

[1] *Journal of State Medicine,* January, 1902.

indigenous to South America, but grown also in the West Indies, Ceylon, etc. The fruit is covered with bristles or spines, and contains seeds about the size of small peas, embedded in a soft, viscous, resinous pulp, of a bright vermilion colour and somewhat unpleasant odour. The colouring matter, or annatto, is prepared in two ways, and appears in the English markets in two forms: (1) The resinous material is removed from the seeds by macerating them in water, pounding them, and straining the liquid through a sieve; the resin is carried through with the water, and after settling it is collected and dried in the shade. When of proper consistence it is made into small rolls, which become hard and dry, brown without, red within, and weigh about 2 ounces. (2) The pulp and seeds are bruised, hot water is poured over them, and they are macerated for several days. The liquid is strained through a sieve, and carries the resinous colouring matter with it; it is allowed to ferment spontaneously, and after a week the liquid is poured off, the residue dried into a solid paste, and made into a mass weighing several pounds. This variety is of a bright yellow colour and rather soft. Annatto is soluble in alcohol, and imparts a yellowish or deep red colour according to the amount used; it is largely used in cheese-making. The colouring agent is a peculiar yellow crystalline substance, named *bixin* ($C_{10}H_{26}O_2$), and the colour produced by it is not changed by acids or alum.

Beetroot is used to give a red colour to various foodstuffs—*e.g.*, cheap wines, syrups, jam, etc.

Brazil-wood, *Cæsalpinia brasiliensis*, N.O. Leguminosæ, yields a beautiful orange or red-coloured tincture by maceration. Red lake is prepared from it, and it enters into the composition of red ink. The colouring matter is a crystalline principle called *braselin*. It is sometimes used for colouring foodstuffs.

Caramel (Burnt Sugar): This is obtained by heating ordinary sugar to 200° C.; it consists of a thick treacly substance, and is used for giving colour, varying from a light straw to a dark brown colour, to many liquids and solids. Caramel is not a simple substance, but consists of a mixture of caramelan ($C_{12}H_{18}O_9$), caramelen ($C_{36}H_{50}O_{25}$), and caramelin ($C_{96}H_{102}O_5$). Caramelan can be extracted from the mixture by dilute alcohol; cold water then dissolves the caramelen, and leaves behind the caramelin. They all reduce Fehling's solution.

Carmine is a red colouring matter prepared from cochineal, and used for the same purposes.

Carrots are used to give a yellowish colour to various substances. The colouring principle is *carotin*, which also exists in tomatoes and some other vegetables. It is considered by some authorities to be the special chlorophyll of these vegetables.

Chinese Ink, Indian Ink, is said to consist of lampblack and animal glue.

Chlorophyll: The colouring matter of plants is used for various substances—*e.g.*, absinthe, which is coloured green by various herbs.

Spinach gives a green, parsley an emerald, and mallows a violet colour. Chlorophyll is defined as the whole of the pigments producing the green coloration of plants. But the pigments in chlorophyll are several, yellow, blue, and green, and are divided by Isvett[1] into two groups: (1) *Xanthophylline group* (yellow), including carotin, erythrophyll, chrysophyll; (2) *Chlorophylline group*, including chlorophylline blue. Etard[2] says a plant may contain several of these pigments, but he considers the special chlorophylls of a plant, if chemically distinct, should bear a botanical name; *e.g.*, he has isolated from lucerne, among others, the following: Medicagophyll-*a* ($C_{28}H_{45}NO_4$) and medicagophyll-*b* ($C_{42}H_{63}NO_4$).

Cochineal gives a colour of various scarlet or crimson shades, according to the amount used. It is used for artificially colouring jam, jelly, sweets, and other confectionery. Cochineal is the insect *Coccus cacti*, which breeds and feeds upon the cactus **Nopal,** *Nopalea coccinillifera*. The production of cochineal is carried on as a commercial enterprise in Mexico, Java, and the Canaries. The insects are preserved during the rainy season, to be distributed over the plants in the season of fecundation; the eggs, being deposited on the plant, are hatched by the sun, and speedily develop. In due time the fecundated female insects are removed from the plant, killed by being dipped in boiling water, and dried. To make a colouring liquid, the insects are powdered, infused in water with some carbonate of potash, some alum, citric acid, and sugar, being subsequently added to the liquid. The chief constituent of cochineal is 10 per cent. of carminic acid, which occurs in red prismatic crystals, is soluble in water, alcohol, and dilute alkalies.

Cudbear is used to give a red colour to jams, jellies, syrups, etc. It is the dye obtained from a lichen (*Lecanora tinctoria*) by means of maceration (see Litmus); the product is a purplish-red powder.

Dragon's Blood is the powdered resin obtained from various palms, but chiefly *Calamus draco*, growing in Oriental regions. The palm bears small fruits of the size of a cherry, covered with scales, which become encrusted with a red resin. The resin is obtained by shaking the fruits in a sack, afterwards sifting out the resin, which is softened by warming it, and made into masses. It contains 56 per cent. of a red resin (*draco-resinotannol*, combined with about 3 per cent. of benzyl-acetic acid), 13 per cent. of a yellow resin (*draco-resene*), 2·5 per cent. of a white amorphous body (*draco-alban*), also 1·6 per cent. of oxalate of lime and 3·7 per cent. of phosphate of lime. The following plants of this order also yield a similar resin: *Dracæno draco*, *Pterycarpus draco*, *Croto draco*, and *Croton sanguifluum*.

Litmus: Litmus, archil (or orchil), and cudbear, consist of the pigments obtained from various lichens, called "orchella weeds," N.O. Discomycetes, but chiefly from *Roccella tinctoria*, collected at Cape Verde; *R. montagnei* from Madagascar and Mozambique; and *Dendographa leucophæa*, from California. The powdered lichen

[1] *Compt. Rend.*, 1900, cxxxi. 21. [2] *Ibid.*, 1895, cxx. 6.

is macerated for weeks in an ammoniacal solution, and submitted to a process of fermentation, during which a red colouring matter is produced, which gradually turns to blue. The mass is then powdered and dried ; this is cudbear. When chalk or gypsum is added to the liquid and passed through a sieve, it is dried in small rectangular cakes, *litmus*, which are soluble in water and alcohol, forming a deep blue solution which is changed to red on the addition of acids. Litmus consists chiefly of chalk and gypsum, with the colouring matters. The latter are erythrolitmin, azolitmin, spaniolitmin, and erythrolein, of which the two first named are the principals. *R. tinctoria* contains lecanoric acid, which is converted by alkalies into orsellinic acid and orcin ; *R. montagnei* contains orcin and erythin ; erythin is converted into erythite and orsellinic acid, which are colourless ; the orsellinic acid is, however, changed by the action of air and ammonia into orcin, the oxidation products of which, including amino-orcinol, are the colouring matters.

Logwood is used to give a red colour of various shades to cheap wines and syrups. It consists of chips of wood from the heart of *Hæmotoxylon campechianum*, N.O. Leguminosæ, a tree indigenous to Central America and naturalized in the West Indies. The chips are moistened with water, thrown into large heaps, and allowed to ferment. The unfermented wood contains about 10 per cent. of a colourless crystalline body, *hæmatoxylin*, which gradually becomes red on exposure to air and ammonia, and is transformed into *hæmatein-ammonia*. The latter is visible upon fermented chips as a green lustre, and is the colouring agent of the wood.

Safflower : the florets of *Carthamus tinctorius*, N.O. Compositæ, used to give a red colour to many substances by means of an infusion. It is a native of Egypt and the Levant, extensively cultivated as a commercial product in France, Spain, Germany, Italy, and the Levant. The florets are pressed into cakes. The colouring agents consist of carthaminic acid, which is red, and a smaller proportion of a yellow material.

Saffron : the dried stigmas and styles of *Crocus sativus*, N.O. Irideæ, imported from Spain, France, Austria, and Italy. It yields to hot water and alcohol an orange-yellow colour, which is much used for colouring pastry, cakes, sweets, jellies, liqueurs, soups, etc. It contains *crocin*, which resembles and is probably identical with carotin, and a bitter principle—*picrocrocin*.

Turmeric : the root of *Curcuma longa*, N.O. Zingiberaceæ or Scitaminaceæ, a native of Southern Asia, and cultivated largely in India, China, Java, and other tropical countries. The powder is much used to give a yellow colour to curries, pickles, spices, egg-powder, and mustard. The root consists of lignin, starch, gum-resin, *curcumin*—the principal colouring matter—another colouring matter which is brown, about 5 per cent. of an acrid volatile oil, and a small amount of chloride of calcium. **Curcumin** is a yellow crystalline substance, which dissolves in alcohol and forms a deep

yellow colour ; alkalies change it to a reddish-brown, and strong sulphuric acid to a deep crimson ; boric acid changes it to a reddish-brown, which becomes a greenish-blue colour on the addition of alkalies.

In France, according to Weyl,[1] foods may be legally coloured artificially with the following substances, which are considered to be harmless :

White : Chalk, barium sulphate (a small amount), flour, or starch.

Red : Cochineal, carmine, red-wood, cherry juice, beet juice, artificial alizarin and purpurin, carthamic acid from saffron.

Orange : Annatto.

Yellow : Saffron, safflower, turmeric, yellow-wood, French berries, quercitron, yellow ochre.

Blue : Indigo, litmus, archil ; ultramarine, Berlin, or Prussian blue.

Green : Spinach green, Chinese green, ultramarine green.

Violet : Archil, India-wood, ultramarine violet.

Brown : Caramel, liquorice, catechu, chestnut-wood, manganese brown, ochre.

In Austria-Hungary, according to the same authority, only the following colouring agents may be used in food or beverages :

White : Tragacanth. **Red** : Cochineal, carmine, kermes, infusion of red poppy. **Yellow** : Turmeric, saffron, and safflower. **Blue** : Indigo, March violet, bluebottle, ultramarine blue, sea-blue (an artificial ultramarine). **Green** : Spinach juice. **Violet** : Cochineal infused in lime-water. **Gold** : Pure gold-leaf. **Silver** : Pure silver-leaf.

[1] *Op. cit.*

CHAPTER XXV

NUTS

NUTS are highly nutritious; unlike the seeds of cereals, they are rich in protein and fat, and comparatively poor in carbohydrates. Some nuts contain so much protein and fat as to be of practically the same food value as meat. So rich in fat are they, that Hutchison estimates that 100 grammes of shelled walnuts, averaging thirty in number, contain as much fat as 2·75 pounds of lean beef. But, on the contrary, 2·6 ounces of such beef would equal them in protein; in fact, it would be necessary to consume 700 walnuts daily in order to obtain the amount of protein required by the body. Most other nuts are similar to walnuts. Chestnuts, on the other hand, are rich in carbohydrates and deficient in protein and fat. As a general rule it may be stated that nuts are not suitable for the sole food of man, but, owing to the average excess of fat and deficiency in carbohydrate, must be consumed with foods containing sugar or starch. Attempts have been made, by combining nuts with other materials in proprietary foods, to form a standard food which is calculated to satisfy the needs of the body—*i.e.*, to provide a well-balanced food. **Bromose** is an example of such preparations, and is made from nuts and figs. It has the following composition:

COMPOSITION OF BROMOSE.[1]

Protein (N × 6·25)	16·54 per cent.
Fat	21·83 ,,
Sugar, starch, etc.	42·17 ,,
Crude fibre	2·52 ,,
Mineral ash	2·06 ,,

Heat of combustion, 2·081 calories per gramme.

Although nuts alone do not provide a physiological diet, there are numerous faddists, **Nuttarians,** who endeavour to live upon them. But even if they did supply a well-balanced diet, the amount of nuts produced is insufficient to supply any large proportion of mankind with the quantity necessary for their support.

An examination of the structure shows that a nut consists of a fibrous or cellulose stroma enclosing the protein, fat, and starch cells. Now, it is well known that by far the largest part of cellulose which is consumed leaves the body unchanged. This being so, a

[1] Jaffa, "Investigations among Fruitarians."

nut requires the most careful and thorough mastication, to break up the cellulose stroma in order to allow the digestive secretions to act upon the really nutritious portion. It is true the physical hindrance to their digestion may be overcome by thoroughly cooking them or grinding them to a fine meal. Even then, however, nuts are not easily digested in the stomach, because of the high proportion of fat. They have to pass through the pylorus into the intestines before they can be digested, and a considerable proportion of protein and fat may be lost through non-absorption. An endeavour has been made by the Nuttarian supporters to overcome these difficulties, and they have to some extent succeeded by means of Nut-meal, Bromose, Nuttose, nut-meat, nut-paste, and similar preparations which are now on the market.

Many people, however, cannot eat nuts in any form ; they cause indigestion, dyspepsia, heartburn, constipation, and other symptoms of discomfort. The high percentage of fat is one cause of their difficult digestion. The cellulose is another. A diet in which nuts form a prominent feature necessitates an active and out-of-door life, by which the digestive functions will be stimulated ; in such cases nuts are of extreme value as a food. Nuts therefore should not be eaten by persons of feeble digestive power, by those subject to constipation or chronic diarrhœa ; but they are, when well masticated, suitable foods for the obese and corpulent, for those suffering from chronic Bright's disease, and for the diabetic when not under a very strict regimen. Diabetic persons, acting under advice, may eat them freely, *an entire meal* being sometimes made of walnuts, almonds, Brazil nuts, butternuts, hickory-nuts, pignolias, or Sabine pinenuts. These and other nuts can be obtained ready ground. They are less likely to cause dyspepsia when they form the sole element of a meal than when they are eaten by way of dessert at the end of a mixed meal.

Nuts are for the most part heat- and energy-producing foods, by reason of the large amount of fat in them ; but they are also tissue-builders by virtue of the proteins.

It should be observed that nuts become rancid in a few months, even with great care, and their palatabilty and value is thereby diminished. Various fats and oils are prepared from them, and are sold under various names (see Fats and Oils) ; they are quite as easy to digest as butter, and some of them are more economical for cooking.

Acorns, or Biotes : The fruit of various species of oak (*Quercus*), consisting of a one-seeded oval nut fixed in a cup. They were formerly much used for human food, and, although now chiefly given to swine, are still consumed in some parts of the Continent, being used for making bread and other purposes. They contain a considerable amount of carbohydrate, and about 14 per cent. of extractive matter, including tannin and a bitter principle. It is the custom in Turkey, where they are largely used, to bury the acorns in the earth for some time, during which period they undergo various changes,

such as occur in cocoa during its preparation. It is considered that some enzyme is formed by which the change is produced, for while buried they lose their bitterness. When taken from the earth they are washed, " sweated," and dried ; finally they are reduced to a powder, mingled with sugar and spices, and called **palamonte.** Of this powder a beverage named *raccahout* is made, and largely consumed by the ladies of the harem. Various processes have been recommended for removing the tannin, such as the ammonia process used by Soltsien. It was also found by Soltsien that good results were produced by extracting the acorns six or eight times with cold soft water, and drying them immediately afterwards. The acorns, however, lose 25 per cent. of the nutrients in this manner. But the bitterness can be removed or destroyed by fermentation, for Soltsien found that by reducing them to a powder and making them into a paste with milk, and allowing it to ferment, the bitterness is destroyed and loss prevented. By preparing acorns in this manner an acorn-meal can be prepared which costs about fourpence per kilogramme.[1] Composition of

CALORIC VALUE OF NUTS—EDIBLE PORTION.

	Fuel Value per Pound : Calories.[2]	Heat of Combustion per Gramme : Calories.[3]
Almonds	3,030	3·129
,, blanched	—	3·147
Brazil nuts	3,265	3·397
Chestnuts, dried	1,875	—
Cocoanut	2,760	2·712
Filberts and hazelnuts	3,290	7·254[4]
Hickory	3,345	7·375[4]
Litchi	1,505	—
Peanuts	2,560	3·040
Peccans	3,435	3·437
Pignolias	2,845	2·976
Piniones	3,170	—
Piñons	3,205	—
Walnuts	3,300	3·318
,, black	3,140	—
,, soft shell	3,105	—
,, butternut	3,165	—
Bromose	—	2·081
Peanut butter	—	6·228
Cocoanut milk	—	·342

acorns : Water 6·3, protein 5·2, fat 43·0, carbohydrate 45·0, ash 3·6, per cent. **Acorn coffee** consists of the seeds roasted, ground and sweetened with sugar or chicory. It is a useful remedy

[1] *Chemical News*, 1891, ii. 204.
[2] Atwater, Bulletin 28, U.S. Department of Agriculture.
[3] Jaffa, Bulletin 132, U.S. Department of Agriculture.
[4] Fuel value, not heat of combustion.

for atonic indigestion, and catarrhal conditions of the stomach and bowels.

Almonds : The fruit of *Amygdalus communis*, genus Amygdalus, N.O. Rosaceæ. The almond is considered to be a native of Persia and Northern Africa. It is cultivated throughout the countries of the Mediterranean basin, Southern Europe, Persia, Syria, Palestine, Northern Africa, the Canaries, and China ; it also flourishes well in California, and moderately in Florida. British supplies are mostly obtained from Southern Europe and the adjacent countries. The fruit is a drupe, consisting of an external downy covering, a layer of fibrous pulpy material, the shell, and the kernel. The entire fruit is egg-shaped, measures 1½ to 2 inches long, and splits open as it arrives at maturity. There are two varieties.

Sweet Almonds (*A. communis*, var. *Dulcis*), further classified as Jordan, Valencia, Sicily or Italy, and Barbary almonds, their value being in the order named. Jordan almonds are imported from Malaga ; they are the best quality ; the shell is thick and hard, longer, narrower, and more pointed, than Valencia almonds. The kernel may be flat, rather tough, but sweet, and is covered by a thin cinnamon-coloured cuticle ; another variety has the kernel rather plumper and thicker, more brittle, but also pointed. Valencia almonds, from the district of that name, are broader and shorter than the former ; the kernel is also flat, but shorter and broader than in Jordan almonds, one end being rounded and the other pointed, and the cuticle is of a dusky brown colour. Sicily and Barbary almonds are shorter, and not so flat.

Bitter Almonds (*A. communis*, var. *Amara*) are grown chiefly in Morocco, and imported from Mogador ; they are also grown in France, Sicily, and Barbary, their value being in the order given. The kernels are shorter and broader than those of sweet almonds ; they have a bitter taste, and, when ground to a powder and made into a paste with water, have a characteristic odour. The latter is due to the hydrolyzation of the glucoside—amygdalin—under the influence of emulsin, an enzyme, whereby it splits up into the oil of bitter almonds (benzaldehyde), prussic acid, and glucose.

Amygdalin = $C_{20}H_{27}NO_{11}$; it forms crystals with three molecules of water. Bitter almonds contain 3 or 4 per cent. of amygdalin, 50 per cent. of fixed oil, various proteins, and the enzymes, emulsin and laccase.

Green Almonds are young sweet almonds, before the shell is formed ; they are preserved in sugar like green apricots.

The uses of almonds need not be dilated upon. They are eaten as nuts, and used for culinary purposes. Ground into flour, almond paste, cakes, biscuits, bread, marzipan, and various other confections, are made from them. Bitter almonds are unsuitable for consumption as nuts, owing to the development of the essential oil and prussic acid. They are not much used in cooking or confectionery for the same reason, although a large proportion of the prussic acid and essential oil are dissipated by heat, in consequence

COMPOSITION OF ALMONDS—NUTRIENTS PER CENT.

	Water.	Protein.	Fat.	Carbo-hydrate.	Cellulose.	Ash.	Authority.
Sweet almonds, fresh	27·70	16·50	41·00	—	2·80	2·00	Brit. Pharm. Codex.
Dried, as purchased	2·70[1]	11·50	30·20	9·50	—	1·10	Atwater, Bulletin 28.
	2·25[2]	8·87	27·58	9·47	1·31	1·41	
Edible portion: Minimum ..	2·00	16·60	48·90	12·80	1·60	1·60	
Maximum ..	5·30	25·30	60·00	21·40	2·50	2·50	
Average ..	4·80	21·00	54·90	17·30	2·00	2·00	
European, edible portion ..	4·80	21·00	54·90	17·30	—	2·00	Wiley.
Californian ,, ,, ..	6·00	23·50	53·00	14·40	—	3·10	
Average ,, ,, ..	4·42	17·28	54·30	18·64	2·58	2·78	Jaffa.
	6·00	24·00	54·00	10·00	3·00	3·00	Hutchison.
Blanched	4·00	17·68	54·75	19·19	1·68	2·70	Jaffa.

[1] Refuse, 45 per cent. [2] Refuse, 49·2 per cent.

COMPOSITION OF BRAZIL NUTS—NUTRIENTS PER CENT.

	Refuse.	Water.	Protein.	Fat.	Carbo-hydrate.	Cellulose.	Ash.	Authority.
As purchased	49·0	2·69	9·18	33·70	1·93	2·15	1·35	Jaffa.[1]
	35·6	2·60	8·60	33·70	3·50		2·00	Atwater.[2]
	—	5·30	17·00	66·80	7·00		3·90	
Edible part	—	4·33	19·78	63·31	6·00	2·96	3·62	Jaffa.[1]
	—	5·28	18·00	66·07	3·78	4·22	2·65	
	—	8·00	15·31	65·60	7·39		3·70	Corenwinder.[3]

[1] Bulletin 132, U.S. Department of Agriculture. [2] Bulletin 28. [3] "Year-Book of Pharmacy," 1874, 35.

of which less danger arises if *cooked* bitter almonds are eaten in mistake for the sweet variety. *Roasted almonds* are an important part of the dessert in some districts. *Blanched almonds* are preferred for most culinary preparations, and they are obtained by scalding and skinning the kernels. *Almond milk* is made by pounding together 2 ounces of blanched Jordan, and ½ ounce of blanched bitter almonds, together with 2 ounces of water, until it forms a smooth paste ; 1 pint of water is then added very gradually ; it is allowed to stand two hours, and afterwards strained through muslin.

Almonds contain **no starch** ; the carbohydrates consist of sugar, gum, and fibro-cellulose ; the absence of starch renders them a suitable food material for diabetics, the almond meal being made into cakes or biscuits. The fat averages about 50 per cent., and is a bland oil consisting chiefly of olein, with some palmitin and stearin. Almond-oil is of the same nutritive value as olive-oil, but is more agreeable. The protein consists chiefly of conglutin, of which sweet almonds contain an average of 15 per cent., according to Ritthausen.

A more extended analysis is as follows :

	Sweet Almonds (Boullay).	Bitter Almonds (Vogel).
	Per Cent.	Per Cent.
Proteins, including emulsin	24·0	30·0
Fixed oil	54·0	28·0
Liquid sugar	6·0	6·5
Gum	3·0	3·0
Seed coats	5·0	8·5
Woody fibre	4·0	5·0
Acetic acid, etc.	·5	
Water	3·5 loss	19·0
Volatile oil undetermined		

Beechnuts : The fruit of *Fagus sylvestris*, N.O. Cupuliferæ. The beech-mast consists of small triangular seeds, which have long been known as nutritious foods ; hogs fatten quickly upon them. They are sometimes consumed by human beings, and may be eaten quite safely in small quantities ; but when consumed in excess they are said to cause giddiness, delirium, or convulsions, as the result either of acute indigestion or of some noxious principle contained in them. Similar effects have been observed in horses. The husks yield a narcotic principle called *fagin* (Hogg). But whatever the principle may be, it appears to be dissipated by heat, for in some countries the seeds are dried and ground to a meal, which makes wholesome bread. Their composition, according to Wiley is—Water 9·1, protein 21·7, fat 42·4, carbohydrate (chiefly starch) 22·9, ash 3·9, per cent. The oil expressed from the seeds equals olive-oil in flavour

and delicacy ; it does not become rancid by storage. In Silesia it is used as a substitute for butter.

Brazil Nuts : The fruit of *Bertholletia excelsa*, N.O. Myrtaceæ, a native of Para, Brazil ; now cultivated largely in Brazil and Guiana. The fruit consists of a large oval or round pericarp of thick wood, 5 or 6 inches in diameter, divided into four compartments, each of which contains six or eight nuts. Like other nuts, they contain a kind of vegetable milk, a considerable amount of nitrogenous material, 60 per cent. of oil, or even more, with a little sugar and starch (see p. 686). The oil contains 74 per cent. of elaïdin and 26 per cent. of stearin (Corenwinder). The mineral substances include 1·35 per cent. of phosphoric acid, 2·35 per cent. of silica, lime, and potash.

Breadnuts : The fruit of *Brosimum alicastrum*, N.O. Urticaceæ, are called " breadnuts." They are eaten roasted or boiled, and are said to rival chestnuts, being agreeably flavoured, easy of digestion, and very wholesome.

Butternuts : Two different fruits are called by this name : (1) The **souari**, or butternut, which is the fruit of *Caryocar nuciferum*, N.O. Rhizobolaceæ, a native of South America, but also cultivated in the West Indies. The nuts have a fine bland milky flavour, the kernel being soft, white, and fleshy, and mild as a sweet almond. The fruits of *C. butyrosum* are also edible, and have the flavour of Brazil nuts ; several other species of *Caryocar* also produce edible nuts. (2) In America and Canada the nut usually called " butternut " is the fruit of *Juglans cinerea*, N.O. Juglandaceæ, which belongs to the walnuts. It grows abundantly in the United States and Canada, where it is chiefly consumed, and has the following composition : *Edible portion*—Water 4·4, protein 27·9, fat 61·2, carbohydrate 3·5, ash 2·9, per cent.[1]

Chestnuts : The fruit of *Castanea vesca et dentata*, N.O. Cupuliferæ. The chestnut-tree grows wild over a large area. It forms forests and woods in the mountainous parts of the temperate zone from the Caspian Sea to Portugal ; it is also found wild in the mountains of Algeria. If we take into account the varieties *japonica* and *americana*, it is also wild in Japan and America. It is difficult to know whether it is indigenous to the South and West of Europe, for it has been cultivated so long that the wild or semi-wild trees found there may have escaped from cultivation. Its cultivation is ancient. The Romans distinguished eight varieties in Pliny's time, and they introduced it into Great Britain at a later date. The best chestnuts came from Sardis in Asia Minor, and from the neighbourhood of Naples. In the sixteenth century Olivier praised the *Sardonne* and *Tuscane* chestnuts, from which **the single-kernelled variety** called the *Lyons marron* is descended. At the present period the cultivation of the chestnut consists largely in grafting good varieties upon trees which produce inferior fruit, for which purpose the single-kernelled variety is preferred to the natural

[1] Atwater, Bulletin 28.

species, which contains two or three kernels separated by a membrane.

Chestnuts form a wholesome and nutritious food, which is highly esteemed by the inhabitants of many countries, but especially in Southern Europe. Before the advent of railways, and especially in hilly districts such as Auvergne, Limousin, and Vivarais, they were largely consumed for several months in the year. They are the most important nuts as a source of food, because they contain a large proportion of carbohydrates. When they are kiln-dried, they will keep good for several years. They are eaten steamed, boiled, roasted, and raw. They are cooked in special ways in different countries. The French *galette* is made of chestnut meal, butter, eggs, and salt ; it is a more satisfactory food than wheaten bread, and contains the elements of a perfect food in due proportion. *Polenta* is a porridge made of chestnut meal and milk. *Necci* is a cake made of chestnut meal and water, and baked on hot stones in the Apennines. The Koreans eat boiled chestnuts as an accompaniment of meat, in place of potatoes.

Chestnuts contain less protein and fat than other nuts ; but they contain a large proportion of carbohydrate, which is chiefly starch and sugar. Roasted chestnuts contain 40 per cent., and boiled ones 72 per cent., of water.

The **Horse Chestnut** (*Æsculus hippocastaneum*, genus Hippocastaneæ, N.O. Sapindaceæ) is a native of the temperate regions of Asia, but is common in Europe. The nuts are used in Turkey and Switzerland as a food for horses and sheep. They abound in starch (68·25 per cent.), but contain sapotoxin and tannin, which render them unfit for human food. Attempts to remove the sapotoxin are not very satisfactory, owing to the great loss of substance. Neither does roasting yield very good results ; the sapotoxin is destroyed thereby, but the fatty oil becomes unpleasant in flavour in the process of roasting. Most of the tannin is in the skin and outer portion of the nut. Soltsien recommends the removal of the tannin and poisonous alkaloid by soaking them in a 10 per cent. solution of ammonia.

Cocoanut, Coconut, Cokernut : This is the fruit of the cocoanut palm, *Cocos nucifera*, grown largely in the East and West Indies, Indo-China, China, Japan, the Pacific Islands, Polynesia, etc. This nut is the staple food of many people where it is grown ; without it the Pacific Islands would be uninhabitable, and the natives would die of hunger and thirst. The small green undeveloped fruit is only of medicinal value, but when fully grown the interior consists of a soft gelatinous mass, which is highly prized as a food by the natives, and the "milk." As the fruit attains maturity the internal substance becomes concrete from the circumference to the centre, forming what is known as the kernel, and the "milk" is gradually absorbed and deposits its solid constituents. The youngest part of this deposit is of a creamy consistence, and is eaten with sugar or used in various culinary preparations. The liquid "milk" is used in the same way as cow's milk for making puddings and other foods. When quite ripe the edible flesh, consisting of the perisperm, is white, firm, and compact. This substance is scraped or rasped,

COMPOSITION OF CHESTNUTS—PERCENTAGES.

		Water.	Protein.	Fat.	Carbo-hydrate.	Cellulose.	Ash.	Authority.
Fresh chestnuts :	Minimum	52·8	2·01	·45	31·54	·74	·57	Balland.[1]
	Maximum	62·6	4·31	1·73	40·74	1·36	1·22	
Dried ,,	Minimum	—	4·45	1·17	82·17	1·76	1·24	
	Maximum	—	11·05	3·74	85·61	3·29	3·06	
Fresh ,,	Average	42·7	6·50	6·30	43·10	—	1·40	Wiley.[2]
Dried ,,	,, ...	4·8	11·60	15·30	65·70	—	2·60	
Fresh ,,	edible part : Minimum ..	29·2	4·10	2·00	36·90	1·40	·70	Atwater.[3]
	Maximum ..	53·8	8·00	10·80	54·00	2·50	1·80	
	Average	45·0	6·20	5·40	42·10	1·80	1·30	
Dried ,,	,, Minimum ..	4·8	8·20	3·90	65·70	2·40	1·50	
	Maximum ..	6·6	13·50	15·30	80·30	3·00	2·90	
	Average	5·9	10·70	7·00	74·20	2·70	2·20	

[1] *The Analyst*, 1897, 216. [2] Wiley's "Foods," p. 417. [3] Atwater, Bulletin 28.

COMPOSITION OF COCOANUT—NUTRIENTS PER CENT.

	Refuse.	Water.	Protein.	Fat.	Carbo-hydrate.	Cellulose.	Ash.	Authority.
Entire nut: As purchased	48·8	7·20	2·90	25·9	14·30	—	·90	Atwater.
Without milk	37·3	8·90	3·60	31·6	17·50	—	1·00	
Edible portion	—	14·10	5·70	50·6	27·90	—	1·70	
	—	19·17	5·35	51·0	9·67	13·77	1·14	Jaffa.
Dried edible portion : Minimum ..	—	2·80	6·00	51·0	24·10	—	1·20	Atwater.
Maximum ..	—	4·30	6·50	63·7	39·00	—	1·40	
Average	—	3·50	6·30	57·4	31·50	—	1·30	
Cocoanut milk	—	92·70	·40	1·5	4·60	—	·80	Hutchison.
	—	90·30	·50	—	9·00	—	—	

and eaten with rice in curries, or mixed with water, and the milky solution used as cow's milk. In Europe the kernel is eaten in its natural state by those who have good digestive powers. Cut into slices and dried, or dried and ground, it is a favourite constituent of cakes and biscuits, and is also used in making curries. The " milk " is a pleasant beverage, mild, sweet, and slightly acidulous, and forms a delicious drink which is much used in tropical countries.

Cocoanut contains less protein than most nuts. The amount of carbohydrate is fair, and includes some sugar ; the milk contains 4.5 per cent. or more of sugar. The proportion of fat is high ; it is readily expressed, and is used in culinary preparations ; it is sold as vegetable butter, nucoline, cocos-butter, cocoleum, etc. (see Fats and Oils).

Hazelnuts, Filberts : The fruit of *Coryllus avellana*, N.O. Cupuliferæ, and other varieties, both wild and cultivated. The tree is found wild in most European countries, and is cultivated in all temperate regions of the earth, especially in the Asiatic countries bordering on the Black Sea. Large quantities are exported from Trebizond and from Spain. The varieties are chiefly distinguished by the shape of the nut and its flavour. The best dessert nuts, called " filberts " (*Coryllus tubulosa*), are little inferior to almonds ; they are rather long, well pointed, and contain 50 or 60 per cent. of oil. Another variety, the cobnut (*Coryllus grandis*), consists of broader and shorter nuts ; they are not of such fine quality as the former. They are grown largely in Kent and Sussex, and when quite new are known as " Kent cobs." *Barcelona nuts* are another variety, which are largely imported into England after being kiln-dried. Hazelnuts contain a large amount of oil, which is expressed and sold commercially as nut-oil.

Composition of Hazel and Filbert Nuts—Percentages.

	Water.	Protein.	Fat.	Carbo-hydrate.	Cellulose.	Ash.
Fresh nuts, edible part	48·0	8·0	28·5	11·5	2·5	1·5
Dried nuts, edible part	3·7	14·9	66·4	9·7	3·2	1·8
	3·7	15·6	65·3	13·0	—	2·4
Dried nuts as purchased	1·8	7·5	31·3	6·2	52·1[1]	2·0

Groundnut (Pignut, Earth Chestnut) : The tuberous root of *Bunnium bulbocastanum*, N.O. Umbelliferæ (*q.v.*).

Hickory-Nuts : This name is applied to the fruit of *Hicoria orata*, *Carya glabra*, *C. alba* (also called " Kisky Thomas " nuts), *C. tomentosa* (also called " mocker " nuts), and *C. porcina* (also called " pignuts "), all of N.O. Cupuliferæ. Hickory-nuts are amongst the most highly esteemed nuts of North America, especially those of *Hicoria orata*, which are sweet and very nutritious ; *C. porcina* are

[1] Shell, etc.

also sweet; the others contain more tannin and may be bitter. They contain a large amount of fat, and, like all other nuts rich in fat, are apt to become rancid. They should be eaten in the winter following their growth. Atwater gives the composition of the *edible portion* as follows: Water 3·7, protein 15·4, fat 67·4, sugar and starch 11·4, ash 2·1, per cent. (see Peccan Nuts).

Litchi-Nuts: These are not really nuts, but the fruit of *Nephelium litchi*, N.O. Sapindaceæ, grown largely in China, and consumed by the Chinese wherever they live. The *fresh* fruit is esteemed very highly in the East. It is of the size of a date, covered with a scaly, hardish rind, red on one side and green on the other. They contain a delicious white pulp of sweetish subacid taste and an aroma of grapes, and a large obovate brownish seed. The Chinese dry them like prunes for the winter; they eat them with, or infuse them in, their tea, to which they communicate a subacid flavour, which is preferred to the sweetness of sugar. They are grown all over Southern China, India, and the Malay Archipelago. Nearly one-half the fruit is refuse. Atwater gives their composition per cent. as follows:

	Refuse.	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.
Entire nut	41·6	10·5	1·7	·1	45·2	·9
Edible portion	—	17·9	2·9	·2	77·5	1·2

Longan: The fruit of *Nephelium longana* is very like the former, as the **Rambutan** (*N. lappaceum*) also is. They are all of very ancient cultivation, as is shown by the large number of species.

Peanut: This also is not a nut, but the legume of *Arachis hypogæa*, N.O. Leguminosæ, a native of Africa, but also cultivated in South and North America, Southern Europe, Africa, and Asia. It is an annual plant of a more or less trailing character, which has this peculiarity: as the flower withers, the stalk, or spike, of the ovary grows rapidly in length, and pushes into the earth, so that the pod develops and is matured under the surface. If anything prevents the spike pushing into the ground, it soon withers, and the fruit does not come to maturity. Owing to this peculiarity it has been called the "earthnut," "groundnut," "ground-pea," "godber," and "pindar." About 4,000,000 bushels are produced annually in America, three-fourths of which are consumed as *roasted peanuts*, the remainder being used by confectioners in candy and other foods. At the present time they are eaten merely as an adventitious or extra food, but their digestibility and nutritive qualities deserve better recognition. The vegetarians or nuttarians, however, consume them as a substantial portion of the repast, as they do other nuts. In Great Britain they are consumed only to a small extent, except by vegetarians. But in countries where they are

grown to a large extent, as in Algeria, Egypt, Senegal, and parts of Asia, they form a far more important foodstuff.

The peanut consists of a slender fibrous pod, containing two seeds surrounded by a soft envelope. As a food they are eaten raw or roasted. Roasting developes in them a nutty flavour and aroma which is highly esteemed. They are rich in protein and fat, but poor in carbohydrates, for which reason they should be consumed at a meal which consists partly of potatoes, rice, sago, or other farinaceous food. The carbohydrates include 4 per cent. of pentosanes. They are not palatable to everybody ; the raw nuts are apt to become rancid quickly, but most people are able to eat the roasted nuts with salt.

Composition of Peanuts—Percentages.

	Water.	Protein.	Fat.	Carbohydrate.	Cellulose.	Ash.	Authority.
As purchased[1]	3·29	22·03	31·95	7·16	1·34	1·73	Jaffa.
Edible portion	4·88	32·64	47·33	10·61	1·98	2·56	
Minimum ..	4·90	19·50	32·30	15·30	2·00	1·90	Atwater.
Maximum ..	13·20	29·10	48·80	40·40	3·00	2·40	
Average ..	9·20	25·80	38·60	24·40	2·50	2·00	

The principal reason for the commercial production of peanuts at the present time is the valuable oil or fat which they contain in such a high proportion. This is a fixed oil, having a sweet taste, said to be equal to olive-oil. It does not readily become rancid, but is considered by some authorities to improve by keeping. Besides the oil, which has been referred to (Fats and Oils), two other preparations are made from peanuts : (1) **Peanut butter,** an oily preparation consisting of the roasted peanuts ground to a meal, and combined with 3 or 4 per cent. of common salt ; it is of such consistency that it can be spread on bread. (2) **Peanolia** is a similar preparation. The composition of Peanolia and peanut butter (*a*) is given from Wiley's " Foods " (p. 421), and peanut butter (*b*) from Bulletin 132, by Jaffa.

	Peanut Butter (*a*).	Peanut Butter (*b*).	Peanolia.
	Per Cent.	Per Cent.	Per Cent.
Water	2·10	2·10	1·98
Protein	28·66	29·30	29·94
Fat	46·41	46·50	46·48
Sugar and dextrin	6·13		5·63
Starch	6·15	17·10	5·58
Cellulose	2·30		2·10
Common salt	3·23	5·00	4·95
Ash	·80		1·08

[1] Refuse, 32·5 per cent.

Peccan-Nut: The fruit of *Hicoria peccan*, or *Carya olivæformis*, indigenous to the United States. The nuts are highly esteemed, and grown largely in the Southern States for the American markets (see Hickory-Nuts). The kernel is somewhat aromatic, but similar to that of the hazelnut. Composition of the dry edible portion : Water 3·0, protein 11·0, fat 71·2, starch and sugar 13·3, ash 1·5, per cent. (Atwater).

Pinenuts : The fruit of various species of pine-tree is edible, and is consumed wherever they grow. In America they grow throughout the Pacific States, and as far eastward as Colorado. The varieties are pignolia (*Pinus*, spp.), piñon (*Pinus edulis*), pinione (*P. monophylla*), and Sabine pinenut (*P. sabiniana*). About 50 per cent. of the substance is edible. They form a considerable article of commerce in California. The composition is given in the adjoining table.

Pistachio-Nuts : The seeds of *Pistachio vera*, N.O. Anacardiaceæ, originally obtained from Syria, where it is wild ; grown in France, Spain, Italy, Sicily, and to a less extent in California and the Southern States of America. The fruit is of the size of an almond, convex on one side, concave on the other. It has a tender crimson-coloured pulp which surrounds the nut ; the latter opens with two valves, and discloses a greenish kernel covered with a red pellicle. The kernel is the part used. It is sweet, of agreeable flavour, and has an aroma resembling that of almonds. It is much used in confectionery for flavouring ice-creams, ices, and various dishes for the table. The kernels are also coated with sugar or chocolate to be eaten as a sweetmeat. The finest kernels come from Syria and Arabia, but large quantities are also imported from Sicily. The kernels of American nuts are larger than the Syrian, but they are deficient in aroma.

Quandang-Nuts : The fruit of *Santalum acuminatum*, N.O. Santalaceæ ; grown in Australia, where they are eaten like almonds. Those of *Cervantesia tomentosa* are eaten in the same way in Peru.

Sapucaia-Nuts : The seeds of *Lecythis allaria*, N.O. Myrtaceæ, allied to the Brazil nut ; grown in Brazil and surrounding countries. The fruit consists of a capsule as large as a child's head, and when it is ripe the seeds fall out. These seeds are nuts 1½ to 2 inches long, slightly curved and grooved, of a light brown colour, and in appearance somewhat like a gherkin, or small cucumber. The shell is soft, the interior mild, yellow, and having a flavour of cream or custard. They are eaten raw or roasted. They contain but little starch and sugar, and therefore may be eaten by diabetics.

Walnut : The fruit of various species of *Juglans*, N.O. Juglandaceæ. The black walnut-tree, *Juglans nigra*, grows wild over a large extent of the American continent, especially along the Ohio and Mississippi Valleys. The nuts are edible. The white walnut-tree (*J. regia*) is said to be a native of Persia, although it is commonly called the "English walnut," it having been cultivated in England for centuries.

COMPOSITION OF PINENUTS—PERCENTAGES.

	Refuse.	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.	Authority.
Pignolias, edible part	—	6·13	33·7	47·0	7·47	4·15	Jaffa.
	—	6·40	33·9	49·4	6·90	3·40	
Piniones, entire	41·7	2·20	3·8	35·4	15·30	1·60	
,, edible part	—	3·80	6·5	60·7	26·20	2·80	
Piñons, entire	40·6	2·00	8·7	36·8	10·20	1·70	Atwater.
,, edible part	—	3·40	14·6	61·9	17·30	2·80	
Sabine nuts, entire	77·0	1·20	6·5	12·3	1·90	1·10	
,, edible part	—	5·10	28·1	53·7	8·40	4·70	

COMPOSITION OF PISTACHIO-NUTS—PERCENTAGES.

	Water.	Protein.	Fat.	Carbo-hydrate.	Cellulose.	Ash.	Authority.
Pistachio nuts	7·4	21·7	51·1	14·0	2·5	1·0	Hutchison.
First quality, shelled	4·2	22·3	54·0	16·3	—	3·2	Atwater.
Second quality, shelled	4·3	22·8	54·9	14·9	—	3·0	

COMPOSITION OF WALNUTS—PERCENTAGES.

	Water.	Protein.	Fat.	Carbo-hydrate.	Cellulose.	Ash.	Authority.
Fresh walnuts, European	44·5	12·0	31·6	9·4	·8	1·7	Huchison.
Dried ,, ,,	4·7	15·6	62·6	7·4	7·8	2·0	
,, ,, white, Californian	2·5	18·4	64·4	13·0	1·4	1·7	
,, ,, ,, ,, (soft-shell)	2·5	16·6	63·4	16·1	2·6	1·4	Atwater.
,, ,, black ,,	2·5	27·6	56·3	11·7	1·7	1·9	
,, butternuts	4·4	27·9	61·2	3·5	—	—	Wiley.

In 1551 Turner wrote : " It is so well knowen in all countries that I nede not it to describe." It is grown in large orchards in the South and South-East of France. Another species of walnut is the *J. cinerea*, or butternut, grown extensively in the United States (*vide ante*).

The young and immature nuts are eaten as a pickle ; boiled with sugar they make an excellent confection. Ketchup is also made from them, and is used as a basis for various sauces. The kernels of the ripe fruit or nuts are a valuable foodstuff ; when shelled and properly dried they will keep good for some months, but should be eaten in the winter following their growth. They easily become rancid, and will then give rise to pyrosis and other symptoms of gastric disorder.

The small proportion of carbohydrates in nuts of this order especially the butternuts, shows their adaptability as a foodstuff for diabetics. Atwater found that the ash of seven samples of walnut kernels had the following composition : CaO 5·6, MgO 16·6, Na_2O 1·0, K_2O 12·7, MnO_2 0·3, Fe_2O_3 and Al_2O_3 3·2, P_2O_5 57·8, SO_3 1·3, SiO_2 0·7, Cl 0·7, per cent.

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PART IV

CONDIMENTS AND SPICES

CHAPTER XXVI

SUGAR—GLUCOSE—HONEY, ETC.

Sugar.

THE use of sugar in Europe is comparatively recent, but it is a very ancient form of food. It is believed to have been known to the ancient Hebrews. Sugar from the sugar-cane was known in China 2,000 years before its use became common to Western civilization, the cane being a native of China, the East Indies, and the South Sea Islands. It was, moreover, in use amongst the Greeks before the Christian era, having, according to Strabo, been brought from the East Indies by Nearchus, an Admiral of Alexander the Great, 325 B.C.; and subsequently by the merchants who traded with Persia and India for spices, perfumes, and costly merchandise; the Greek warriors became accustomed to its use during the invasion of India. An Oriental nation, in alliance with the Romans in the time of Pompey, according to Lucan, used the sugar-cane juice as a beverage. Sugar was prescribed as a medicine by Galen in the second century A.D., and the Greek physicians called it the "Indian salt." It was brought into Europe from Asia A.D. 625, but it was little known until the twelfth or thirteenth century. One of the earliest records of its use in our own country is found in the statement of accounts of the Chamberlain of Scotland for 1319, wherein it is said that the price of sugar was 1s. 9½d. per pound. About the year 1150 the Portuguese sailors began to bring it to Europe, and attempts were made to establish the sugar-cane in Sicily and Spain; later on it was taken by the Spaniards to the Canary Islands, and thence transplanted to St. Domingo in 1506, whence it gradually spread over all the West Indies and the tropical regions of America.

The nature and origin of sugar were very obscurely understood by the early European consumers. It was confounded with manna, and was thought to exude from the stem of a plant or tree, and dried "like gum, white and brittle"; while others called it "honey made from reeds." It was not until Don Sebastian, in the sixteenth

century, sent home some young canes to Madeira, the Canaries, and the West Indies, that it began to be more commonly used by the wealthy, and a knowledge of its origin became diffused. The new food was looked upon with suspicion for a long time, and consequently it was chiefly used in medicine. It was believed to be heating, to be bad for the lungs, and to cause apoplexy. Honey was thought more wholesome than sugar, because more natural than the " products of forced invention."

The consumption of sugar made from the juice of sugar-cane continued to increase up to the year 1850, when the amount used *per capita* in the United Kingdom reached 28 pounds per annum ; sugar-cane was the chief source of supply. It was, however, not the sole source of sugar. Maple-sugar had been used in America for centuries. Robert Boyle in 1663 published a book at Oxford, wherein he says : " There is in some parts of New England a tree . . . whose juice, that weeps out of its incisions, if it be permitted to exhale away the superfluous moisture, doth congeal into a sweet and saccharine substance." Statistics show that the amount of maple-sugar produced in the United States increased, until in 1894 it amounted to 7,500,000 pounds.[1]

In 1747 a chemist of Berlin, named Marggraf, discovered that beet and other fleshy roots contain a crystallizable sugar which is identical with that derived from the sugar-cane. It remained, however, for Achard, his pupil, to erect the first manufactory for beet-sugar in 1796, on his farm in Silesia ; in 1797 he presented loaves of refined beet-sugar to Frederick William III., King of Prussia ; and in 1799 he brought the matter before the French Academy. Achard, however, had to deal with beetroots containing only 6 per cent. of sugar, and he could only extract half of that ; furthermore, he was not able to purify it sufficiently to make it equal in quality to that derived from sugar-cane, nor was his mode of manufacture at all profitable. A new stimulus was, however, given to the industry by the sugar-bounties of Napoleon in 1806, and the mode of manufacture was so much improved that a larger proportion of the sugar was extracted. Two great difficulties still remained : the sugar in the roots only averaged 6 per cent., and it could only be separated with difficulty from non-sugar constituents, some of which gave it an acrid and unpleasant taste. By the aid of science better methods of purification were ultimately found, and the beet-root has been so much improved by cultivation that it now contains from 15 to 18 per cent. of saccharine principles, at least 12 per cent. of cane-sugar being considered necessary for profitable manufacture. Barber gives the following figures to show the progress in the development of beet :

In the year	1838	1 ton of sugar	was	yielded by	18·00	tons of roots.
,,	1850	,,	,,	,,	13·80	,,
,,	1860	,,	,,	,,	12·70	,,
,,	1889	,,	,,	,,	9·25	,,

[1] " Sugar as Food," Farmers' Bulletin 93, U.S. Department of Agriculture.

In consequence of the increased productibility of sugar from beetroot, and partly owing to the emancipation of slaves in the sugar-producing countries of the West Indies, the manufacture of beetroot sugar advanced by leaps and bounds. In 1850 nearly all the sugar consumed was derived from the sugar-cane ; at the present time two-thirds of the sugar is derived from beetroot. In 1896 the world's production consisted of—

Total sugar	7,707,500 tons.
Sugar-cane sugar	2,747,500 ,,
Beetroot sugar	4,900,000 ,,
Maple sugar	60,000 ,,

The consumption of sugar in the United Kingdom in 1907 amounted to 87·75 pounds per annum for each individual ; and an inquiry by the Board of Trade in 1908 into the condition of the working classes showed that the consumption per working-class family was 5½ pounds per week, or about 57 pounds per annum for each person.

Sugar consists of sucrose, or saccharose, in the proportion of 75 to 95·9 per cent. Refined sugar is therefore the purest foodstuff known. Loaf-sugar is almost chemically pure, not a trace of nitrogen being obtainable, and it can be burnt without leaving any residue. Out of 500 samples of sugar analyzed by the U.S. Department of Agriculture, not one was found to be adulterated.

Raw sugar and yellow sugar consist of 72 to 95 per cent. of sucrose or saccharose, and 2 to 11 per cent. of other sugars. The latter consist of invert sugar—*i.e.*, a mixture of glucose and maltose. It also contains from 0·25 to 10·0 per cent. of non-saccharine organic materials. These consist of impurities arising from the source of sugar—sugar-cane, beetroot, sorghum, etc. The following table, showing the average composition of raw sugar from the different sources, is from " Sugar as Food " (M. H. Abel, Farmers' Bulletin 93, U.S. Department of Agriculture) :

Average Composition of Raw Sugar—Percentages.

Source.	Water.	Cane-Sugar.	Other Organic Matters.	Ash.
Sugar-cane	2·16	93·33	4·24	1·27
Sugar-beet	2·90	92·90	2·59	2·56
Sorghum	1·71	93·05	4·55	·68
Maize	2·50	88·42	7·62	1·47
Palm	1·86	87·97	9·65	·50
Maple	—	82·80	—	—

As a food, sugar is a pure carbohydrate, supplies the system with heat and energy, and contributes to the formation of fat.

THE COMPOSITION OF SUGAR—PERCENTAGES.

	Cane-Sugar.	Invert Sugar.	Other Organic Matters.	Ash.		Moisture.	Authority.
				Soluble.	Insoluble.		
Raw sugars : China	79·46	8·62	4·55	2·39		4·98	Thorpe's "Dictionary of Applied Chemistry," vol. iii., p. 633.
Sugar-cane sugars : Dominica ..	92·80	2·74	·97	1·11		2·38	
Havana	94·00	2·23	1·41	·30		2·06	
Jamaica	91·00	4·17	·71	1·08		3·04	
Manila	82·40	6·94	3·98	1·72		4·96	
Peru	94·30	1·99	·99	·72		2·00	
Porto Rico	91·30	3·60	·90	·86		3·34	
St. Kitts	89·70	3·91	·84	1·15		4·40	
St Lucia	89·60	4·48	2·00	1·02		2·88	
St. Vincent	90·50	4·00	·84	1·04		3·62	
Suranim	83·00	6·94	2·56	1·94		5·56	
Trinidad	88·60	4·31	1·58	1·53		3·98	
Beetroot sugars : First quality ..	95·00	—	1·25	1·75		2·00	"The Modern Baker and Confectioner," vol. ii., p. 279.
Second quality	91·00	·25	2·50	3·25		3·00	
Average quality	93·64	trace	1·67	2·07		2·62	
Refined sugars : Cane-sugar, granulated	99·90	—	—	trace	—	trace	Thorpe's "Dictionary," *loc. cit.*
Beetroot sugar, 75 per cent. extraction	92·10	—	·87	3·08	·19	3·76	
Tate's crystals	99·38	—	—	·10	—	·53	

Duncan's granulated	99·80	trace	·10	—	—	·10	"The Modern Baker and Confectioner," *loc. cit.*
Friezel's crystals	99·86	—	—	·10	—	·13	
White coffee crystals	91·00	2·40	·80	·30	—	5·50	
Tate's cubes	99·20	—	trace	trace	trace	trace	
Martineau's tablets	99·80	—	—	·10	,,	·10	
French pulverized	99·70	trace	—	·10	—	·20	
Beet loaf-sugar	99·10	,,	—	·15	—	·25	
Yellow sugar XC	87·00	4·50	1·50	1·00	—	6·00	
Yellow sugar	82·00	7·50	2·50	2·00	—	6·00	
Other sugars : Egyptian sugar ..	88·62	4·14	·43	3·13	—	3·68	Thorpe's "Dictionary," vol. iii., p. 660.
Mauritius sugar	87·20	5·39	2·10	1·57	·38	3·36	
Manila, unclayed	83·50	3·94	6·39	2·72	·52	2·93	
West India	82·00	6·79	3·24	2·00	—	5·97	
Java	81·06	6·14	6·09	1·93	—	5·81	
China	76·00	11·79	2·60	2·09	·76	6·76	
Jaggery sugar, E.I.	77·35	11·06	·95	2·46	3·07	5·11	
	77·20	9·26	2·51	3·43	·24	7·36	
Maple sugar : Minimum ..	76·80	·43	—	·31		6·77	Wiley.[1]
Maximum ..	86·89	12·19	5·58	1·50		11·57	
Sorghum sugar	93·05	—	4·55	·68		1·71[2]	

[1] *Chemical News*, 1885, ii. 89.

[2] "Sugar as Food," Bulletin 93, U.S. Department of Agriculture.

FUEL VALUE OF ONE POUND OF SUGAR.[1]

Granulated sugar	1,860 calories.
Powdered sugar	1,860 ,,
Brown or coffee sugar	1,765 ,,
Maple-sugar	1,540 ,,
Maple syrup	1,330 ,,
Cane molasses	1,290 ,,

In the alimentary canal, cane-sugar—that is, sucrose or saccharose, no matter what its source may be—is inverted by an enzyme into a mixture of dextrose and lævulose ; it is then absorbed. It is digested more readily than starch. It cannot, however, be consumed in unlimited quantity ; an excessive consumption upsets gastric digestion by causing a profuse secretion of mucus, which surrounds the particles of meat, etc., and prevents the gastric secretion from acting upon them. When the quantity consumed exceeds 300 grammes daily, sugar is excreted in the urine (*alimentary glycosuria*). Sugar, and especially treacle, has an aperient tendency.

The Manufacture of Sugar.[2]

I. SUGAR-CANE SUGAR.

The sugar-cane (*Saccharum officinarum*) is a huge jointed grass which is a native of Asia, and especially of the East Indies and China ; it, however, grows over the whole of tropical Asia and Africa. It was introduced into the West Indian and other tropical islands in the fourteenth or fifteenth century, and, the soil proving suitable, a large industry sprang up and flourished for several centuries. In the eighteenth century the cane was brought to the United States, and for generations an important industry flourished in Louisiana, but the injury arising from the frosts was a cause of the harvest being uncertain. The greatest growth now occurs in Hawaii, Cuba, and other places in the tropics, although the West Indian and American crops are still valuable.

According to Humboldt, the generic name of the plant is derived from the Sanskrit word *scharkara*, which signifies "grains of sand," and refers to the product extracted from it. From this the Hindoo word *schakar* and the Persian *schukur* have been derived. The varieties of sugar-cane are several : *S.O. communis*, the common plant, having a yellow stem ; *S.O. purpureum*, called in India *karambou kari*, has a purple stem and richer juice ; *S.O. giganteum*, a very thick cane, of light colour, called in India *karambou valli* ; *S.O. violaceum*, the native of Tahiti, distinguished by the greater length of cane, distance between the joints, and length of the hairs which surround the flowers.

The plants are propagated by cuttings, and generally flower when a year old ; in four or five months after flowering the canes are completely ripe, and contain a sweet viscid juice. They are cut down

[1] Atwater and Bryant, Bulletin 28, U.S. Department of Agriculture.
[2] M'Intosh's "Technology of Sugar" and Loch's "Sugar Growing and Refining" have been referred to.

close to the ground, the tops and leaves removed, and crushed between revolving cylinders. The cane contains about 85 per cent. of juice, but in practice little more than 50 per cent. is obtained, the best mills expressing 60 to 65 per cent. ; consequently 25 to 30 per cent. is left in the refuse, called the " begass " or " megass." The best time for cutting the canes is known by their appearance and condition, and is learned by experience as the degree of ripeness which will yield the greatest proportion of juice.

Composition of the Sugar Cane and Juice—Percentages.

	Entire Sugar-Cane.	Sugar-Cane Juice.
Water	71 to 76	79·44 to 83·84
Sugar, crystallizable	14 ,, 18	15·64 ,, 20·90
,, uncrystallizable	—	·120 ,, ·30
Nitrogenous matters	·35 to ·55	
Fatty matters	·15 ,, ·35	·023 ,, ·37
Cellulose	8·86 ,, 9·56	
Ash	·35 ,, ·48	·014 ,, ·25

The juice is clarified, first passing it through wire screens to remove coarse fibre. It is then neu ralized by lime, which precipitates organic matter and checks fermentation, and it is submitted to the action of sulphurous acid gas either before or after the addition of lime. It is then heated, by fire or steam, to 170° or 180° F., which coagulates and separates the suspended materials ; these impurities rise to the surface as a scum, which is removed, or deposited and allowed to settle at the bottom. It is at this stage some manufacturers add the lime. The juice is next filtered through bone-black or animal charcoal. It is then evaporated in a series of pans set over a flue, at one end of which is a fire. After remaining for some time in the first pan, it is transferred to the next, and afterwards to the next and the next—a series of four pans. It becomes more concentrated in each pan, and in the fourth reaches the point of crystallization. It is then transferred to coolers, where it is allowed to " grain," or crystallize, being afterwards put into a cask, which has a number of holes in the lower part, temporarily stopped with plugs. When the chief mass is crystallized, the plugs are removed and the liquid residue, or " molasses," drained off ; the crystals constitute *muscavado*, or raw sugar. This more or less imperfect process has now been replaced by improved methods, especially by concentrating the juice to the point of crystallization in a **vacuum pan,** and removing the molasses by centrifugalization.

The **raw sugar,** from its having been concentrated in open pans over a fire, was very crude, and resulted in the formation of a dark, sometimes nearly black, crystalline mass, in a pasty condition, and

more or less dirty, according to the care taken in clarifying and concentrating the juice. Such sugar was sold as " foot-sugar " to refiners in all parts of the world, or was refined at the place of origin. " Foot-sugar " was prized by confectioners for its dark colour, which gave an appearance of richness to their cakes, but it is no longer known. Raw sugars have now most of their impurities removed ; most of the crystallizable sugar is extracted, and consequently less molasses comes into the market. Only better-grade *muscavados* are allowed to leave the plantation, for all the uncrystallizable syrup can be removed by centrifugalization.

Raw sugar has different characteristics, according to its source. **Demerara** is accorded the first position ; it is the best raw sugar, has a fine rich flavour and golden colour, and is highly prized for domestic purposes. **Barbadoes** is of a reddish-brown colour. **Cuban** is very dark-coloured and somewhat harsh in flavour. **Brazilian** is white and pure ; it contains scarcely any residue. Raw sugars owe their moisture to the presence of " glucose," or invert sugar, and their flavour to a small amount of non-saccharine materials. Raw sugar, especially Barbadoes, Jaggery, and Bastards, is often very impure, and contains, among other things, the spores of fungi, bacteria, acari, etc. These include *Leuconostoc mesenteroides*, which causes viscous fermentation in sugar refineries, called *gomme de sucrerie* by the French, and *Froschlaich* by the Germans ; it is a cause of ropy fermentation in wine and beer. But owing to modern methods of sugar manufacture there is very little *genuine* raw sugar on the market, compared with former supplies. The demand for Demerara crystals is supplied by some firms in the following manner : Just before the concentrated juice is run out and allowed to crystallize, a small amount of sulphuric acid is added ; this converts a small amount of sugar to caramel, and gives the whole a golden-yellow tint. Yellow crystals which have been coloured by aniline dyes are sometimes fraudulently sold for genuine Demerara.

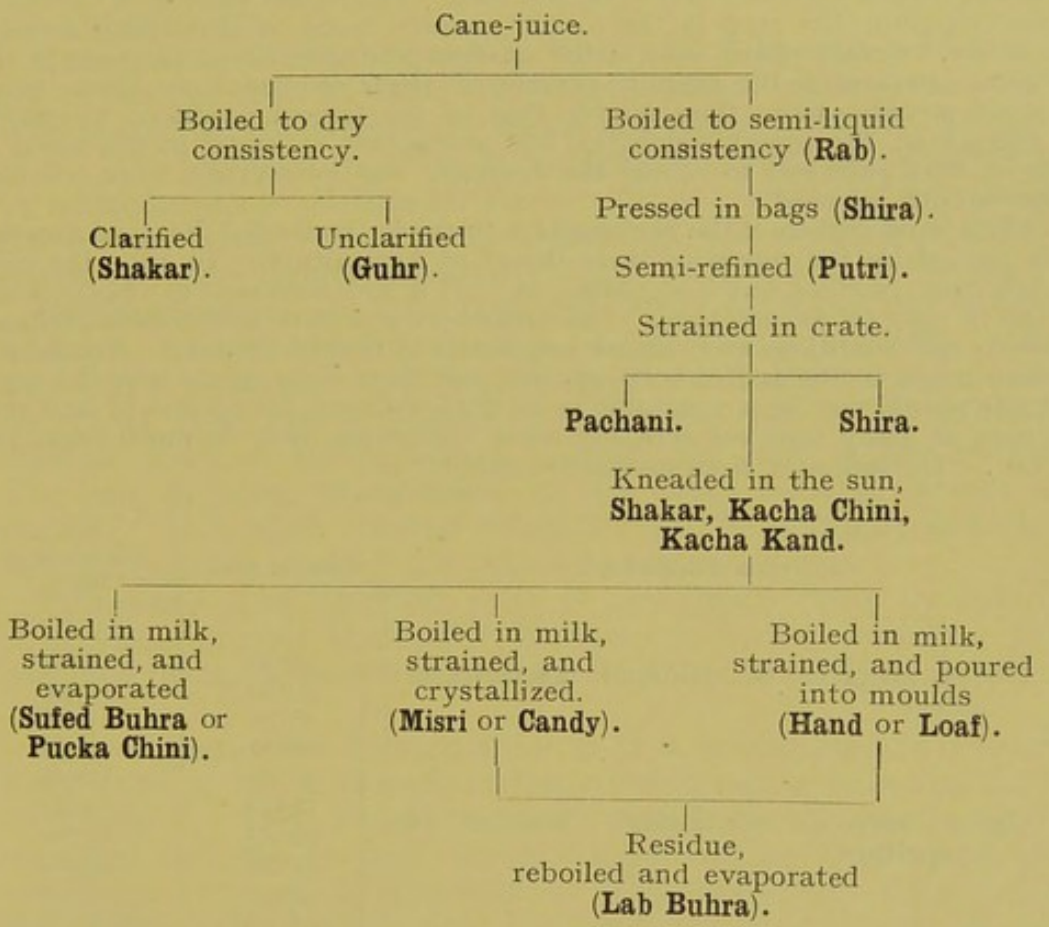
II. Sorghum-Sugar.

Sorghum, *Andropogon saccharatum*, is a cereal native in India, and largely grown as a foodstuff throughout Asia, particularly in India, China, and Japan ; also in Egypt, and to a less extent in the United States. The stalk of this grass, like sugar-cane, abounds in a sweet sugary juice, on account of which the Americans, when it was first introduced, called it the " Chinese sugar-cane." The amount of sugar in the stalks varies from 8 to 14 per cent. of crystallizable sugar, and 1·5 per cent. of uncrystallizable sugar, the rest being made up chiefly of starch, cellulose, pentosans, and mineral matters. The juice is obtained and the sugar manufactured in the same way as that of the sugar-cane. Sorghum is a more hardy plant than the latter, and will grow from Florida to Maine, and is therefore more suitable for cultivation in the United States. It yields a syrup equal to that of the best sugar refineries, and, although

there is a little difficulty owing to the presence of starch, the sugar is refined and crystallized as well as that of sugar-cane. It is manufactured largely in Asiatic countries.

Sugar-Making in India.—The following table, by T. O. Miller, shows the varieties of sugar produced in India from sorghum, sugar-cane, and other sources :

Indian Sugars.



III. Beetroot-Sugar.

The discovery of cane-sugar in beet and other roots revolutionized the sugar industry. Beetroot was first made by Margraff in 1747, and by Achard in 1796. In the early days of the French Revolution, Napoleon was induced to take a great interest in its manufacture, because the prolonged Peninsular War interfered greatly with the ordinary supplies of sugar. It was by means of bounties that the French Government of that day fostered the industry, which at that time was not profitable ; and by that Government, also, the cultivation of the sugar beet was ordered, on a scale sufficiently large to supply almost entirely the national demands for the food. The manufacture of beetroot-sugar has sprung from this small beginning into one of the most important industries of France, Germany, Holland, and America.

Importation of Sugar.—According to Board of Trade returns, England imported in 1908 twenty million pounds' worth of sugar, of which seventeen millions were from the Continent. Germany and Austria alone sent 1,250,000 tons of beet-sugar, valued at thirteen and a half million pounds sterling. Some interesting statistics with reference to the world's produce and consumption of beet-sugar are contained in an American consular report from Antwerp. During 1908 the 4,860,645 acres under cultivation yielded a beet crop of 44,626,563 tons, the sugar product being 2,040,870 tons. In Germany —the leading country engaged in the beet-sugar industry—11,719,931 tons were produced from 1,074,622 acres. Austria, Russia, and France, follow with between 5,000,000 and 8,000,000 tons. The richest yield is in Germany and Belgium, the crop in the former country being of more than average quality. Great Britain—one of the smallest producers—is at the head of the list of consumers, the average amount of sugar consumed *per capita* being 86·93 pounds—more than double that of the largest producer, Germany. Altogether, the report concludes, the production of sugar in the world is more than sufficient to supply the demand. On the average, 1,000,000 tons per month are used.

The rapid growth of the beet-sugar industry in the United States of America is proved by the report of their Board of Agriculture. In 1891 the total American produce was 6,000 tons ; in 1901 it had increased to 184,600 tons, and in 1907 to 500,000 tons. The sugar beet is a profitable crop in Holland, where the conditions and climate are similar to that of England. Trials have been made in England of beet-growing, and there is no reason why the sugar trade should not be as profitable as on the Continent, for an acre of land produces as many tons per acre, the roots containing quite as much sugar per cent. The following is an instructive table :

Cultivation of Sugar-beet.	Tons per Acre.	Percentage of Sugar.
Under auspices of Midland Agricultural College	18·80	15·84
	20·80	15·75
	18·70	15·68
Under auspices of Suffolk Chamber of Agriculture	18·00	17·39
	20·20	16·16
	14·00	19·40
	20·00	13·70
	25·10	14·80
	17·40	16·50
	15 to 20	16 to 18·4
Essex Chamber of Agricultural Experiments, average	18·30	16·70

Manufacture of Beet-Sugar.—The roots are cleaned from earthy matter, trimmed and cut into slices, or reduced to a pulp. The juice is then removed by hydraulic pressure or **diffusion.** The latter mode is usually employed. The pulp is put into a " diffuser," which consists of a row or circle of twelve " cells," through which warm water is successively driven. The water takes up some sugar as it passes through the first " cell," more as it passes through the second, and so on through each one, until, as it leaves the twelfth, it is practically saturated with sugar. Between each two cells the liquid is heated in its passage to the next one by means of a steam-heated tank. The water enters the first cell at a temperature

of 30° C., and its temperature is gradually raised as it passes from one to another until it attains a maximum of 70° to 80° C., and it leaves the diffuser at 50° or 60° C.

The juice thus obtained is almost black. It is now treated by an excess of lime and heated again, carbonic acid being afterwards driven through it to precipitate the lime, which has the effect of carrying down with it the chief impurities ; the liquid is then filtered, evaporated, bleached, and purified, in the same way as cane-sugar. These processes are called defæcation, carbonatization, filtration, evaporation, etc.

Defæcation.—Being previously neutralized by the addition of 0·5 to 3·0 per cent. of lime, the juice is passed into a tank, where it is heated by the passage of steam through a " worm," or coiled pipe. The temperature of the liquid gradually rises to boiling-point, by which means impurities are thrown out as a scum and a sediment, the former being removed by skimming. As soon as ebullition begins the clear liquid is carefully decanted into another tank.

Carbonatization.—In this tank the liquid is treated by carbonic acid gas, which enters it through perforations in a similar worm. The CO_2 is generated in a kiln or by the action of sulphuric acid on chalk. The gas is allowed to act upon the liquid until the alkaline reaction disappears—*i.e.*, until the lime is precipitated. The lime in being precipitated carries down with it various impurities. It is then allowed to settle until it is bright and clear, and the liquid is usually of a yellow colour.

Filtration.—The clarified juice is now decolorized by filtering it through animal charcoal. In some factories, however, it is bleached by the action of sulphurous acid, and then filtered through sand.

Evaporation.—The filtered juice is then evaporated in vacuum-pans until it has a concentration corresponding to a density of 20° Beaumé. The vacuum-pan is a vessel heated by steam, and so arranged that the air and watery vapour arising from the boiling syrup are removed by exhaustion. This system is employed on the well-known principle that the lower the atmospheric pressure the less heat is necessary to boil water ; the liquid therefore boils at a lower temperature in the vacuum-pan than at ordinary atmospheric pressure, and requires less heat to evaporate it. When it has attained to the desired density it is filtered again, and then again concentrated in the vacuum-pan until it reaches the point of crystallization, when the mass is called the " massecuite." This is transferred to a centrifugal machine, where it lies in a wire cage, through which the moisture is driven by rapid revolutions ; the crystallized sugar is obtained from it in successive crops. The first crop of crystals, or " first jet," consists of 50 per cent. of the sugar. The syrup or molasses removed by the centrifuge is again concentrated to the point of crystallization, and being centrifugalized a second time results in a further crop, known as the " second-jet sugar." The syrup from this is again evaporated and centrifugalized,

and a third crop, known as "third-jet sugar," is obtained. The "first-jet" sugar is the finest quality, the second and third "jets" being much inferior; the latter sugars, having a disagreeable taste and odour, are sold as "beet crystals." All the sugar is purified by the Weinrich process, that is by washing with steam and crystallization.

The Yield of Sugar.—As previously seen, beetroot contains from 10 to 18 per cent. of sugar; this is obtained in the following proportions:

First-jet sugar	50 per cent.
Second-jet sugar	15 ,,
Third-jet sugar	5 ,,
Sugar in molasses	15 ,,
Lost in scum and pulp	15 ,,
	100

Beetroot Molasses is never palatable, owing to the large proportion of salines contained in it. It is usually mixed with cattle foods, but some finds it way to the distilleries. It has the following composition:

Beetroot Molasses.

Sugar	50 per cent.
Other organic matters	20 ,,
Mineral substances	10 ,,
Water	20 ,,

Some manufacturers manage to recover most of the sugar from the molasses. There are several methods of doing this: (1) *By osmosis:* the molasses is placed in a vessel of parchment-paper and surrounded by warm water. The sugar remains inside, while the salines diffuse through the parchment into the water—*i.e.*, the salts and other compounds which hinder crystallization pass through more readily. The syrup is then treated as before. (2) *By lime, strontia, or baryta:* alkaline earths being added form a compound with the sugar, which is deposited; it is then washed, and decomposed by CO_2, which converts the earthy base into an insoluble carbonate and sets free the sugar.[1]

IV. Maple-Sugar.

The sugar-maple (*Acer saccharinum*) is a native of America, from Canada to Pennsylvania. Sugar is also produced from the silver maple, red maple, and back maple. The sap of the tree abounds in sucrose, or cane-sugar, which is obtained in the following manner: In February or March, while the cold is still intense, the tree is bored with an auger in two places, 5 inches apart, at a height of about 20 inches from the ground, and on the south side of the tree. The holes, $\frac{1}{2}$ inch in diameter, are made obliquely upwards, so that

[1] Thorpe's "Dictionary of Applied Chemistry," vol. iii., art. "Sugar."

a tube fixed into them directs the sap into a vessel placed below. The sap continues to flow for a month or six weeks, warm, sunny days and frosty nights being favourable to the flow. The sap is collected each day, strained, and boiled at once, never being kept longer than twenty-four hours. It does not need clarification by lime. It is boiled in open pans or kettles to the point of crystallization, and is then poured into moulds, where it sets. Maple-sugar is not refined, as that would destroy the peculiar characteristics of the sugar, chiefly due to ethereal substances which produce flavour and aroma. The liquid which drains from the crystals is maple syrup. Both sugar and syrup possess slight laxative properties.

An average tree yields about 4 pounds of sugar in a season, each pound being derived from 4 or 5 gallons of sap. The whole of the sugar in the sap is sucrose or saccharose, and varies from 1·87 to 4·30, or an average of 2·82 per cent.[1]

The sap contains no reducing-sugar, but a small quantity becomes inverted by the heat during evaporation. The sugar arises from the starch stored in sapwood cells during the preceding summer, and is transformed by enzymes for the use of the tree when the sap rises the next year. Therefore a large leaf area and plenty of sunshine are essential to a good yield of sugar. The sugar is brown, and has the following composition :

Cane-sugar	89·00 per cent.
Glucose	2·50 ,,
Ash	·54 ,,
Moisture	4·30 ,,
Undetermined	3·66 ,,

The farmers possess no other means of making maple-sugar than the pans or kettles in which the sap is concentrated, and the moulds in which the sugar crystallizes and the syrup drains away. They thus make 200 or 300 pounds in two or three weeks. But it can be made more easily and expeditiously by the modern vacuum-pan and centrifugalizer. The sugar can also be refined, and 100 pounds will yield 83 or 84 pounds of refined sugar. But, as already indicated, refining is rare, because there is a sufficient demand for unrefined or brown maple-sugar, which commands a higher price than cane or beet sugar, because of its flavour ; it is used as a luxury throughout Lower Canada.

V. Palm-Sugar.

Palm-sugar, also called " date " or " jaggery " sugar, has been used in India from time immemorial, and is consumed throughout the East. It is obtained from the sap of various palms—*Borassus flabelliformis, Phœnix sylvestris, P. dactylifera, Caryota urens, Melia azadirachta, Saguerus saccharifer,* etc.—grown in China, India, Ceylon, and islands of the Eastern Archipelago. The juice or sap of these trees, obtained by incisions into the tree or by cutting

[1] Wiley, *Chemical News*, 1885, ii. 89.

the spathe, or flower-stalk, contains a large amount of cane-sugar, or sucrose; it is readily fermented, and forms palm-wine, which, being distilled, yields the spirit known as "arrack." In sugar-making the sap is neutralized by lime, boiled immediately, filtered and clarified, as in making sugar from sugar-cane juice. Three quarts of sap are necessary for the production of 1 pound of sugar. The sap, however, contains more glucose, or invert sugar, than sugar-cane juice does; consequently the product is of low quality, and remains as moist or raw sugar. The *composition* is as follows:[1] Cane-sugar 78, glucose 8·93, moisture 6·74, undetermined 3·76, per cent. It was formerly imported into Europe to a considerable extent, especially when the sugar-cane harvest was poor; but owing to the development of the beet-sugar industry there is now little demand for it, although it is still used to some extent by brewers and distillers.

There are other sources of sugar not yet of commercial interest; one of these is the fruit of *Parkia biglobosa*, which contains 25 per cent. of sugar, and is used by the natives of tropical Africa as a nourishing article of food.

VI. Sugar-Refining.

Raw sugar-cane sugar has a sweet, aromatic taste, and refining is not absolutely necessary, as it can be used for all domestic purposes. But raw beet-sugar is not so agreeable; it has a soapy taste and odour, which renders refinement essential.

Raw sugar was formerly refined by being boiled with lime-water, and after due concentration, allowing it to crystallize in conical moulds having an aperture at the apex, whence a plug could be withdrawn when required. After crystallization the mass was covered at the base of the cone with a mixture of thin clay and water; the plug was then removed from the aperture at the apex, and the water from the clay permeated through the sugar and the coloured syrup was driven out of it by gravitation, and escaped from the lower aperture. Sugar thus refined constituted the **clayed sugar** of commerce. To make *loaf-sugar*, the common muscavado, or raw sugar, was mixed with hot water until it formed a soft pultaceous mass, which was then put into the conical moulds in order to allow the molasses to drain away. It was next mixed with a small quantity of lime-water, bullock's blood, and animal charcoal, and heated by steam until the whole was incorporated into a mass of syrupy consistence. This syrup was then filtered again, and again if necessary, until a highly clarified and limpid syrup remained, which was evaporated and transferred to coolers, where it was agitated to cause it to granulate. In this state it was poured into unglazed earthenware moulds of conical shape, having a hole in the apex which could be closed by a plug or spigot. The moulds were placed, apex downwards, over a vessel to receive the

[1] Thorpe's "Dictionary of Applied Chemistry," vol. iii., art. "Sugar."

uncrystallizable syrup. When the mass was sufficiently concrete, the spigot was drawn, and the coloured syrup allowed to drain away. To aid the removal of the syrup, the operation of *claying*, as already described, was performed. About 1 inch of sugar was removed from the base of the cone, and replaced by pure white powdered sugar, upon which was poured a mixture of pipeclay and water of the consistence of cream. The water from the clay dissolved the powdered sugar, and gradually percolated through the mass, replacing the coloured syrup which gravitated away, after drawing the spigot, by a colourless syrup. After a few days the loaves, being sufficiently hard to be removed entire, were placed in a store to dry at a temperature of 130° to 140° F., where they remained until they were baked quite hard.

Modern Refining.—The former methods have almost entirely given place to modern methods of refining. The *muscavado*, or raw sugar, is brought to the factories, where it is dissolved, treated by lime, clarified and filtered. It is then decolorized by mixing it with animal charcoal or bone-black, and filtered again. The result is a clear, transparent, slightly yellow fluid of about 28° Beaumé, to which a trace of ultramarine blue is added.[1] It is now transferred to a vacuum-pan, and evaporated until it is of sufficient density to crystallize, and then centrifugalized.

But other methods are practised in which the raw-sugar crystals receive a preliminary washing by water or steam, thus separating it into undissolved sugar and the washings, which are boiled down and yield a crop of low-quality crystals. The most popular is the **Weinrich process,** in which the crystals are purified by steam in a centrifugal machine, revolving 800 to 1,200 times per minute. As the crystals are washed a syrup is formed which drains out. When the syrup leaving the machine becomes light-coloured, the steam is shut off, and the crystals are dried by the machine continuing to revolve two or three minutes longer. The process of refinement is then continued as follows : The washed crystals are dissolved in water, the syrup filtered, and decolorized by sulphurous fumes, or by passing it through animal charcoal. The syrup is now concentrated in vacuum-pans until it will form massecuite, which is dried in a centrifugal machine. The final treatment differs as to the kind of sugar desired. If the massecuite is allowed to crystallize as it is, it will yield a crop of small crystals or fine-grained sugar. When larger crystals or coarse-grained sugar is desired, some small crystals are put into a vacuum-pan, the massecuite is then added in quantities which are insufficient to dissolve those crystals, and consequently the evaporating syrup is deposited upon the already existing crystals, which are thereby increased in size. When still larger crystals are wanted, the process is repeated several times. Other modes of refinement are those of Langan, Fontenille and Desormeaux, La Fontaines, Crossfield and Stein, Robin-Langlois, and the Ranson process.

[1] The " bluing " mixture is added in proportion of 4 parts per 1,000.

Loaf-Sugar.—To produce refined loaf-sugar, massecuite of a known density is heated to 187° F., and poured into the conical moulds referred to ; when cold it consists of a mass of fine crystals. The moulds are left for twelve hours, until the sugary mass is so thick that there is no danger of the crystals settling out, and forming an unequal mixture. The spigot is then drawn, a wire pushed into the sugar 2 or 3 inches, and it is left to drain. After twenty-four hours the syrup ceases to run, and the surface of the loaf is then hardened by pouring in a highly concentrated syrup ; in twenty-four hours more the loaves are removed from the moulds, and racked for ten to fourteen days in a drying-room where the temperature is 120° F.

Cube-Sugar.—The process of making loaf-sugar is slow, and cube-sugar has to be made from it by cutting it with clippers or machinery. Various means, however, are now taken to accelerate the final stages of the process, for which purpose machines have been invented to form **slabs** or **sticks** of sugar which are readily dried and cut. In Langan's method the massecuite is run into segmental moulds, where it is allowed to set, and the moulds are afterwards put into a centrifugal machine to wash them and remove the syrup. Another invention is Hersey's machine, which is largely used both in Europe and America. Perfectly white moist refined sugar is fed to the machine by a hopper, after being mixed with just sufficient syrup to bind the crystals together. The machine consists of a revolving drum whereon are a series of moulds for making cubes of sugar ; the sugar passes from the hopper into these moulds, which are beneath it, and a plunger presses the sugar into them. The moist cubes are afterwards dried in a steam-heated stove.

Granulated Sugar is also quickly made by concentrating the syrup at the massecuite stage until it has a sharp grain ; it is then centrifugalized to remove syrup or molasses, and washed to cleanse the crystals from syrup or adherent débris. The wet crystals are then transferred to a Hersey's granulating machine, which consists of a double cylinder heated by steam, and is made to revolve about five times per minute. The cylinder is fixed at an inclination ; it is fed at one end with moist crystals, which drop in a continuous shower upon the central steam-heated cylinder as the machine revolves. A current of air passing through the large cylinder carries away the moisture. Owing to the inclination of the cylinder the sugar gradually passes to the lower end, where it makes its exit as pure white crystals. The dried crystals are sorted by a dressing machine into (*a*) large or coffee crystals, (*b*) medium or ordinary granulated sugar, and (*c*) small crystals, or castor-sugar.

Icing or powdered sugar is made from the waste obtained from the cutting of loaf or cube sugar, and from the dressings left from granulated sugar ; these remnants are reduced to a powder in a disintegrator, and passed through dressing reels to separate it into various grades of fineness. Icing-sugar is used in confectionery and pharmacy.

Pieces.—Beet molasses is not palatable enough to be used as a syrup, but a sugar of low quality is obtained from it. The syrup is boiled to a jelly, and allowed to stand for a few days in order that the sugar may crystallize. It is then centrifugalized to remove the syrup, and thus is produced a crude mass of soft pasty material, having little or no grain, which is called " first pieces." The syrup derived from it is again boiled until it will set, when it also is centrifugalized, and results in the production of second pieces. The latter contain a considerable proportion of the salines and other substances from the beetroot, which give it an unpleasant flavour and odour ; it is therefore unfit for domestic use. Both kinds are used in confectionery, in making cakes, biscuits, etc., and also in brewing and distilling.

Characteristics of Sugar.—Cane-sugar, sucrose, or saccharose, is a sweet granular crystalline substance, soluble in half its weight of cold water. It forms large colourless monoclinic prisms. It is dextro-rotatory, does not reduce Fehling's solution or other alkaline solutions of copper, nor ammonio-silver nitrate solution. When treated with alkalies, it becomes of a dark brown colour on heating, and is gradually decomposed. This decomposition occurs more or less in cakes or biscuits containing sugar and an excess of soda. Boiled with dilute alkalies, it splits into equal parts of dextrose and lævulose, with assumption of water, forming **invert sugar** ; the liquid now reduces Fehling's solution or ammonio-silver nitrate solution, and rotates the plain of polarized light to the left, invert sugar being lævo-rotatory. The inversion of cane-sugar is also effected by diastase, by yeast and the enzymes of the alimentary canal. The fermentation of cane-sugar by yeast does not occur until it is inverted by the *invertase*, an enzyme, of the yeast cells. When cane-sugar is boiled at ordinary atmospheric pressure, as in jam-making, some water is given off, and it is inverted to dextrose and lævulose, and thus loses the power of crystallizing when it cools.

Barley-Sugar.—When ordinary cane-sugar is heated to 160° C. (320° F.), it melts and forms a golden-yellow liquid, which upon cooling sets into a solid, brittle, glassy-looking confection or candy known as "barley-sugar." It thus undergoes such a change in its physical characters that it no longer crystallizes.

Sweets or Confectionery.—If the temperature of sugar be raised from 104·5° to 177° C. (220° to 350° F.), the sugar undergoes those changes in colour and ductility which are taken advantage of by the " boiler " or confectioner in making sweets or candy, the substance being ductile while hot, and brittle when cold. Every shade of colour, from pure white to straw, fawn, brown, reddish-brown to nearly black, is given to it by various degrees of heat.

Caramel.—If, however, the temperature be raised still higher, from 190° to 210° C. (374° to 406° F.), the sugar becomes transformed into a dark-brown substance, called " caramel," " burnt-sugar," or " black-jack." This substance is largely used as a colouring agent

by cooks, confectioners, vinegar-makers, brewers, distillers, etc. It is also made from glucose (*q.v.*).

The Purity of Sugar.—The extreme cheapness of sugar at the present day prevents any intentional adulteration, by gum, dextrin, glucose, chalk, whiting, gypsum, bone-dust, sand, or common salt, such as was formerly common. It should, however, be free from dirt and other impurities. This is ascertained by making a solution of the sugar in a conical glass, and collecting the deposit which may occur, and examining the same by a pocket-lens or the microscope. It is, as we have said, dextro-rotatory, but invert sugar is lævo-rotatory. For Revenue purposes or Customs duties the sugar is examined by polarized light. A solution is made of 26·048 grammes of sugar in distilled water, enough to make 100 c.c. The solution is clarified by the addition of phosphotungstic acid or subacetate of lead, until no further precipitate falls. It is then filtered until it is perfectly clear. The polariscope tube is filled, and the reading taken by the aid of a polarimeter. If the polarimeter indicates a dextro-rotation of 98°, a duty of 50 pence per hundredweight is charged; if it shows a rotation of only 77°, a duty of only 25 pence per hundredweight is charged, or a like proportion, according to the amount of tax on the higher quality. *Yellow crystals* are often sold as genuine Demerara sugar, but consist usually of sugar coloured by aniline dyes. This fraud may sometimes be detected by a pocket-lens, which shows the inequalities in colouring. But it may also be detected by washing the crystals in alcohol, which is coloured by the dye, and the crystals themselves become colourless. This may be confirmed by pouring a little dilute acid upon the aniline-coloured crystals, when they will turn pink or red. The finest sugar has naturally a yellow tint, usually hidden by the addition of a trace of ultramarine blue to the syrup, which produces an optical appearance of whiteness in the crystals. The amount of "blue" should not be excessive; its presence is shown in the following way: Dissolve several ounces of sugar in water, allow the deposit to fall, collect and wash it in a little water; add a few drops of hydrochloric acid, when the colour, if due to ultramarine blue, will be destroyed.

The Sugar-Mite (*Acarus saccharei*) occurs in moist or raw sugar, but not to the same extent as formerly. It is detected by dissolving 2 or 3 drachms of the sugar in 2 ounces of water, and allowing it to rest for an hour or two; at the end of that time the animalculæ will be found upon the surface of the water or in the sediment, and can be examined by a low-power microscope, or they may even be visible to the naked eye. It is a cause of grocer's itch.

Molasses, Treacle—Syrup.

Molasses or Treacle is a saccharine residue separated from sugar during its manufacture—*i.e.*, it is the liquid which remains after separation of the crystals. The clarified juice of the cane or beetroot,

having been concentrated, is allowed to crystallize. Formerly this was broken up into fragments, put into a barrel having a perforated bottom, and the molasses allowed to separate by gravitation, the raw sugar, or muscavado, being left behind. The raw sugar consisted of 87 to 91 per cent. of the saccharine material of the juice, and the rest was contained in the mother-syrup, or molasses, which drained away. This molasses or treacle was of a dark brown or greenish-black colour, contained some crystallizable sugar, all the uncrystallizable sugar and salts. It was used as a food, but chiefly by confectioners, bakers, and distillers. It is still obtainable to some extent from places where the old-fashioned methods of sugar-making are adhered to, and especially where sugar is made on a small scale.

Composition of Sugar-Cane Molasses—Percentages.[1]

	Cane-Sugar.	Invert Sugar.	Other Organic Matter.	Ash.	Water.
West India molasses ..	47·00	20·4	2·70	2·60	27·3
Plantation molasses ..	45·64	20·8	10·58	4·07	18·9
Sugar-house molasses ..	43·50	15·2	5·60	10·10	30·6

Sugar is now chiefly made by modern methods, the massecuite being centrifugalized, the syrup concentrated again in a vacuum-pan ; consequently much more sugar is extracted from the syrup, and much less molasses comes into the market ; further, the quality of the molasses has declined. The massecuite is centrifugalized three times, and the resulting syrup concentrated three times—*i.e.*, before each centrifugalization ; before the third centrifugalization the molasses is stored in a warm room for some months.

Composition of Molasses after Centrifugalization—Percentages.[2]

	First-Jet Molasses.	Second-Jet Molasses.	Third-Jet Molasses.
Total solids	80·00	80·00	80·00
Cane-sugar	53·60	41·70	31·70
Invert sugar : Dextrose ..	8·76	12·00	15·00
Lævulose ..	8·00	12·50	16·50
Ash	4·00	5·35	6·50
Albuminoids	·20	·25	·30
Amides	·94	1·50	2·00
Acids, gum, etc.	4·50	6·50	8·20

The molasses or treacle from sugar refineries is somewhat better than " third-jet " molasses, because the syrup has been filtered for

[1] Thorpe's " Dictionary of Applied Chemistry," vol. iii., p. 660.
[2] Wiley's " Foods and their Adulteration," p. 479.

the refinement of the sugar, thereby removing various impurities. It is very dark, and hence called "black-strap"; "it is frequently diluted before it is sold."[1] Its composition is as follows:

TREACLE.

Cane-sugar	34·2 to 36·6 per cent.
Invert sugar	29·7 ,, 32·0 ,,
Ash	3·4 ,, 6·4 ,,
Undetermined	3·5 ,, 8·0 ,,
Water	18·5 ,, 23·5 ,,

Molasses or treacle therefore contains all the residues from the sugar-cane which are in solution—that is, it contains, besides some sucrose, the normal dextrose and lævulose of the cane, and still more dextrose and lævulose arising by the inversion of cane-sugar (sucrose) during the process of manufacture—the albuminoids, some amides, gum, organic acids, and mineral substances.

Beetroot Molasses is not used for human food, because of its nauseous flavour, arising from the large amount of saline impurities and organic matters. Its composition, according to Girard, is as follows:

BEETROOT MOLASSES.

Cane-sugar	49·00 per cent.
Invert sugar	traces
Organic matters	19·86 ,,
Mineral matters	12·74 ,,
Water	18·10 ,,

With modern methods of manufacture a large proportion of the cane-sugar is extracted, and the residue is used for cattle foods.

"German treacle" is a substance made from juniper-berries, and is quite different from ordinary treacle or molasses.

Golden Syrup, etc.

The syrups which are now sold are not the same thing as treacle or molasses; they contain more sucrose and less invert sugar (glucose). When properly made, they are prepared by evaporation of the sap or juice to the required density. They are maple-syrup, cane syrup, sorghum syrup, and mixed syrups. The latter include golden syrup, amber syrup, etc.

1. *Maple-Syrup* is the most highly esteemed, especially in America. It consists of the sap of the maple-tree concentrated until it contains only 30 per cent. of water—*i.e.*, just enough to prevent crystallization of the sucrose. It is also made by dissolving maple-sugar in water, just as it is required, but this is not the same thing as the former; it lacks the flavour of syrup made by concentration of the sap.

2. *Cane-Syrup* consists of the expressed juice of the sugar-cane, properly clarified and purified, and concentrated by evaporation until it contains 30 per cent. of water. The concentration is done by preference in an open pan, whereby a greater proportion of the

[1] "The Practical Grocer," vol. ii., p. 163.

sucrose is inverted than in the vacuum-pan. The more invert sugar there is, the less probability is there of the sucrose crystallizing. This syrup is darker than maple-syrup, owing to the formation of a little caramel by the mode of preparation. When such a syrup is unduly light-coloured, it has most likely been bleached by the action of sulphur fumes.[1]

3. *Sorghum-Syrup* is the juice of *Andropogon saccharatum* obtained by pressure, clarified by gravitation, and concentrated. It has a flavour which distinguishes it from cane or maple syrup.

4. *Mixed Syrups* usually consist of commercial "glucose" combined with the product of the sugar-cane, maple, or sorghum. The molasses of sugar refineries are used to a large extent in its manufacture. The latter usually contains 8·0 per cent. or more of ash, but it is clear, bright, and has a distinct flavour, and when mixed with nine times its bulk of "glucose" it forms a palatable and pleasant-looking syrup.

The best **Golden Syrup** is from sugar-cane, and, properly speaking, is the uncrystallizable residue of the manufacture of cane-sugar. It contains much sucrose, dextrose and lævulose (invert sugar), besides saline and organic matters. The sucrose is nearly all recoverable by modern methods, but it is unnecessary to do that, so great is the demand for syrup. The invert sugar owes its origin to the heat of concentrating the juice, but usually a large amount of commercial "glucose" is mixed with it to prevent the sugar from becoming granular. We have, however, seen that this is unnecessary, as the presence of 30 per cent. of water will prevent its crystallization. Amber and other syrups differ chiefly in their colour. Such goods should be so marked that the purchaser may know whether they contain "glucose." It should be observed that the "glucose" frequently contains recognizable quantities of sulphuric acid, and if the latter be impure it may also contain arsenic; there may also be a little sulphurous acid, used for bleaching; and the salts are chiefly sulphates and chlorides.

THE COMPOSITION OF SYRUPS—PERCENTAGES.

	Water.	Sucrose.	Invertose.	Ash.	Undetermined.	Authority.
Maple-syrup:						
Minimum ..	19·01	22·94	trace	·33	1·80	Wiley, *Chemical News*, 1885, ii. 89.
Maximum ..	40·26	64·45	32·79	1·14	23·65	
Twenty analyses, average ..	31·40	64·10	1·30	·30	—	Wiley, "Foods," etc., p. 473.
Cane-syrup, average	25·80	52·00	17·60	1·20	—	
Sorghum-syrup, average	28·60	36·70	26·60	4·00	—	
Golden syrup, average	22·70	39·00	33·00	2·50	2·80	"Practical Grocer," ii. 163.

[1] Wiley's "Foods," etc., p. 473.

AVERAGE COMPOSITION OF GOLDEN SYRUP.[1]

Moisture	22·74 per cent.
Cane-sugar	11·30 ,,
Dextrose	15·56 ,,
Maltose	16·84 ,,
Dextrin	13·20 ,,
Gallisin	14·40 ,,
Combined maltose	·61 ,,
Ash	1·34 ,,

There are several ways of ascertaining the amount of sugar in a syrup—*e.g.*, by the specific gravity. The S.G. of water is 1000, and this is raised 3·86 for every gramme of sugar in 100 c.c. of syrup. Therefore if the S.G. of a syrup is 1062,

$$\frac{1064 - 1000}{3{\cdot}86} = 16{\cdot}76$$ grammes per 100 c.c., or sugar per cent.

It is obvious, however, that this applies to simple syrups only, and not to a complicated syrup which partly consists of commercial "glucose," as in the golden syrup, whose average composition is given above.

"Glucose," or Starch-Sugar.

Properly speaking, glucose is the generic name for the *Hexoses* ($C_6H_{12}O_6$), or six carbon-atom carbohydrates, and more particularly of dextrose, or grape-sugar, which occurs in so many plants and fruits. It crystallizes with a molecule of water in warty masses, melts on being heated to 146° C., and is converted into **glucosan** at 170° C., and into caramel at a higher temperature. It is *dextro-rotatory*, not very sweet, reduces Fehling's solution or ammonio-silver nitrate solution, and is readily fermentable. There is not much commercial demand for the pure substance.

There is, however, a great demand for artificial "glucose," or starch-sugar. This is a combination of dextrose, maltose, dextrin, and unfermentable bodies. It is produced from starch by hydrolysis with dilute acids. Potato starch is used for this purpose in France and Germany, but it is chiefly made from maize starch in the United States. The hydrolysis is usually produced by sulphuric acid, but oxalic, phosphoric, and acetic acids are used for special purposes. Ordinarily the starch is treated by dilute sulphuric acid (4 per cent.); it is then boiled for twenty minutes, neutralized by chalk, and filtered. In **Mambré's process** 56 pounds of sulphuric acid, of density of 66° Beaumé, is mixed with 560 gallons of water, and heated to 212° F. in a converter. In another vat the same quantity of sulphuric acid and water are mixed, and heated to 85° F., 1 ton of starch being then added, mixed well, and the temperature raised to 100° F. The two mixtures are then mingled together in the converter, and the temperature raised to 320° F. by passing steam into it at a pressure of 6 atmospheres. When this temperature is attained, the steam is allowed to escape, carrying with it the

[1] *The Analyst*, 1897, xxii. 28.

volatile products. The mixture is then tested with iodine to show that all starch is converted, and with silicate of potash and lead acetate to show the absence of dextrin, which occurs when no turbidity is caused by the reagents. The complete conversion occurs in from two to four hours. The liquor is then run off, neutralized with lime, and the lime precipitated with carbonic acid gas. Finally the liquor is clarified with charcoal, evaporated to 28° Beaumé for glucose syrup, and 38° Beaumé for hard glucose. In the United States maize starch is converted by mixing it with 50 per cent. of water to form a cream of 20° Beaumé density. It is then treated with hydrochloric acid in proportion of 0·0006 per cent. of the weight of starch, and submitted to the action of steam of 30 pounds pressure, and afterwards neutralized by carbonate of soda. The product is sold in several grades :

1. *Anhydrous Starch-Sugar*, or dextrose : a solid crystalline substance containing 90 per cent. of dextrose, 0·8 per cent. of ash, but without water of crystallization.

2. *Hydrous Starch-Sugar*, containing water of crystallization. There are two varieties :

(*a*) Brewer's sugar, or buffalo chips, called " standard 70 sugar " ; it contains not less than 70 per cent. of dextrose and 0·8 per cent. of ash.

(*b*) Acme or climax sugar, also called " standard 80 sugar " ; it contains not less than 80 per cent. of dextrose, and not more than 1·5 per cent. of ash.

These substances are sold under various other names, as " solid grape-sugar," " chipped grape-sugar," " granulated, powdered, confectioner's, or brewer's grape-sugar." They consist of large lumps, or " chips," having a pearly lustre and cheesy consistence.

3. " Glucose," or glucose syrup, also called " confectioner's glucose," " jelly glucose," and " mixing or corn syrup," etc. It is a thick syrupy substance, colourless, and not very sweet, obtained by incompletely hydrolyzing the starch or starch-containing substance, decolorizing and filtering the product. It is sold in six degrees of concentration—viz., 39°, 41°, 42°, 43°, 44°, and 45° Beaumé, at a temperature of 37° C. (100° F.). When of 41° density it should not contain more than 21 per cent. of water and 1 per cent. of ash ; when of 45° density it should contain not more than 14 per cent. of water. The ash is chiefly sulphates and chlorides.

The uses of starch-sugar are as follows : (1) The manufacture of golden, amber, and other syrups ; (2) the manufacture of vinegar ; (3) substitute for malt in brewing ; (4) as a substitute for cane-sugar in confectionery—*e.g.*, making " caramel " and other forms of sweets or candy ; (5) adulteration of cane-sugar ; it has been found in raw sugar to the extent of more than 20 per cent. ; (6) to make artificial honey.

" The Modern Baker and Confectioner " says that solid glucose, or ' buffalo chips," is very suitable for the use of bakers and con-

fectioners ; that it is chiefly used by bakers for starting a vigorous fermentation of the dough, by providing *dextrose* ready for the action of the yeast-plant ; it is customary to add about 12 ounces to each sack of flour ; it has the further effect of giving a nice bloom to the bread.

THE COMPOSITION OF GLUCOSE—PERCENTAGES.[1]

	Solid Glucose.	Liquid Glucose.
Dextrose	72·0 to 99·40	18·75 to 36·50
Maltose	·0 ,, 1·90	4·60 ,, 36·10
Dextrin	·0 ,, 9·00	25·41 ,, 45·30
Ash	·3 ,, ·85	·22 ,, 1·00
Water	·5 ,, 20·00	14·22 ,, 19·52

The Salutariness of Glucose.—It still remains to be asked, Is artificial glucose healthy and safe for human consumption ? The pure chemical substances, dextrose, maltose, and dextrin, cannot be injurious to the human organism, no matter what is their source or origin. But it does not necessarily follow that beer made from "glucose" is as good as beer made from malt, or that an artificial syrup is as innocuous as genuine molasses or treacle. The artificial product may contain something injurious to the health of the consumer. A serious impurity may arise in the form of arsenic, when the acid used in its manufacture contains that metal ; epidemics of poisoning, peripheral neuritis, etc., have occurred amongst heavy beer-drinkers owing to the use of glucose as a substitute for malt.

The glucose may also contain small quantities of organic substances which are decidedly poisonous. In Germany, where large quantities of glucose are manufactured from potato starch, experiments bearing on this point have been made. Some of these experiments indicated that after the fermentation of glucose there were left certain injurious substances which caused bad symptoms when administered to animals, and to man caused headache, sweating, and loss of appetite. Nessler concluded that there is, beyond doubt, in the liquid obtained by the fermentation of potato-sugar, some substance injurious to health. Whether it is contained in *all* commercial potato-sugar is not known. But in all the potato-sugars which he examined there remained, after evaporation of the fermented liquor, a bitter extract, which he considered

[1] The National Academy of Sciences, U.S.A., found as follows :

Solid glucose contained—	
Dextrose	72·0 to 73·4 per cent.
Dextrin	4·2 ,, 9·1 ,,
Liquid glucose contained—	
Dextrose	34·3 to 42·8 ,,
Dextrin	29·8 ,, 45·4 ,,

to be probably the injurious substance. On the other hand, von Mering believed that the unfermentable residues of potato-sugar are not objectionable.[1]

Lævulose, levulose, also called "fruit-sugar" or "*d*-fructose," is widely distributed throughout the vegetable kingdom in fruits, flowers, and especially in honey. It is also formed by the hydrolytic cleavage of cane-sugar, inulin, and other carbohydrates, by acids or enzymes. It is hardly ever met with alone, but chiefly in combination with dextrose as "fruit-sugar." It is very sweet, and usually in the form of a brownish syrup. It crystallizes with difficulty in needles, which are partly anhydrous and partly hydrous. It is readily soluble in water and boiling alcohol, barely soluble in cold alcohol. It reduces Fehling's solution and ammonio-silver nitrate solution, but not to the same extent as dextrose. It is lævo-rotatory.

It is seldom met with as a dietetic article, but it is sometimes prescribed for diabetics, who are said to be able to consume it to the extent of 1 ounce daily without increasing their glycosuria, and that it is decidedly better borne by them than dextrose or sucrose.

Invert Sugar, also called "fruit-sugar," is a mixture of dextrose and lævulose in nearly equal proportions. It occurs very largely in fruits, being the usual combination of dextrose therein. It also occurs abundantly in molasses or treacle, maple and other syrups, jam, marmalade, and "glucose."

As a commercial product it is manufactured from cane-sugar, which is inverted by enzymes, by heat, or by heat and dilute acid, as in the preparation of "glucose." In Wohl and Kollrep's process, 1 ton of powdered white sugar is melted in a closed pan with 2·4 hectolitres of water heated to 95° C.; 0·22 litre of pure hydrochloric acid diluted with 10 litres of water is then stirred in, and the temperature of the mixture maintained at 80° to 90° C. for about half an hour, when the inversion is complete. The product is a white or faintly yellow mass, intensely sweet, and having a flavour of honey. When cold it is viscous, but on standing some weeks the glucose crystallizes out. One ton of sugar yields about 2,355 pounds of invert sugar. It is also prepared by Thompson's yeast process.

Composition of Commercial Invert Sugar.[2]

Invert sugar	76·6 per cent.
Cane-sugar	2·5 ,,
Other carbohydrates	·9 ,,
Water	18·0 ,,

We have seen in the account of jam-making that the inversion of cane-sugar is an important part of the process, and that it is inverted by heat assisted by the fruit acids. Invert sugar does not crystallize; hence when jam crystallizes it has not been boiled long

[1] Report of National Academy of Sciences to the U.S. Government.
[2] "Thorpe's Applied Chemistry," vol. iii., 667.

enough—*i.e.*, the inversion has not been carried far enough. When sugar is added to fruit tarts or other fruit *before* being cooked, a considerable amount of the cane-sugar becomes inverted, and, as invert sugar is not so sweet as cane-sugar, this accounts for the fact that fruit sweetened before cooking requires more sugar to make it palatable than fruit sweetened *after* cooking.

Caramel, or Burnt Sugar, which is used so largely as a colouring agent for beverages, gravies, and sweetmeats, is made by the action of heat on sugar or glucose. The methods of manufacture are based on those of Asrymusry, but improvements have been made by Salmon and Goldie (1900) and Gonville and Jarvis (1904). Salmon and Goldie's recipe is as follows: 5 hundredweights of maize-glucose is melted at 95° C. in an iron vessel; the temperature is then raised to 110° C. for about twenty minutes; afterwards about 45 ounces of carbonate of ammonia and 15 ounces of chloride of ammonia are stirred in, and it is again boiled for about two hours. During this time a considerable amount of greyish-yellow pungent vapour is given off. The temperature is gradually raised to 150° C., at which it is maintained for another hour, and the caramel becomes so thick it can scarcely be stirred. The heat is now turned off. Solid caramel is formed by cooling it on iron plates, liquid caramel by adding water to make it of the required density; it is then heated, and passed through sieves to remove carbonaceous and solid particles. It should have the following characters: Specific gravity, average, 1·377; copper-oxide-reducing power, 33·87 per cent.; mineral matters, 0·80 per cent. It should not be affected by proof spirit or organic acids (acetic, citric, or tartaric) in solution; a solution of 0·1 per cent. in water should have a colouring power equal to 18° on Lovibond's scale, determined by comparison with yellow-tinted glass.

Maltose—Extract of Malt.—Pure malt-sugar, $C_{12}H_{22}O_{11}$, is not a commercial product. It occurs principally in malt extract, and wherever diastase acts upon starch:

$$5(\underset{\text{Starch.}}{C_{12}H_{20}O_{10}}) + 4H_2O = 4(\underset{\text{Maltose.}}{C_{12}H_{22}O_{11}}) + 2(\underset{\text{Dextrin.}}{C_6H_{10}O_5}).$$

Malt-sugar is dextro-rotatory, soluble in water and alcohol, but not so sweet as cane-sugar. It crystallizes in tiny needles or warty masses with one molecule of water, which is expelled by heat (100° C.). It reduces Fehling's solution, but has a feebler action than dextrose. It is completely fermented by yeast, after being inverted to dextrose by the *invertase* enzyme.

The production of maltose from grain starch is due to the presence of *diastase*, an enzyme whose chief characteristic is the transformation of gelatinized starch into this form of sugar. The action is not direct, as it has been shown by O'Sullivan that the starch is first transformed into malto-dextrins (*q.v.*). Malt diastase is secreted by the germinating grain during the process of malting, and this enzyme is secreted expressly to provide the growing plant

with soluble carbohydrates. But diastase is not able to break down or dissolve the cellulose envelopes of the starch granules. However, during the growth of the young plant, *cytase*, another enzyme which dissolves cellulose, is secreted and does this work, thereby exposing the *granulose* to the action of diastase. The diastatic ferment increases in activity as the temperature of the medium rises up to a certain point ; the maximum effect occurring between 160° and 165° F., and is arrested by destruction of the enzyme at a temperature of 212° F. The enzyme is not involved in the new compounds—that is to say, it is not used up, for a large amount of starch may be transformed by a small amount of diastase. Various theories of enzyme action exist ; according to one theory enzymes act by **catalysis,** and according to another by the exhibition of **radiant energy.**

Extract of Malt is prepared by macerating coarsely powdered malt with an equal weight of water for six hours, then adding six times the original quantity of water, heated to 30° C., digesting the substance for one hour at a temperature not exceeding 50° C. (the diastase is destroyed if it reaches 75° C.), straining with strong pressure, and afterwards evaporating the liquid over a water-bath or in a vacuum-pan, until the liquid is of the consistence of thick honey. It is a thick, viscid, amber or brownish-yellow liquid, having a sweet mucilaginous taste, a characteristic odour, and faint acid reaction. It is soluble in all proportions of water, and precipitated from solutions by alcohol. It has a S.G. of 1·375.

Composition of Extract of Malt.

Albumin	6·39 per cent.
Maltose	45·00 ,,
Dextrin	7·20 ,,
Invert sugar	14·49 ,,
Cane-sugar	3·40 ,,
Diastase	—
Mineral salts	1·20 ,,

The diastatic value of a sample of extract is stated in terms based upon the proportion of starch it is capable of converting into sugar in a given time. This is determined thus : Mix 1 gramme of anhydrous starch with a little water, making it into a thin mucilage with boiling water, boil it to insure complete gelatinization, cool to 46° C., add 2 decigrammes of extract of malt thinned down with a little water, and maintain it at 40° for half an hour ; then boil it to destroy the diastase, and estimate the sugar by titration with Fehling's solution. Deduct the amount of maltose originally present in the extract of malt ; the remainder is that produced from the starch by the diastase.

When extract of malt is properly prepared, the chief ingredient is maltose ; there is also some protein, a little glucose, dextrin, and diastase. But the preparations on the market consist of other things also. Thus starch-glucose is sometimes added ; the proportion of

dextrose is normally small in amount, but when the proportion of reducing-sugar in the extract is very high, it may be presumed that glucose has been added. Another substance added is dextrin; this is usually obtained from potato starch; it is added to the malt extract during the stage of concentration, and becomes partly converted into maltose by the enzymes of the malt. Pure malt extract contains an average of 6 per cent. of protein; when dextrose or dextrin is added this proportion is lowered. Various preservatives, such as salicylic, sulphurous, or benzoic acid, or even formaldehyde, are often added.

Composition of Extracts of Malt.[1]

	Total Solids.	Reducing-Sugars (Maltose chiefly).	Protein.	Dextrin.	Ash.	Alcohol.	Diastatic Power.
Allen and Hanbury's extract	79·0	65·2	4·55	13·4	1·2	—	39
Bynin	52·9	51·6	3·39	3·1	·9	8·3	38
Diamalt	74·0	63·9	6·52	12·7	1·2	—	1060
D.C.L. malt extract ..	78·3	70·9	6·25	10·0	1·4	—	366
Hoff's malt extract ..	7·8	2·5	·40	2·3	·2	3·1	—
Kepler's malt extract	78·4	67·7	5·66	7·4	1·5	1·5	380
Maltine	67·3	61·9	5·25	5·0	1·2	—	940
Oppenheimer's cream of malt	73·8	60·8	5·55	13·8	1·8	—	86
Standard extract of malt	76·6	70·0	5·30	12·2	1·4	—	382
Standard liquid malt	53·7	51·6	5·50	2·3	1·1	5·0	866
Trommer's extract of malt	73·6	55·9	4·06	8·3	1·1	—	23

The combinations of malt and cod-liver oil contain from 13 to 25 per cent. of fat. Virol contains 12 per cent. of fat said to be bone-marrow; Cremalto contains 12 per cent. of fat from Devonshire cream; Ovaltine, 13 per cent of fat from milk and eggs.

Milk-Sugar, Lactose, or Lactobiose, $C_{12}H_{22}O_{11}+H_2O$, is believed to be the exclusive product of the mammary gland of animals. Commercial sugar of milk is obtained from whey by gently evaporating it to a low bulk, or a syrupy fluid of 11° to 25° Beaumé, and setting it aside for a day or two, when the sugar crystallizes out as a yellow granular mass, subsequently redissolved in water, the casein precipitated, purified by filtration through animal charcoal, recrystallized, and centrifugalized. Ramage's method consists in evaporating the slightly alkaline whey to half its bulk, precipitating the casein by an acid, straining, still further evaporating the liquid, and then precipitating the lactose by methyl alcohol. In Kennedy's method the whey is evaporated until it has a density of 15° to 25° Beaumé, when the temperature of the liquor is reduced

[1] *British Medical Journal*, 1909, ii. 1478.

to induce crystallization of the sugar. The crystals are removed by centrifugalizing it, and afterwards washed in cold alkaline water. In the Swiss process the whey is evaporated to dryness, the residue dissolved in hot water, casein precipitated by alum, the liquor filtered through charcoal, boiled down to a syrup, and allowed to crystallize. Much milk-sugar is made in Switzerland and Illinois. It forms small colourless rhombic prisms, hard and granular, and appears *en masse* as a white or greyish-white powder, gritty, odourless, having a faint sweet taste, but not nearly so sweet as cane-sugar. It is soluble in six times its bulk of cold and an equal bulk of boiling water, but it is insoluble in ether, alcohol, or chloroform. It has a neutral reaction, is dextro-rotatory, reduces Fehling's and ammonio-silver nitrate solution, and combines with bases. Heated to 130° C. it loses its water of crystallization without melting, and leaves a white hygroscopic anhydrous substance. It becomes brown on being heated with alkalies. It is converted by dilute acids to dextrose and galactose. Sprinkled on the surface of concentrated sulphuric acid, a reddish or greenish coloration may appear, but there should be no brown or black coloration (showing absence of cane-sugar). Burnt with free access of air the ash should not exceed 0·25 per cent.

Milk-sugar is a valuable food material, especially useful when the stomach is irritable. It is chiefly used in the preparation of infants' and other artificial foods. It may especially be used in the preparation of humanized cow's milk. First a " milk-powder " is prepared by mixing together milk-sugar with 3½ per cent. of compound pancreatic powder ; then take :

Milk powder	6½ parts.
Water	62 ,,
Fresh cow's milk	62 ,,
,, cream	15 ,,

Mix together the milk-powder and water, add the milk and cream, put the mixture into sterilizing bottles, heat them to 38° C. for fifteen minutes, then quickly bring them to boiling temperature ; cool rapidly to 37° C. (body temperature), and use it. It should be prepared immediately before use.

Milk-sugar is not fermented by ordinary yeast (*Saccharomyces cerevisiæ*), but is fermented by special yeasts which contain *lactase*, an enzyme which hydrolyzes the lactose into galactose and dextrose, both of the latter sugars being fermentable by the ordinary yeast. The special yeasts occur in the preparation of koumiss, kefir, and leban (*q.v.*).

Manna.

Manna is a saccharine substance containing various sugars. It is the juice exuded from the stems of *Fraxinus ornus et rotundifolia*, N.O. Oleaceæ, which are species of ash-trees native in Sicily, Calabria, and other parts of Southern Europe. The trees are cultivated for the purpose of obtaining the manna, which is a

considerable article of commerce. When the trees are about ten years old, a vertical series of oblique incisions is made in the stem. The juice which exudes either dries on the stem, constituting *flake manna*, or it drops from the stem, and is caught on tiles or cactus-leaves. Flake manna is the best; it consists of oblong pieces or flakes of a pale yellow or whitish colour, light, friable, and somewhat transparent. It has a sweetish taste, mixed with slight bitterness, and a somewhat peculiar odour. It consists chiefly of a crystallizable sugar, called "mannite," and some uncrystallizable sugars. According to Tanret,[1] the composition is as follows:

Composition of Manna—Percentages.

	No. 1.	No. 2.
Water	10·0	10·00
Salts	2·0	1·50
Mannite	40·0	55·00
Dextrose	3·0	2·20
Lævulose	3·4	2·50
Mannotetrose	16·0	12·00
Manninotriose	16·0	6·00
Fraxin (resin)	·1	·05

Mannotetrose, $C_{24}H_{42}O_{21}$, and manninotriose, $C_{18}H_{32}O_{16}$, were discovered by Tanret. Each molecule of mannotetrose is split by dilute acids into two molecules of galactose, one molecule of dextrose, and one of lævulose. Manninotriose is the product of the spontaneous hydrolysis of mannotetrose. Mannite is the hexatomic alcohol $C_6H_8(OH)_6$, and may constitute 80 per cent. of manna. The term "manna" is very old, and is applied to the exudation from other plants—*e.g.*, oak manna, from *Quercus persica et vallonea*; Briançon manna, from *Larix europæa*; tamarisk manna, from *Tamarix mannifera*; Alhagi manna, from *Alhagi maurorum*, etc.

Honey.

Honey is the saccharine substance collected by bees (*Apis mellifica*, genus Hymenoptera), and stored in combs as a reserve of food for their own use in winter. Honey has been used for food by man from the earliest days of which we have any record. In prehistoric periods it was probably the only saccharine substance known to mankind. It has, however, lost much of its importance since the production of sugar in large quantities. At the present day, whether considered as a delicious article of food or the base of a wholesome vinous beverage, it is of no mean value even in this country. In many inland countries of Europe, where sugar is much dearer than it is with us, few articles of rural economy, not of prime

[1] *Bull. de la Soc. Chim. de Paris*, vol. xxxii. 18, 19.

importance, would be dispensed with more reluctantly. In the Ukraine, some of the peasants have hundreds of beehives, and make more profit from their honey than they do from their corn ;[1] and the number of hives in parts of Spain was formerly almost incredible, a single priest having been known to possess 5,000.[2]

Honey is the sweet viscid juice or nectar collected and elaborated from the flowers of various plants by several kinds of insects, and especially by the honey-bee (*Apis mellifica*). The domesticated hive-bee is the same in every part of Europe, excepting in Italy, where the *A. ligustica* is cultivated, and is probably the same bee as in the Morea and isles of the Grecian Archipelago. There are other domesticated bees in various parts of the world which gather honey—*e.g.*, the *A. fasciata* in Egypt, which was probably domesticated ages before our hive-bee ; *A. unicolor*, in Madagascar ; *A. indica*, in India ; *A. adansonii*, in Senegal ; *A. acrænsis*, *A. laboriosa*, and others, in the East and West Indies.[3] Bees are not the only insects who collect saccharine substances which may be called "honey." Wasps in general do not store honey, but it is sometimes found in the cells of the European species of *Polista*, and in those of the American *Polybia apicipennis*. Honey is also produced by the honey-ant of Mexico (*Myrmecocytus mexicanus*). These honeys, however, are syrupy fluids, scarcely comparable with the honey of commerce.

Honey is derived from the nectar of flowers. Some of these saccharine fluids have been analyzed, and A. von Planta gives the following as the composition of such fluids examined by him :[4]

THE COMPOSITION OF NECTAR—PERCENTAGES.

	Glucose.	Sucrose.	Glycerine.
Protea mellifera	70·08	1·310	—
Bignonia radicans	14·84	·437	—
Hoya carnosa	—	36·650	4·99

Some flowers yield nearly all glucose or dextrose, and others chiefly sucrose. The saccharine matter having been extracted from the nectaries of the flowers by the bee, the sucrose is inverted to glucose by the invertin enzyme in the intestine of the insect, secreted as honey, deposited in the cells of the comb, and sealed over with wax.

Honey is either extracted or sold in the comb. Honey in the comb is more delicate and aromatic than that which has been extracted for some time from the comb. When collected in large quantities honey is always extracted. There are various ways of doing this, the most ancient being, naturally, by the action of

[1] Communication to the Board of Agriculture, vii. 286.
[2] Mill on Bees, 77.
[3] Latreille's "Hist. Nat." ; *cf.* Kirby and Spence's "Entomology," 188.
[4] Biedermann's *Centralb. f. Agrik. Chemie*, vol. xi., part 6

gravity—the top is removed from the cells, and the honey drained out. Such honey is of very fine quality, and is often erroneously termed "virgin honey." When it ceases to flow at ordinary temperature, the comb is heated and subjected to pressure, whereby a less pure honey of darker colour, and containing various impurities, is obtained. Another method of obtaining honey without pressure is by putting the combs into a centrifuge ; the honey so obtained is also of fine quality, the combs are left in almost as good a condition as before extraction, and are put back into the hives. The best qualities are English honey, English heather honey, Narbonne, Transylvanian, West Indian, and Californian. "Virgin honey" is the product of the younger bees before they have swarmed. Narbonne honey is a great delicacy, being light in colour, granular, and very aromatic. Bourbon honey is of a green colour, thin, liquid, but adds to the usual sweetness a peculiar fragrance. Rock honey is as clear as water and very thin, and is the product of wild-bees in some parts of America, which suspend their cells in clusters of thirty to fifty, like a bunch of grapes, to a rock.

The colour, flavour and odour of honey are chiefly due to the foreign substances in it, and mainly to the flowers from which the nectar was gathered. It is the possession of these characteristics which causes certain honeys to be so highly prized. To these peculiarities is due the high estimation in which the honey of Mount Ida in Crete has always been held, and the perfume of the Narbonne honey and our own moorland or heather honey, gathered when the heather is in bloom. Sometimes these foreign substances possess narcotic or other deleterious properties, as in the case of the Trebizond honey, which causes headache, nausea, and even a kind of intoxication, in those who consume it. This quality is derived from the flowers of a species of rhododendron (*Azalea pontica*) from which the honey is extracted. The attention of the American Government was drawn to the general distress at one time caused by honey gathered in the neighbourhood of Philadelphia, and a minute inquiry into the causes of the mortality due to it resulted in the discovery that the honey was gathered chiefly from the flowers of *Kalmia latifolia*. The soldiers of Xenophon, as described by him in the "Retreat of the Ten Thousand," were poisoned by honey, which did not act fatally, but caused those who ate a small portion of it to become intoxicated, and those who ate it freely to become delirious, and finally exhausted. This is the famous Trebizond honey, which to this day produces the same effects.

Honey is a viscid, transparent, syrupy liquid, or soft opaque mass, becoming gradually more opaque, crystalline, and of semi-solid consistence, varying in colour from white or pale yellow to yellowish-brown or reddish-brown. It has a characteristic odour and sweet taste, is exceedingly nutritive, demulcent, and laxative. It consists of 70 to 80 per cent. of a mixture of dextrose and lævulose in about equal proportions, with some cane-sugar and

THE COMPOSITION OF HONEY—PERCENTAGES.

	Water.		Lævulose.	Dextrose.	Cane-Sugar.	Wax, Pollen, and Other Insoluble Matters.	Mineral Matters.
	Expelled at 100° C.	Expelled at Higher Temperature.					
Average of sixty analyses by Sieber[1]	19·28	—	39·24	34·71	1·08	5·02	
Analyses by Hoitsema[2]: Minimum	8·30	—	71·20		·20	·02	·13
Maximum	17·80	—	74·50		2·60	·46	·34
Canadian Reports[3]: Minimum	12·00	—	66·37		·50	—	·03
Maximum	33·00	—	78·80		7·64	—	·50
Analyses by J. C. Brown[4]—							
Source: England	19·10	7·60	36·60	36·55	—	trace	·15
Wales	16·40	6·56	37·20	39·70	—	,,	·14
Normandy	15·50	4·95	36·88	42·50	—	,,	·17
Germany	19·11	11·00	33·14	36·58	—	,,	·17
Greece	19·80	7·80	40·00	32·20	—	1·05	·15
Portugal	18·80	6·66	37·26	34·94	1·20	1·00	·14
Jamaica	19·46	7·58	33·19	35·21	2·20	2·10	·26
California	17·90	8·13	37·85	36·01	—	trace	·11
Mexico	18·47	10·03	35·96	35·47	—	,,	·07
Narbonne[5]	17·10	—	74·00		7·10	1·50	·30

[1] Biedermann's *Centralblatt*, 1885, 134. [2] *Zeit. fur Chim. Anal.*, xxxviii. 429. [3] Canadian Inland Revenue, Bulletin 47.
[4] *The Analyst*, 1878, 257. [5] "The Practical Grocer," ii. 161.

mannite. The reducing-sugars are derived from cane-sugar by inversion. It also contains dextrin, proteins, wax, mucilage, a small proportion of alcohol, formic acid, volatile oil, pollen of flowers, spores, aromatic and alkaloidal principles. It should have a lævo-rotatory action on polarized light, owing to the proportion of lævulose ; if it has a dextro-rotatory action, a suspicion of its purity may justly arise. The detection of adulteration of honey by corn-syrup depends on this action ; glucose mixed in honey would give it a dextro-rotatory action, whereas pure honey is either neutral or lævo-rotatory. Honey gathered from flowers *never* shows a right-handed polarization, but honey from bees fed with ordinary syrup may do so. Honey has a S.G. of 1·45, which is much higher than that of liquid glucose. "Clarified honey" is prepared by melting honey on a water-bath, and straining it through a piece of flannel moistened with hot water. It is a viscid, translucent liquid, gradually becoming opaque and stiff from the crystallization of the dextrose. It has a S.G. 1·4, a sweet, faintly acid taste, and characteristic odour. The slight acidity is due to presence of formic acid, which prevents fermentation. If the honey is impure, it is liable to ferment in warm weather, and develops a pungent taste and deeper colour. Clarified honey is frequently adulterated with commercial "glucose," "invert sugar," or even cane-sugar or molasses ; the composition then varies as follows :

	True Honey (Average).	Adulterated with Glucose.	Adulterated with Cane-Sugar.
Cane-sugar	1·08	·5 to 9·0	15·00 to 45·0
Invert sugar	73·95	45·0 ,, 50·0	40·00 ,, 65·0
Ash	·13	·3 ,, ·8	·05 ,, ·3
Water	24·84	25·0 ,, 45·0	15·00 ,, 44·0

Such adulterations are by no means injurious, but they are fraudulent, inasmuch as the substance is not of the nature represented. It will be observed that starch-glucose always contains dextrin and gypsum, by which its presence can be detected. It may also contain traces of mineral acid, and even arsenic, which further reveal the presence of glucose. The ash of true honey varies from a trace to 0·3 per cent., that of glucose 0·8 per cent. ; it is presumable therefore, until the contrary is proved, that honey which yields more than 0·25 per cent. of ash has been adulterated with glucose, molasses, or some foreign inorganic substance. It is true that a *pure* glucose may have a low percentage of ash, and thus lead to difficulty in its detection ; but the ash of true honey would yield only traces of sulphates and chlorides ; that of glucose is *chiefly* sulphates and chlorides. The presence of starch is proved by the addition of iodine solution to an aqueous solution of honey which has been boiled, when, if any be present, the blue- or violet-

coloured reaction will occur. Similarly, the presence of cane-sugar will be proved by pouring a 20 per cent. solution of honey carefully on to pure sulphuric acid, when an immediate coloration will occur at the point of contact. If at the end of one hour the coloration amounts to nothing more than a yellowish or clear brown zone, the absence of cane-sugar is indicated.

Glycerine, Glycerol.

Glycerine, $C_3H_8O_3$ $[C_3H_5(OH)_3]$, is the trihydric alcohol *glycerol*, obtained by the action of alkalies or superheated steam on fats and fixed oils. It is a thick, sweet, colourless fluid, very hygroscopic, miscible with water and alcohol, insoluble in ether, chloroform, and oils, neutral to litmus ; has S.G. 1·26, boils at 290° C., and has so great an affinity for water that it absorbs it from the air. It should be free from impurities, lead, iron, copper, calcium, potassium, sodium, ammonium, sulphates, chlorides, grape and cane sugars, foreign organic matters, butyric acid, and fixed mineral matter. It should not contain more than 1 part of arsenic in 250,000, and usually contains much less.

Glycerine is sweet, and is used by bakers, confectioners, and others, to confer this property upon various foods. "On account of its hygroscopic properties, glycerine is frequently used in making bread and cake, in order to assist the moist-keeping qualities of the product."[1] It is also used to sweeten various foods for diabetic persons, for whom it is permissible, being an alcohol and not a carbohydrate. Needless to say, the purest glycerine only should be used.

Glycerine is sometimes recommended as a food in various wasting diseases, under the idea that, fats being glycerides, it may contribute to the formation of fat in the human body. The results of such usage, however, are not very encouraging ; indeed, the continued consumption of large doses may be injurious by causing a solution of substances in the red corpuscles, a diffusion of hæmoglobin throughout the plasma, and hæmoglobinuria. It is a well-established fact that the digestion of fat results in its hydrolysis by *lipase*, or the disintegration of the fatty molecules into fatty acids and glycerine, which gain entrance to the blood, and are reconstructed into fat either in the blood itself or, more probably, in the cells of the intestinal mucosa. Any glycerine which is not thus utilized is decomposed in the system into propionic, formic, and other acids ; and the urine of persons who consume much glycerine often contains a reducing agent, which is not sugar, but gives some of the reactions for sugar.

Artificial Sweeteners.

In addition to the various sugars and glycerine, there are other sweetening agents used in the preparation of food.

Saccharin, or **Gluside,** is benzoyl-sulphimide, $C_6H_4.CO.SO_2.NH$, a white powder consisting of microscopic crystals, soluble in 400

[1] "The Modern Baker and Confectioner," ii. 274.

times its bulk of cold water and about 30 times its bulk of boiling water. It is also soluble in alcohol (1 in 30) and glycerine (1 in 50), only slightly soluble in ether and chloroform, but very soluble in solutions of ammonia or sodium bicarbonate. With sodium bicarbonate it forms a neutral soluble gluside. It is manufactured by treating toluene with boiling concentrated sulphuric acid, thus forming sulphonic acids ; the latter are converted into calcium salts, and these in turn into sodium salts. The compound is further treated by ammonia gas, whereby toluene sulphamide is formed, the latter being oxidized by potassium permanganate, and the compound hydrolyzed by an acid into anhydride, gluside, and water.

Saccharin, or gluside, is seldom sold as a chemically pure substance, but it should be free from sugar and other substances blackened by sulphuric acid. According to its purity it has sweetening properties, that of the British Pharmacopœia being 550 times sweeter than cane-sugar, and inferior commercial preparations about 300 to 350 times sweeter. One part of saccharin in 1,000 of commercial glucose will make the latter as sweet as cane-sugar.

Dulcin, or **Sucrol,** paraphenetol carbamide, $C_9H_{12}N_2O_2$, is another white powder having the property of sweetness, and is about 200 times sweeter than cane-sugar. Although not so sweet as the former, it is considered to have a purer taste, and more nearly resembling that of cane-sugar. It is a white powder, soluble in 800 times its bulk of cold and 50 times its volume of hot water, or 25 times its bulk of alcohol.

These substances are not carbohydrates or foods in the proper sense. But their property of sweetness has opened up a wide field of usefulness for them, especially in giving flavour and palatability to foods for the gouty, obese, and diabetic persons and others who require a substitute for sugar. This use is undoubtedly legitimate. But their sweetness has led to their use in making jams, syrups, mineral waters, and other dietetic articles, which is properly objected to by many authorities. It has not been definitely proved whether the prolonged or indiscriminate use of these materials is injurious or not. They are not inert substances, for it has been shown that saccharin has antiseptic properties equivalent to boric acid, and, according to Squibb, exercises a retarding influence upon digestion by its action as an antizyme. Hogarth[1] has also reported cases of acute neuralgia in the solar plexus and its branches, dyspepsia and other alimentary troublss, arising from their continued use. It is therefore justly asserted that they should never be used to sweeten infants' foods, nor even invalids' foods, except under well-defined circumstances.

[1] *British Medical Journal*, 1897, i. 716.

CHAPTER XXVII

CONFECTIONERY

CANDY, sweetmeats, or confectionery, consists chiefly of cane-sugar, combined with various agents to produce colour, flavour, and consistency. They consist of "boiled" and "unboiled" sweets, according to the treatment of the sugar. Each maker has his own recipes, whence the enormous variety of confectionery. Some consist of sugar alone; others are a combination of cane-sugar and commercial glucose, or invert sugar, brought to a proper consistency by boiling or other treatment. Fruit and flowers are preserved entire by dipping them in concentrated syrups. Nuts and seeds are made into some forms of candy, as nougat, candied almonds, etc. Starch is somteimes used as a "filler," etc.

Sugar-Boiling.—Six degrees or stages of sugar-boiling are recognized by the manufacturers, and the process is stopped at the proper stage, according to the confection which he wishes to produce. These **degrees** or **stages** are reached when the temperature of the sugar approximates to the following degrees: The **smooth stage** is arrived at when the temperature of the sugar approximates to 215° F.; the **thread stage** at 230° F.; the **feather,** or **blow, stage** at 235° F.; the **ball stage** at 240° F.; the **crack stage** at 252° F.; and the **caramel stage** at 260° F. If 2 parts of sugar and 1 part of water, or even a proportion of 4 to 1, are heated until the sugar is dissolved, and the boiling continued for ten minutes longer, it reaches the "smooth stage," which is known by drawing a little of the boiled sugar between the finger and thumb after cooling it; with a little longer boiling it reaches the "thread stage," known by the production of a thread-like appearance of the cooled sugar on drawing it out. Very little more application of heat carries it to the "feather" or "blow" stage. On skimming a little of the sugar by a perforated metal skimmer, and blowing through the perforations, little feathery particles come away if this stage is reached. In the "ball stage" the boiled sugar can be worked beween the finger and thumb, and a little later it will "crack" between the fingers or teeth, when it becomes cold. It is in the latter condition that most boiled sugar is worked. The "caramel stage" is that in which the colour changes, and in it a variety of colours may be produced by careful manipulation. As an example, "Everton toffee" is made by mixing together 14 parts of sugar and 7 parts

of water, and boiling until it reaches 245° F.—that is, between the ball and the crack stages. Two pounds of butter are then added, and stirred in while the boiling continues, until the "crack stage" is reached, when it is flavoured with essence of lemon. The soft candies known as "creams" are only boiled to the *thread stage*, after which the material is poured on to a marble slab, and worked with a spatula, or worked in a special machine, until it changes to a creamy substance. Owing to the low degree of temperature the sugar has a tendency to recrystallize; to prevent this, it is customary to add 1 part of cream of tartar to 450 or 500 parts of sugar before boiling; the cream of tartar also produces the effect known as "cutting the grain."

The Colour of Sweets.—They are coloured by the continued application of heat during the caramel stage, or by the addition of caramel and various animal, vegetable, or artificial colouring agents. Some of these are as follows:

1. *Heating the Sugar.*—By careful manipulation during heating various shades of colour can be produced, varying from pure white to straw, fawn, brown, reddish, or black. When the sugar is heated to 400° F. it is converted to caramel, commonly called "burnt sugar," which is used to give various shades of brown to many substances.

2. *Vegetable Colours.*—These consist of the juice of spinach, beet-root, elderberries, cherries, and currants; saffron, safflower, turmeric, annotto, chlorophyll, Brazil-wood, logwood, and fustic; alizarin, purpurin, carthaminic acid, indigo. Even gamboge has been used.

3. *Animal Colours.*—Cochineal and carmine.

4. *Mineral Colours.*—Lake chrome, Vandyke brown, Indian red, emerald green, Brunswick green, yellow ochre, copper, cobalt, arsenic, Prussian blue, salts of zinc or barium.

5. *Artificial Colourings.*—These are chiefly the aniline dyes, and they constitute the main colouring agents used by many confectioners.

Respecting the innocuousness or otherwise of these colouring matters, it may be said that those of animal and vegetable origin are perfectly harmless; thus, *red* may be due to fruit-juice, cochineal, or carmine; *yellow* to saffron, safflower, marigold, or turmeric; *blue* to indigo, litmus, or saffron blue; *green* to a mixture of blue and yellow colours; *black* to Spanish juice or Chinese ink.[1] But many of the colours used by confectioners are not innocent, especially those made of copper, arsenic, Prussian blue, zinc, or barium. The aniline colours, especially those of the "azo" class, are injurious in many ways; it has been found by experiments on animals that picric acid, dinitro-cresol, and Martius' yellow, are poisonous; that magenta, the sulphonated nitro-colours, and most other dyes of the "azo" class, although not directly poisonous, will cause vomiting, diarrhœa, and albuminuria.[2] It is, moreover,

[1] Blyth's "Foods," etc.

[2] Professor Smith, *Journal of State Medicine*, January, 1902.

not safe to assume, because coal-tar products are not poisonous to the lower animals, that they are therefore entirely harmless to human beings. Weber found, for instance, that oroline yellow (acid yellow), diluted to 1 in 16, retards the action of pepsin in artificial digestion, and methyl orange, saffoline (acid red), and magenta, seriously interfere with pancreatic digestion. Most of these colours are used in the manufacture of sweets, and it is therefore important that these effects should become well known.

The Flavour of Sweets is due to—(1) *Essential Oils*, derived from various seeds, fruits, nuts, barks, or roots—*e.g.*, almond, anise, caraway, cassia, cinnamon, cloves, citron, ginger, lavender, lemon, musk, orange, orris, peppermint, vanilla ; (2) *Organic Acids—e.g.*, citric, tartaric ; (3) *Alcohols—e.g.*, various spirituous and vinous flavours ; (4) *Artificial Essences—e.g.*, various fruit flavours or essences, which are combinations of various ethers.

The aroma and flavour of all kinds of fruit and flowers are due to ethers and aldehydes of a delicate flavour and volatile character. It would, however, be impossible to extract these essences from fruit in sufficient quantity to supply the commercial demand for them. They can be imitated by the chemist, and the productions bear a great resemblance to the flavour and aroma of the fruit, but they lack the delicacy of the natural substance. Many of these artificial essences are made from quite a number of ethers and aldehydes, and a table is given on p. 933 showing the composition of a number of them. They are, however, not formed in the same manner by all chemists ; for instance, **apple essence** consists of amyl valerianate dissolved in alcohol, and can be made thus : Amyl alcohol and sulphuric acid are mixed together ; as the mixture cools some valerianic acid is added, and it is then distilled. **Pear essence** consists of an alcoholic solution of amyl acetate, and is prepared in the following way : Amyl alcohol and potassium acetate are mingled together, some sulphuric acid is then added, and the mixture is distilled. **Pineapple essence** consists of butyric ether in alcohol, and is prepared by mixing together equal parts of alcohol and butyric acid, treating the mixture with sulphuric acid, and distilling to obtain the ether. Some of the other flavourings used in confectionery are as follows :

Oil of Peppermint.—It is obtained from *Mentha piperita*, N.O. Labiatæ, which grows wild throughout Europe, and is cultivated in Germany, France, England, and America. There are two varieties, black and white, the former containing more oil than the latter, but it is less fragrant and delicate. The oil is a pale yellow, greenish-yellow, or colourless liquid, becoming darker and thicker on keeping. It has an odour which is characteristic of the plant, a taste which is aromatic, but followed by a sensation of coldness in the mouth. It is a mild antiseptic, a stimulating aromatic substance, and carminative to the digestive tract. The chief constituent is menthol, of which the English oil contains 60 to 72 per cent., the American oil somewhat less, the Chinese and Japanese

oils somewhat more. It contains, in addition to menthol, menthyl acetate, menthyl isovalerianate, cineol, pinene, *l*-limonene, cadinene, phellandrene, acetic acid and aldehyde, isovaleric acid and aldehyde, amylic alcohol, etc. The English oil is obtained from the herb cultivated in Surrey (Mitcham) and Cambridgeshire. The oil is obtained by distillation. Foreign oils are not uncommonly adulterated by menthene—that is, peppermint-oil from which the menthol has been removed.

Oil of Lemon.—This is obtained from the fresh peel of lemons by hydraulic pressure. In this way the oil-glands are ruptured, the expressed liquid escapes, and when mixed with water it rises to the surface and is collected. It is a pale yellow liquid, having the odour of fresh lemons, with an aromatic and slightly bitter after-taste. It consists of 90 per cent. of the terpenes—*d*- and *l*-limonene, 5 to 7 per cent. of citral, traces of phellandrene, 1 per cent. of citronellal and geranyl acetate, and a stearoptene consisting of a mixture of bodies having the formula $C_{14}H_{16}O_6$ and $C_{10}H_{14}O_4$. The really valuable portion is the 10 per cent. of oxygenated bodies, of which citral is the chief, and has a flavouring power about fifteen times greater than that of the oil. The chief adulterants are citral obtained from lemon-grass oil, citral manufactured artificially by oxidizing geraniol with chromic acid, low-grade orange-oils, and turpentine. Essence of lemon consists of 5 per cent. of oil dissolved in proof spirit. It has the stimulant and carminative properties common to other volatile oils, but these are usually disregarded in cookery, and it is used merely as a flavouring agent.

Oil of Lemon-Grass is a reddish-yellow oil having the flavour and aroma of fresh lemons, and is remarkable for containing 75 to 85 per cent. of citral, an inactive aldehyde, besides citronellal, linalool, a trace of cymene, methyl heptenone, and the terpenes—limonene and dipentene—to the extent of 10 per cent. It is obtained from *Andropogon citratus*, grown in India.

Oil of Citronella is allied to the former, being derived from *Andropogon nardus*. It is a yellowish-brown oil, having a flavour resembling that of lemons, but the odour is not much like it ; it consists largely of *citronellal*.

Oil of Oranges is a yellowish liquid obtained in the same way as oil of lemon, from the fresh peel of oranges. It has an odour which is characteristic of the fruit, milder than that of lemon, and it is sometimes mingled with terpenes, and used as an adulterant of oil of lemons. It consists of 90 per cent. of *d*-limonene, the remainder being citral, citronellal, the methyl ester of anthranilic acid, and a stearoptene of which nothing is yet known.

Oil of Bitter Almonds is a colourless liquid having a characteristic odour ; it is sparingly soluble in water, freely soluble in oils, also in ether and alcohol. It is obtained from bitter almonds by distillation after the fixed oil has been expressed, *and should be freed from hydrocyanic acid*. A similar oil is obtained from peach, apricot, and plum kernels, and also from laurel-leaves. The nuts do not

contain the oil preformed, but yield 1 or 2 per cent. when they are crushed and macerated in water, the following reaction taking place through the action of the enzyme *emulsin* upon the glucoside *amygdalin*.

$$\underset{\text{Amygdalin.}}{C_{20}H_{27}NO_{11}} + 2H_2O = \underset{\text{Benzaldehyde.}}{C_7H_6O} + HCN + 2C_6H_{12}O_6.$$

Hydrocyanic acid (HCN) may be present in the natural oil to the extent of 4 or 5 per cent., a dangerous amount ; but it is freed from this by shaking the distilled oil with milk of lime and ferrous sulphate, whereby hydrocyanic acid is precipitated as calcium ferrocyanide. The liquid is then redistilled, and in its most concentrated form constitutes essential oil of almonds. The chief constituent of this is **benzaldehyde,** which is the real almond flavouring ; it is a colourless or yellow mobile liquid, of an acrid bitter taste and strong odour of almonds ; it is soluble in ether and alcohol, but only slightly soluble in water. On exposure to the air it becomes oxidized to benzoic acid. Benzaldehyde is also prepared artificially, by heating benzyl chloride with solution of nitrate of lead, such synthetic product being cheaper than the genuine oil of almonds, and having the advantage of being free from prussic acid. Artificial essence of almonds made from synthetic benzaldehyde is in great demand as a flavouring agent. It should be noted that ratafia and kirsch essences owe their flavour chiefly to benzaldehyde.

Oil of Mirbane is nitrobenzene or nitrobenzol, $C_6H_5NO_2$, obtained by the action of nitric and sulphuric acids upon benzene, the product being washed in weak alkaline solution and distilled in a current of steam. This substance is a pale-yellow-coloured, oily liquid, having a sweet taste and a strong sickly odour of bitter almonds. It is used as a substitute for oil of bitter almonds, as a flavouring agent, and in perfumery. This should be strongly deprecated owing to its extremely poisonous nature ; its use internally is followed by great muscular weakness, cyanosis, and rapid paralysis of the respiratory centre. These effects are due in part to the formation of methæmoglobin, and partly to the inhibition of the central nervous system.

Coumarin is an odoriferous substance obtained from **Tonka beans,** the seeds of *Dipteryx odorata*, a tree native in Guinea. The fruit consists of an almond-shaped pod containing a single seed, which is shaped like a kidney bean, has a dark brown colour, and a brittle skin. The tincture of tonka beans and coumarin are used as flavouring agents. Coumarin is obtained from the coarsely powdered seeds by extraction with alcohol, mixing the solution with four times its bulk of water, filtration, crystallization, washing, redissolving, and recrystallizing the substance. Coumarin, $C_9H_6O_2$, is the anhydride of coumaric acid ; it forms colourless prismatic crystals having a characteristic fragrant odour and an aromatic bitter taste ; it is slightly soluble in water, very soluble in ether and alcohol. It is prepared synthetically by heating together salicylic

aldehyde, acetic aldehyde, and sodium acetate ; the product of the action is aceto-coumaric acid, which decomposes into acetic acid and coumarin.

Vanilla Essence is largely used in confectionery, especially in the manufacture of chocolates. It is derived from vanilloes, the fruit of *Vanilla planifolia* and *aromatica*, N.O. Orchidiaceæ, climbing plants indigenous to Mexico, but cultivated in South America and the West Indies. The fruit consists of a pod of 15 to 20 centimetres long, and 6 to 10 millimetres thick, containing minute black seeds embedded in a thick yellow granular balsam, to which the fragrant odour is due. It is collected in the autumn just before it is ripe; it is then of a yellowish-green colour, and *without odour*. It is submitted to a process of curing, the method of which varies in different districts, during which the characteristic aroma is developed. The process of curing usually includes fermentation, or "sweating," by being alternately exposed to the sun and wrapped in blankets. During this process the fruit changes to a rich dark brown, nearly black, colour, and becomes wax-like to the touch ; they are then packed in tins, and become gradually "frosted," and have the odour of vanilla. The crystals upon the surface and in the seedy, gummy substance of the interior consist of vanillin, which forms small needle-shaped prisms, almost insoluble in water, but soluble in alcohol, ether, and chloroform. Vanillin, $C_8H_8O_3$, is the substance which gives the characteristic odour and flavour; it is vanillic aldehyde, or the aldehyde of methyl-proto-catechuic acid. The proportion varies in the fruit from different countries. Tiemann and Haarmann found that Mexican pods contain 1·69 per cent., Bourbon pods 2·48 per cent., and Java pods 2·75 per cent. It is considered, however, that the fine aroma and fragrance is not due to vanillin alone ; the interior of the fruit contains vanillic acid, resin 4 per cent., fat 11 per cent., sugar 10 per cent., gum, etc., the whole forming a balsam which is insoluble in water, but readily extracted by alcohol. The gums, resins, and oil, probably contribute to the flavour and aroma, for it has been observed that the finest fruit contains the least vanillin. The unripe beans are said to contain coniferin and two enzymes—one enzyme converts coniferin into coniferyl alcohol; the other, coniferyl alcohol into vanillin (vanillic aldehyde). *Artificial vanillin* is prepared synthetically from eugenol by oxidation with ozone, and also from coniferin ; it is isomeric, and chemically identical with native vanillin, but an essence made from it does not possess the full bouquet of essences derived from the pods. *Vanilla essence* is made by digesting 10 parts of the balsamic substance from the interior of the pods in 100 parts of alcohol (proof strength), with a little sugar and glycerine ; it rarely contains more than 0·2 per cent. of vanillin. Adulteration is by no means uncommon, especially with coumarin or tincture of tonka beans ; the odour of coumarin is, however, more powerful than that of vanillin, and predominates over the latter, thereby revealing its presence.

The Manufacture of Candy, Sweets, etc.

Sweets may be classified as—

1. *Boiled Sweets*, including barley-sugar, various kinds of " rock," bull's-eyes, peppermint-balls ; toffee and butter-scotch, caramel, " liqueurs," nougat, jujubes, etc.
2. *Candies :* sugar-candy, marzipan, fondants, dragées, vanilla-almonds, comfits, aniseed-balls, etc.
3. *Lozenges.*
4. *Chocolates :* chocolate creams, cakes, sticks, etc.
5. *Ice-creams.*

1. **Boiled Sweets.**—A very extensive trade is done in sweets of this class. The basis consists of sugar which has been boiled until, after becoming cold and hard, it assumes a brittleness and fracture like glass. By careful treatment it can be made to assume many colours, as previously indicated, and it can be flavoured *ad libitum*, and made to assume all kinds of fanciful shapes. As a rule *small* sweets are formed by being passed through a machine while in a plastic condition. It may also be made to change its appearance from the normal glassy and transparent to an opaque and porous substance by being " pulled "—that is, by vigorous manipulation. It can also be mingled with various kinds of nuts. **Barley-sugar** is one of the best sweets of this type ; it is merely boiled sugar, flavoured with a little lemon and formed into sticks. **Toffee** and **butter-scotch** are similar, but butter, and sometimes honey, enters into the composition. Butter-scotch is usually made of equal parts of ordinary sugar and butter melted together ; by means of the heat some of the sugar is inverted. Everton toffee is similar, and has been found to contain 35 per cent. of cane-sugar, 28 per cent. of invert sugar, and the balance chiefly of butter-fat. **Nougat** also consists of sugar, glucose, butter and cream, boiled together, until some of the mixture poured upon a marble slab sets hard on cooling ; it is then mingled with nuts (hazel, filbert, pistachio, walnuts, etc.) and vanilla or other flavouring essence, poured out, and allowed to cool.

2. **Candies.**—The type of these is **sugar-candy,** which simply consists of sugar crystallized by a special method. Ordinary cane-sugar syrup is concentrated until it attains a high specific gravity (about 1·45), when it is poured into copper vessels in which a number of fine threads are arranged. On these threads the sugar slowly crystallizes, the process being assisted by placing the vessels in a warm atmosphere. **White candy** is the product when pure loaf-sugar has been used ; it consists of 80 per cent. of cane-sugar and 20 per cent. of water of crystallization. It is used largely in the manufacture of champagne. *Coloured sugar-candy*, made chiefly in Holland, Belgium, and Germany, is made from white or brown sugar, and is coloured light brown, brown, straw colour, yellow, pink, or red ; vegetable, animal, or aniline dyes are used.

Fondants.—Fondants, sugar-drops, and small sweets of various kinds, are made by evaporating cane-sugar syrup down to crystal-

lizing-point, or until it will harden, *without actually boiling it*, flavouring, colouring, and pouring it out in separate "drops" or into moulds. The flavouring consists of citric or tartaric acid, essence of lemon, cloves, ginger, or artificial essences. The name "fondant" is likewise applied to the icings used to cover many kinds of cakes and pastries. In theory it consists of sugar dissolved in water and recrystallized. It is, however, the desire of the confectioner to make icing with a *sheen* upon it, which is due to the sugar being crystallized in crystals which are so small as to be almost imperceptible to the naked eye ; the formation of large crystals causes the icing to look dull. This desire of the confectioner has led to the use of substances which *delay* crystallization, such as glucose syrup or cream of tartar, in the mixture. The cream of tartar converts some of the sucrose into glucose, and thereby delays crystallization, and insures a glistening surface and a fine grain to the ice. Glucose also gives a gloss to the ice, but it makes it somewhat tougher than that made with cream of tartar, although the latter product is still soft enough to be moulded with the fingers. The following method of preparing *fondant* is given in the "Modern Baker and Confectioner," vol. iii. :

Take of loaf-sugar	.. ..	12 pounds.
water	.. ..	3 pints.
glucose	.. ..	2 pounds.

Put the sugar and water into a copper vessel over a fire ; stir it thoroughly until every particle of sugar is dissolved before it reaches the boiling-point ; strain it through a sieve, then boil it quickly ; when the temperature reaches 235° F., add the glucose ; continue to boil until it reaches 245° F. Pour it upon a marble slab, turning it over and over and working it with a spatula until it sets into a firm white mass. When it is to be used for icing cakes, pastry, or fruit, this material requires to be softened by warming it, or even mixing with it a little syrup or white of egg and icing-sugar.

The Colour of Fondants.—Many sweets are made of fondant of various colours ; many cakes and pastries are iced with it ; it is therefore of great importance that innocuous colours only are used. The "Modern Baker and Confectioner" [1] recommends the following as yielding attractive colours and a variety of flavours for small sweets and icings :

White fondants : flavoured with maraschino, rose-water, or vanilla.

Pink : coloured with carmine, and flavoured with noyau, rose-water, raspberry or strawberry flavouring.

Lemon yellow : coloured with yellow Breton paste, and flavoured with essence of pineapple or lemon zest (the coloured portion of lemon-peel only).

Pale orange : coloured with a mixture of yellow paste and carmine ; flavoured with curaçoa or zest of orange.

[1] Vol. iii., p. 232.

Pale green: coloured with green Breton paste, or apple-green mixed with yellow; flavoured with kirschwasser and orange-flower water, or with noyau and essence of almonds.

Coffee: coloured with caramel, and flavoured with coffee essence, and occasionally a trace of vanilla.

Chocolate colour is made by mixing red and green.

Violet, mauve, and heliotrope colours are made by mixing red and blue in various proportions; the flavours consist of essence of violets, heliotrope, etc.

Comfits, Sugared Almonds, and Other Hard Confectionery.—When a solid substance is kept in motion in a strong syrup it becomes gradually coated with sugar. Acting upon this principle, many hard confections are made by the confectioner. They consist of a *core* varying in size and character—for instance, an almond kernel, cherry kernel, pistachio nut, clove, aniseed, caraway-seed, or a perfumed sweet, covered with successive layers of sugar. Their formation is accomplished in the following manner: The "cores" are placed in a copper vessel, inclined at an angle of 40° from the horizon, which is caused to revolve. The vessel is kept hot by a steam-jacket. Pure cane-sugar syrup, carefully clarified, is poured in small quantities over the cores; the latter are thus coated with the syrup, which dries and forms a thin envelope around them. The cores are prevented from adhering to each other by constant motion. When they are dry, which is hastened by the heat, a fresh supply of syrup is put into the vessel, and they are again put into motion and dried; and so on, until the nuts or seeds are sufficiently covered, or the sweets (*e.g.*, aniseed-balls) have attained a sufficient size. They are then set aside to harden, and finally receive another coating of syrup, and are kept in rapid motion until they attain sufficient smoothness and polish. They are then dried and hardened in a drying-room.

3. **Lozenges.**—Many sweets are "lozenges"; that is to say, they consist of finely powdered sugar mixed into a paste, with some adhesive substance such as gum arabic or dextrin, coloured and flavoured with various essences. The paste is rendered homogeneous by being passed between rollers over and over again; and when of sufficient texture it is rolled out to the proper thickness, and put under a punching machine, which cuts the lozenges into the requisite shape and size. They are spread upon trays and dried in a warm room. Medicated lozenges are prepared in the same way.

4. **Chocolate Cakes, Sticks, Dragées, etc.**—*Edible chocolate* contains a larger proportion of sugar than that intended for beverage. The composition of several good samples was found to be—Cocoa 60 to 70, sugar 25 to 30, sweet almonds 5 to 10, vanilla 1·0 to 1·5, cloves 0·2, cinnamon 0·5, per cent. But the proportions of cocoa and sugar vary within very large limits, specimens being found which contain 70 per cent. of sugar and very little cocoa. The flavourings also vary, but the principal kinds used are vanilla,

cinnamon, cloves, musk, coumarin, almonds, and their artificial substitutes. The cocoa nibs or flake cocoa is ground in a heated mill, much of the fat removed by hydraulic pressure, and the residue mingled while soft with the sugar and flavourings, and pressed into cakes, etc., of various shapes and sizes.

The finest chocolate is made from Caracas cocoa, and the flavouring consists only of Mexican vanilla with cloves and cinnamon. The *French chocolate* of a celebrated firm of makers consists of 3 parts of cocoa nibs or flake cocoa, and 1 part of sugar into which the vanilla beans have been rubbed. The *Spanish chocolate* of another firm consists of 1,400 parts of Caracas cocoa, 447 of sugar, 150 of sweet almonds, 2 of vanilla, and 1 of cloves, in 2,000 parts. In fact, the variation in the proportion of sugar and kind of flavouring constitute the sole differences in the best brands of chocolate. In addition to the kinds here mentioned are others which contain a proportion of condensed milk, or a paste or " cream " made from nuts, and even whole nut kernels, and other substances ; thus we have " milk chocolate," " nut-milk chocolate," " chocolate nougat," etc.

Chocolate creams consist of a " core " of white sweet *cream* within a " shell " of chocolate. The **shell** consists of 45 per cent. of powdered sugar and 55 per cent. of cocoa-powder, made into a stiff paste which will harden on drying. It contains no glucose or invert sugar, but may contain a little gum arabic or other gummy substance. The **cream** is made differently by various makers, but the following is an example : 15 parts of glucose syrup, 25 parts of water, and 40 parts of powdered sugar, are mixed together in a pan, and gradually heated until the temperature rises to 244° F. It is then emptied on to a slab, and thoroughly mixed and manipulated by means of a spatula until it is cold. In some manufactories this manipulation is performed by machinery, as in making other creams. It becomes stiff without crystallizing, because of the presence of glucose. The latter object is also brought about by the use of cream of tartar (acid potassium tartrate), which causes the inversion of some of the cane-sugar, as in jam-making. In some cases the cream is enriched by the addition of condensed milk, egg-albumin, etc. ; in the cheaper kinds the cream may be a mixture of sugar, glucose, and cocoa butter. The cream, however prepared, is now formed into " cores " ; for this purpose " moulds "are formed by filling a tray with starch-powder and pressing into it a moulder which bears a number of shaped projections, representing the chocolate creams ; when these are pressed into the starch-powder and withdrawn, impressions are left. Into these impressions the melted cream is poured, and, after a time is allowed them to " set," they are removed, and any adherent starch wiped off with a brush. The " cores " are then dipped into a chocolate paste to form the " shell," set aside to become dry and hard, and finally varnished or glazed by dipping them in a solution of shellac dissolved in spirits of wine. Many inferior chocolates, chocolate creams and

sticks, are different from these ; the core consists simply of sugar and cocoa butter, or sometimes starch ; while the shell may be made of powdered cocoa husks, sugar, gum, and dextrin, coloured, and flavoured by cocoa fat and artificial vanilla.

Chocolate caramels are made by boiling together some sugar and glucose or cream of tartar, with some condensed milk or butter, until a little of the mass hardens on becoming cold. The mixture is then flavoured by stirring into it, while hot, a paste consisting of chocolate or cocoa flavoured with vanilla. It is then poured into moulds or on to a slab, and is cut up when cold.

Chocolate Fondants.—The ordinary fondant moulds are partly filled with chocolate cream, and then entirely filled up with chocolate paste. When the sweets have become firm they are " crystallized " by being placed for some time in a syrup, which on drying forms small crystals on the surface.

Marzipan is a confection consisting largely of almonds. It is said to have had its origin at the siege of Lübeck in the Thirty Years' War, when, all supplies of food except sugar and almonds being exhausted, these substances were made into bread. It usually consists[1] of 50 per cent. of almonds, 33·3 per cent. of sugar, and 16·7 per cent. of water. The almonds are blanched, reduced to a pulp, and mixed with the powdered sugar ; the mixture is put into a pan over a slow fire and constantly stirred until the sugar is melted and the paste gains a proper consistency. When well made, it is a smooth paste, plastic as clay. It has a wide sphere of usefulness in confectionery, being used to make sweets, biscuits, wafers, cakes, sandwiches, artificial fruits, flowers, etc. Its flavour and colour are modified by the use of essences and colouring agents, and it is worked into various designs. As a substitute for bread or other foods it is satisfactory, but expensive ; it contains a fair amount of nitrogenous material, about 10 per cent., 28 per cent. of fat derived from the almonds, 40 per cent. of carbohydrate, including the sugar and the starch from the almonds, about 3 per cent. of ash, and 19 per cent. of water. It need not be made of almonds alone, as other nuts have an equal food value ; nor need the nuts be made into a sweetmeat, as there are other ways of making them into food, such as " galette," chestnut cakes, and so forth.

Almond Paste is of similar composition to marzipan. It is made of icing-sugar, eggs, and sweet almonds. The almonds are blanched and ground to a pulp, and the sugar is raw or boiled, according to the use which the confectioner wishes to make of the paste.

Macaroons also consist of a paste made of ground sweet almonds, sugar, the white of eggs, and ground rice, combined into a medium stiff paste, and *baked in an oven.* Macaroons are flavoured and sometimes coloured by the same substances as are used for fondants.

Ratafias are small biscuits likewise consisting of almonds, etc. According to the " Modern Baker," they are made of 8 parts of sweet

[1] *Chem. Zeit.*, 1903 (*cf.* " Food and Hygiene," by W. Tibbles, p. 226).

almonds, 1 part of bitter almonds, 9 parts of coarse sugar, and 7 parts of white of egg, mixed together and baked in an oven at a low temperature.

Meringue consists of castor-sugar and white of eggs beaten to a stiff paste. In Italian meringue part of the sugar is boiled. The substance may be white, coffee-coloured (infusion or extract of coffee), pink (due to carmine), etc. It is chiefly used for pastry.

Gâteau, or Genoese paste, consists of eggs, butter, sugar, and flour or cornflour. It is baked in sheets an inch thick, and cut into pieces.

Royal Icing.—This is usually made of finely powdered sugar, white of eggs, acetic acid, and ultramarine blue. It dries white and hard. The latter fault is overcome by mixing some glycerine with the white of eggs. Acetic acid is added to toughen the albumin, and incidentally to help in hardening the icing and dissolving the blue. The ultramarine blue is used to give an impression of whiteness ; without it the icing dries yellow. As it sets well, it is capable of being moulded into any design. This material is used for covering cakes, etc. ; it is preferred by many confectioners to fondant.

Creams.—These sweets usually consist chiefly of sugar, glucose, a little gelatin, water, with various colouring and flavouring agents. They are prepared in almost the same way as fondant. But the material may be " worked " by machinery until a stiff cream is formed which will set into firm sweets. *Butter creams* are made by beating up fresh butter until it is light and soft, and thoroughly mixing it with cornflour and powdered sugar, flavouring, and working it in the same way as the former.

5. **Ice Creams.**—These articles really consist of frozen custard. The best of them consists of materials used in about the following proportions : 1 pound of powdered sugar, 1 pound of eggs, 2 ounces of butter, and 2 quarts of milk. The eggs are beaten with a whisk, added to the milk, sugar, and butter, and put into a pan over a fire, where the mixture is gently heated and constantly stirred until it thickens. It is strained through muslin, cooled, flavoured with vanilla, lemon, raspberry or strawberry essence, and coloured with saffron or cochineal. The compound is then frozen in a vessel surrounded by a mixture of salt and ice. The inner pan containing the ice cream is rotated quickly, so that the material comes into contact with the cold sides ; the congelated material is removed at intervals from the sides, and mingled with that in the centre until the whole sets. Various ice creams are made, such as *coffee ice cream,* in which the custard is flavoured and coloured with infusion of coffee ; *chocolate ice cream,* chocolate being made into a paste and mixed in the custard ; *cocoanut ice cream,* made by adding grated cocoanut to the materials before making the custard, and afterwards removing it by straining through muslin before freezing. *Pineapple, raspberry, and strawberry ices* are also made by rubbing the fruit through a sieve, and combining the pulp with twice the quantity of custard, before it is frozen. **Water ices** consist of water, flavoured with fruit juice, acids, and essences, com-

bined with white of egg and sugar, and colouring matter; *e.g.*, lemon ice is made by flavouring water with essence of lemon, adding citric or tartaric acid, sugar, and white of egg, and freezing in the usual way.

Cheap Ice Creams contain no eggs; they consist of milk thickened with cornflour, coloured, flavoured with essences, and frozen in the usual way. Sometimes **poisoning** occurs from the consumption of ice cream which has not been carefully and cleanly prepared or kept in a sweet and wholesome room. The symptoms are, vomiting of a soapy, frothy fluid, severe purging of watery, frothy stools, griping pains in the abdomen and stomach, occipital headache, backache, and aching of the bones all over the body. The vomiting lasts two or three hours, and gives place to yawning. The throat becomes dry and swollen, the tongue dry and chapped. Some patients become stupefied; others are dizzy and have a momentary loss of consciousness. There is usually no rise of temperature, but the pulse may range from 90 to 120 per minute. In 1886 Vaughan made an investigation of some cases which it was thought arose from the vanilla flavouring. The vanilla essence was tested on himself and other persons without any ill effect. The ice cream was then tested for tyrotoxicon (the ptomaine of putrefied casein); and an aqueous solution was given to a cat, who speedily became ill—vomiting, retching, purging, etc., followed by prostration lasting three days. The internal organs of the animal were then examined; the mucous membrane of the stomach was very white and soft, but there was not the slightest sign of hyperæmia anywhere. Both the stomach and bowels contained frothy fluid, similar to that vomited. Vaughan says the production of the ptomaine (*tyrotoxicon*) is due to a micro-organism, which requires further study. He found also that there is always butyric acid in milk, cream, or cheese, containing the ptomaine, and suggests that there is some relation between butyric fermentation and the production of the poison. Selmi obtained a ptomaine, which resembles coniin, and pointed out that it could arise from the interaction of butyric acid or butyric anhydride and ammonia, thus:

$$2C_4H_8O_2 + NH_3 + 2H_2 = C_8H_{15}N + 4H_2O;$$

or

$$2C_4H_8O + NH_3 = C_8H_{15}N + 2H_2O.$$

Other acids of the aliphatic series may also react with the products of decomposing nitrogenous substances to produce alkaloidal bodies of a toxic nature. This may especially occur in ice creams containing eggs, where the albumin becomes decomposed by means of micro-organisms, and alkaloids are formed. The bacteria are usually derived from the surrounding air.

Adulterations of Confectionery.—The colouring and flavouring agents of confectionery cannot be regarded as adulterations if they are themselves pure and free from toxic properties; they are part

of the confection. But colouring with aniline dyes and other artificial colours and various mineral substances cannot be regarded as other than an adulteration of a serious nature. Aniline colours do not undergo any change in metabolism ; they are excreted by the kidneys in the urine. Their toxic effect is in proportion to the quantity consumed. Salts of copper, lead, and chromium (*chrome*), employed for colouring purposes, are also toxic in proportion to the amount used. The glucose used may be impure from the presence of sulphuric acid, etc. Artificial flavourings are used to a great extent, especially compounds of benzaldehyde (peach kernel flavouring, almond essence). Sweets containing almond or peach nuts should yield not more than a trace of hydrocyanic acid, and the use of artificial almond essence ought to be abandoned. The enclosure of a drop of wine or other alcoholic liquid in the interior of sweets is a reprehensible practice. Sometimes sweets are adulterated with chalk, powdered marble, talc, silicates, and other mineral substances, to increase their weight. Whether harmless or not, the mixture of these materials in sweets is a fraud which ought to be forbidden.

CHAPTER XXVIII

VINEGAR: ACETUM

Vinegar is an ancient condiment, and is used universally. The date of its origin is unknown. Boaz, a rich citizen of Bethlehem, is represented in the Bible as providing vinegar for his reapers to drink (1312 B.C.)—a custom which still prevails in Spain and Italy. The Roman soldiers were accustomed to take it in their marches. Probably several kinds of vinegar were known to the ancients. The Hebrews seem to have had two kinds, one of which was used as a beverage, and was probably a weak red wine ; the other as an acid diluted with wine or water. Vinegar was also made from honey and the juice of the palm.

Vinegar is an acid liquid prepared from various substances by the acetous fermentation of alcoholic liquors, the alcohol being oxidized under the influence of a ferment, and the chief product being acetic acid. Alcohol may be converted into acetic acid by powerful oxidizing agents, such as chromic acid, nitric acid, spongy platinum, etc. If a tray of spongy platinum be placed over a vessel of alcohol, with free access of air, the platinum absorbs at the same time oxygen from the air and the alcohol vapour, which, being brought into immediate contact, combine and produce acetic acid and water. It is called a *catalytic* action. Some acetic aldehyde is also produced, partly as an intermediate in the action, but in the presence of oxygen it also is transformed into acetic acid. The following equations show these reactions ; but this method of producing acetic acid on a large scale is far too expensive :

1. $\underset{\text{Alcohol.}}{CH_3{\cdot}CH_2{\cdot}OH} + O_2 = \underset{\text{Acetic Acid.}}{CH_3{\cdot}COOH} + H_2O$;

or

2. $\underset{\text{Alcohol.}}{CH_3{\cdot}CH_2{\cdot}OH} + O = \underset{\text{Aldehyde.}}{CH_3{\cdot}COH} + H_2O$;

and

3. $\underset{\text{Aldehyde.}}{CH_3{\cdot}COH} + O = \underset{\text{Acetic Acid.}}{CH_3{\cdot}COOH}$.

The Vinegar-Plant.—The transformation of alcohol into acetic acid by oxidation is assisted in other ways. The vinegar-plant, or "mother of vinegar," has the same power as platinum of absorbing oxygen and of oxidizing alcohol in its pores. The vinegar-plant is a tough gelatinous substance, in appearance somewhat like an

animal membrane, and requires for its growth albuminous substances and mineral salts, such as are always present in wine, beer, etc. If these substances are absent, the vinegar-plant has no influence on alcohol, unless some alkaline phosphates and ammonium phosphate are added to supply the food elements. The vinegar-plant is a large congeries of cells, and is called the *Mycoderma aceti* or *M. vini;* but although it always assumes the membranous form, no matter how the conditions are varied, yet in reality it consists of numerous bacteria called *Bacterium zylinum.* These bacteria consist of minute elongated cells, whose greatest diameter varies from 0·001 to 0·005 millimetre, or 1 to 5 microns. They are united in chains or in the form of curved rods, and they multiply by the transverse division of fully-developed cells. The conditions necessary for the development closely resemble those required for the development of beer yeast. Mineral salts, alkaline and earthy phosphates, and either ammoniacal salts or albuminoid substances, are essential. The maximum activity of the plant is between 20° and 30° C. (68° and 86° F.); it ceases to act below 10° C. (50° F.). There are other acetic-acid-producing bacteria—the *Bacterium aceti*—but the latter never assume the membranous form. Another characteristic of the vinegar-plant is that it gives all the reactions for cellulose, which *B. aceti* never does. This formation of cellulose by a single cell—for the cells of the mycoderma have a separate and single existence—is very interesting, and experiments were made by Adrian Brown[1] to discover from what bodies the cellulose was made. He found that ethylic alcohol, cane-sugar, and starch, are not used for this purpose; but dextrose is so converted, the cells producing from it gluconic acid, out of which they build up the cellulose; mannitol and lævulose are also converted to cellulose.

But while both these bacteria are specifically distinct, their action is similar. Both have the same action on alcohol—viz., the alcohol is oxidized to acetic acid, and the latter is finally decomposed into methane (CH_4) and carbon dioxide.

Vinegar Manufacture.—In all the varieties of vinegar and modes of manufacture, advantage is taken of the oxidizing power of the vinegar-plant—*i.e.*, of *B. zylinum*, described above, and *B. aceti.* Wines and other alcoholic liquids become sour through the agency of these ferments. The spores are always in the air, and, being deposited in a suitable medium, develop and flourish therein. The action of the fungus is more rapid when the liquid is rich in vegetable matters, especially albuminous matters and salts, poor in alcohol, and when the surface exposed to the air is large. There is an *optimum* of alcohol for vinegar-making, which appears to be about 3 or 4 per cent.; an excess of alcohol defeats the purpose of acetification by inhibiting the action of the ferment; so likewise when the liquid contains less than 3 per cent. the process of acetification is too slow to be profitable for commercial purposes.

[1] Proceedings of the Chemical Society, May 6, 1886.

1. **Home-made Vinegar** is usually made by putting a piece of the vinegar-plant into a solution of cane-sugar. The pure ferment (*B. zylinum*), as we have seen, has no action on cane-sugar ; but the ordinary plant is impure, and contains among other things yeast cells (*Saccharomyces cerevisiæ*). The yeast cells invert the cane-sugar and ferment it, the resulting alcohol being afterwards transformed into acetic acid by *B. zylinum*. The following is said to yield a strong and pleasant household vinegar : 3 parts of brown sugar, 12 parts of brandy, 1 part of cream of tartar, 120 parts of water, and ½ part of sour dough ; it is left in a rather warm place for some weeks.

2. **Malt Vinegar** is prepared from an infusion of malt or of malted and unmalted grain, which is fermented to produce alcohol. *Pure malt vinegar* is made from a liquor such as the following : Take of crushed malt 6 bushels, extract it with water three times—first with water at 72° C., next with water at about 80° C., and finally with boiling water. The entire product, called "the wash," measuring 100 gallons, is cooled to 24° C., and fermented by the addition of 2 or 3 gallons of brewer's barm. It is fermented for forty hours, and then filtered ; the after-treatment depends upon whether the vinegar is made by the ordinary or quick-vinegar process.

(1) **The Ordinary Vinegar Process**—(*a*) *Pickling Vinegar.*—The fermented liquor is stored for a few months to allow the deposition of extractive matters, which are apt to lead to putrefaction. The process is completed by putting the liquor into large casks, which are placed side by side in a room at a temperature of 24° C. while the "acetification" goes on. Each cask has a bung hole for adding or removing liquor, and a small hole at each end for ventilation. The germs of the organism, being in the air, readily gain access to the liquor. Sometimes the "acetification" is conducted in the open air in a "vinegar-field," from ten to twenty casks being collected in one spot. In this case the manufacture is begun in the spring of the year, and the acetification goes on out of doors in the three warm months of summer. Finally, the vinegar is filtered, to remove extractive matters and other impurities, by passing it through shavings or "rapes." The latter sometimes consist of the pressed cake of the skins and stalks of raisins which have been used for making British wine or brandy. The filter consists of a wooden tub or tun, wider below than above, having a false bottom upon which the rapes or shavings rest. Through this substance the vinegar is filtered time after time, until every trace of alcohol is oxidized and the liquid is clear and bright.

(*b*) *Household Vinegar.*—The malt liquor is put into an upright cask having a false bottom covered with rapes or shavings. The next day it is drawn off by a tap, and transferred to another cask containing rapes or shavings. It is allowed to remain here for three or four days, after which it is transferred to a third or even a fourth flask. A little **argol** is now added to give it a wine flavour, and it is clarified by isinglass.

(2) **The Quick-Vinegar Process.**—When this method is used, not only malt liquor, but beer, treacle, beetroot molasses, "glucose," rice, maize, and spirits such as brandy, whisky, grain spirit, potato spirit, etc., are used. The process known as Schützenbach's is very much more rapid than the former, being considerably hastened by exposing the liquid containing alcohol to a larger surface of atmospheric air, 1 gallon of liquor being sometimes spread over a surface of 100 square yards. The vat generally used is about 6 feet high and 3 or 4 feet wide, but may be much larger. About 15 inches from the bottom, holes are perforated all round the vat to allow the entrance of air. Just above this level a perforated false bottom is placed, upon which there is a quantity of beech-wood shavings or charcoal in pieces of the size of a walnut. Near the top of the vat is arranged another disc perforated by small holes about an inch apart; through each hole a piece of yarn or cotton passes down to the charcoal or shavings. A tight lid now closes the vat, there being only a hole for the entrance of liquid and escape of air. The liquor is poured through this opening on to the upper disc, and trickles slowly down the threads to the shavings. The latter are soaked in vinegar for twenty-four hours before being used, in order to get some of the vinegar-fungus upon them, and they speedily become covered with a thin pellicle of the mycoderma. When the acetification is going on satisfactorily, the temperature in the interior of the vat rises on account of the oxidation to 37° C., which causes a constant upward current of air through the openings in the vat below the false bottom. The process is rapid, but as the heat increases so the evaporation of alcohol increases, and, unless due care is exercised, much alcohol, and therefore acetic acid, may be lost. There must, however, be free admission of air in order to convert the alcohol *directly* to acetic acid; otherwise there will be a further loss by the formation of the volatile acetic aldehyde. At the best, about 6 per cent. of the maximum of acetic acid is lost in this process.[1] Various liquors or forms of "wash" are used in the quick-vinegar process—*e.g.*:

(*a*) Beer or malt-wort, 18 gallons; whisky, brandy, or other spirit, 22 gallons; honey or molasses, 4 pounds; soft water, to make 100 gallons.

(*b*) Wheat meal, 40 pounds; barley meal, 80 pounds, infused in 40 gallons of water at 50° C.; after settling and decanting the liquor, another 40 gallons of water at 70° C. is added to the meal, infused and decanted as before; finally 20 gallons of boiling water are poured upon the residue. The total wash therefore measures 100 gallons; it is fermented with 15 pounds of yeast for five or six days, when it is ready for acetification.

3. **Wine Vinegar** (*French*, Vinaigre; *German*, Weinessig); **French Vinegar.**—The mode of formation is practically the same as that already described. When wine becomes sour, it is because the alcohol is transformed to acetic acid. Any wine may therefore be used for this purpose. The manufacture of wine vinegar is an

[1] Thorpe's "Dictionary," *loc. cit.*

industry of importance in France, Germany, and Holland. In the Orleans district all sorts of wine are used for the purpose, but especially any that have become sour. Wine of a year old and full-bodied is preferred. If it contains above 10 per cent. of alcohol, it is diluted or mixed with weaker wines until the mixture attains that standard. Before being acetified the wine is left for some time in contact with beechwood shavings, on which wine lees have been deposited, to clarify it. The *vinaigerie* usually consists of a low-roofed building with plenty of openings for ventilation, which, however, could be closed if the temperature sunk too low. The temperature best suited to the activity of the bacterium is 25° C., and this is maintained, when necessary, by means of a stove.

The Orleans Method.—The wine is put into a large cask capable of holding 50 to 100 gallons. The cask is made of well-seasoned oak, has a large bunghole for addition of wine, and a smaller one for admission of air. Such a cask is at first treated by being scalded with boiling water ; it is afterwards filled one-third full with boiling vinegar and allowed to stand for eight days. After this time 10 pints of wine are added daily until the cask is two-thirds full ; it is then allowed to rest for about fourteen days while acetification is going on. At the end of this time from 10 to 30 gallons of vinegar are drawn off by siphon, and the daily addition of 10 pints of wine begun as *ab initio*. The process of acetification is known to be complete by the appearance of the froth : if a spatula plunged into the liquid and withdrawn has *red* froth adhering to it, more wine is added and the temperature of the atmosphere raised ; if the froth is *white* (*flowers of vinegar*), the process is complete. The time occupied at first is about fourteen days, but when the cask is in good working order the process is generally complete in eight days, and such a cask may last for twenty-five years. The vinegar is clarified by being passed through rapes, consisting of the skins and stalks of grapes from the winepress.

A new commercial method of producing vinegar is employed at Orleans. The following is the process :[1] " The *Mycoderma aceti* is first sown on the surface of an aqueous liquid containing 2 per cent. of alcohol, 1 per cent. of vinegar, and traces of alkaline and earthy phosphates. When the surface is covered with the membrane, the alcohol begins to acidify. This action being fully set up, some alcohol, wine or beer mixed with alcohol, is added to the liquid in small quantities every day. This is continued until the oxidation becomes slower ; the acetification is then allowed to terminate and the vinegar drawn off, the membrane being collected, washed, and used for a new operation."

A more rapid formation of wine vinegar is performed in Holland, the Valley of the Rhine, and some parts of France, by adopting Boerhaw's method. Two vats open to the air are used : each has a perforated false bottom, about 1 foot above the true bottom, on which are placed the rapes. By this means a large surface is exposed for the growth of the vinegar plant or fungus. One vat is

[1] " Fermentation," by Schutzenberger, p. 238.

half filled and the other completely filled with wine ; the acetification goes on more rapidly in the former than the latter. Each day, however, the half-filled vat is filled from the full one, and this daily transference from one cask to the other goes on until acetification is complete. After acetification is complete, the vinegar is run into casks containing birchwood chips or shavings, on which the lees are deposited, and the vinegar is clarified ; it is ready for storage or for the market in fourteen days.

4. **Wood Vinegar.**—Acetic acid occurs normally in certain plants —*e.g.*, *Sambucis niger*, *Phœnix dactylifera*, and *Rhus typhenus ;* but it is usually manufactured by the dry distillation of wood, which yields in this manner 8 or 9 per cent. of acetic acid, besides various hydrocarbons and gases. The liquid products of the distillation form two layers. One layer is the wood-tar, consisting of substances which do not mix with water : naphthalene, benzene, toluene, etc. The other layer is the raw *wood vinegar*, or pyroligneous acid, which consists of acetic acid, but also contains methyl alcohol, acetone, phenol, valerianic, propionic and formic acids. This is readily poured off and distilled ; the vapour is then passed through milk of lime, which retains the acetic acid and forms calcium acetate, the latter being in turn decomposed by hydrochloric acid, and the acetic acid recovered by distillation. This acid is used as a table vinegar in an aqueous solution of 3 to 6 per cent. The pyroligneous acid or raw-wood vinegar is sometimes used as an adulterant of malt and other vinegars.

5. Vinegar is also made from cider or perry in districts where these beverages are manufactured, also from crab-apples, tarragon, and other vegetable substances ; ale vinegar is also made from strong sour ale, and glucose vinegar from glucose, sugar vinegar from sugar, etc. In Germany household vinegar is made from a " wash " consisting of 14 pounds of honey or brown sugar, 50 gallons of soft water, 7 gallons of whisky or grain spirit, and 1 pound of cream of tartar.

Composition and Characters of Vinegar.—*Pure Malt Vinegar* has a special flavour and aroma of its own, is aromatic and refreshing, due to the presence of acetic acid, acetic ether, and aldehyde. It also contains a notable quantity of phosphates and chlorides, with a little alcohol, sugar, dextrin, albuminoids, etc. It is the product of the alcoholic, and secondly of the acetous, fermentation of an infusion of barley-malt or any other malted cereal. It has S.G. = 1·017 to 1·025, is dextro-rotatory, contains 3 to 7 per cent. of absolute acetic acid ($C_2H_4O_2$), and, according to the British Pharmacopœia, should contain not less than 5·41 per cent. By acetic acid is meant absolute acetic acid ($C_2H_4O_2$), and not acetic anhydride ($C_4H_6O_3$). The standard of strength varies in different countries ; thus, in the United States it is 4·6, Russia 5·0, Belgium 5·6, Germany and Austria 6·0, and France 8 or 9, per cent. The American Government demand that 100 c.c. of malt vinegar at 20° C. shall contain not less than 4 grammes of absolute acetic acid, 2 grammes of solids, and 0·2 gramme of ash. The ash from 100 c.c. should contain not less than 9 milligrammes of phosphoric acid (P_2O_5), and require not

less than 4 c.c. of a decinormal acid solution to neutralize its alkalinity. The percentage of acetic acid, however, varies up to 7 per cent.; and in 1874 the English Society of Analysts decided that a pure and genuine malt vinegar contained a *minimum* of 3 per cent. But although the British Pharmacopœia has fixed a *standard*, and the Society of Analysts a *minimum*, there is no legal standard in Great Britain. Commercially four standards are recognized, which are determined by the amount of sodium bicarbonate which is required to neutralize it. These are known as Nos. 18, 20, 22, and 24 vinegars; 1 ounce of the first neutralizing 18, and of the last 24, grains of sodium bicarbonate. No. 24 is also called "proof vinegar," and contains 6 per cent. of acetic acid. The specific gravity of these vinegars is not less than 1·017, 1·019, 1·020, and 1·022, respectively.

Vinegar, however, is made of malted and unmalted grain, of wholly unmalted meal; glucose, sugar, molasses, beer, rice, maize, wood; cider, perry, and fruit such as crab-apples, gooseberries, and currants. Vinegar made from many of these things is of an excellent quality, but cannot be called "malt vinegar." They are often used for adulterating the genuine article, and may themselves, as well as it, be adulterated by excess of water, commercial acetic acid, pyroligneous acid (wood vinegar), sulphuric acid, grains of paradise, and chillies. The law allows vinegar to contain 1 per cent. of sulphuric acid, of which 0·5 per cent. should be in combination as sulphates. Weak vinegar is brought up to average strength by addition of commercial acetic acid, which is an adulteration, as the acid in vinegar should be the result of fermentation, and not of destructive distillation. The following analyses of vinegar from malted and unmalted grain are by A. H. Allen :[1]

Composition of Vinegar—Percentages.

	A.	B.	C.	D.	E.	F.	G.
Specific gravity ..	1·02	1·017	1·02	1·02	—	1·013	1·018
Acetic acid ..	6·61	6·390	5·26	4·86	4·23	5·220	5·820
Total solids ..	2·81	2·670	3·96	2·31	2·70	1·560	2·450
Ash	·55	·340	·40	·47	·34	·300	·390
Albuminoids ..	·75	·620	·59	·62	—	·320	·610
Phosphoric acid ..	·06	·070	·09	·05	·10	·060	·040

	H.	I.	J.	K.	L.	M.
Specific gravity ..	1·019	1·016	1·010	—	1·007	1·010
Acetic acid	5·580	5·700	3·510	4·92	4·700	7·000
Total solids	2·980	2·090	1·520	1·76	·210	·100
Ash	·300	·430	·270	·27	·040	·150
Albuminoids ..	·650	·390	·080	·10	—	·130
Phosphoric acid ..	·010	·020	·010	·01	·090	none

[1] *The Analyst*, 1894, 15.

Malt Vinegar has a flavour and aroma which are distinct and unique; they are possessed by none of its substitutes. Malt vinegar is recognized by the P_2O_5 in the ash and the residue of carbonized dextrin.[1]

Sugar Vinegar, made from solutions of sugar, molasses, treacle or refiner's syrup, by alcoholic and subsequent acetous fermentation, should contain 4 per cent. of acetic acid. The deficiency in the characters of malt vinegar distinguish it from the genuine article.

Glucose Vinegar, prepared by the conversion of an amylaceous substance into glucose by means of dilute *acetic acid* and subsequent acetification, gives a precipitate of dextrin on the addition of alcohol, and the presence of glucose in the residue is shown by its reducing Fehling's solution. The admixture of this with malt vinegar is therefore detected by the presence of dextrin and dextrose in the residue. The residue would also give an odour of burning corn in the Bunsen flame, and as the last spark glows through the carbonized mass it usually emits the garlic odour of arsenic, from the use of impure H_2SO_4, when the vinegar is made from commercial glucose.[2]

Spirit Vinegar, made from the acetous fermentation of a diluted spirit, whisky, grain, or potato spirit, is detected by the absence of phosphoric and sulphuric acids in the residue, or phosphates, sulphates and chlorides, which are always present in genuine malt vinegar.

Ale Vinegar contains a residue amounting to 5 or 6 per cent. This is considerably more than in malt vinegar, where it varies from 0·10 to 2·86 per cent. The residue in ale vinegar is liable to lead to speedy putrefaction of the liquid.

Cider or *Apple Vinegar* is the product of the alcoholic and subsequent acetous fermentation of apple-juice. It therefore contains malic acid and various ethers from the fruit. It is lævo-rotatory, has S.G. = 1·013 to 1·015, and should contain not less than 4·5 per cent. (4 per cent. according to U.S. Regulations), and a maximum of 6 per cent., of absolute acetic acid. On evaporation it should yield not less than 1·6 or an average of 3·0 per cent. of apple solids; the ash should be not less than 0·25 per cent.; and the ash from 100 c.c. of vinegar should contain not less than 10 milligrammes of phosphoric acid (P_2O_5), and require not less than 30 c.c. of a decinormal acid solution to neutralize its alkalinity. Davenport[3] found that the solids are usually 3 per cent., and never fall below 2 per cent. of apple solids. This residue is a soft, mucilaginous, viscid substance, having the flavour and odour of baked apples, somewhat acid, but not astringent to the taste. On being burnt in a wire loop, it gives to the flame the pale lilac colour of a pure potash salt, no yellow due to sodium ever being visible. The ignited residue left in the wire loop, consisting of the ash, is strongly alkaline, and effervesces briskly on immersion in an acid. The presence of the

[1] Brannt, "Manufacture of Vinegar," etc. (Sampson Low and Co.).
[2] Davenport, *The Chemical News*, 1887, ii. 3.
[3] *Ibid.*

slight trace of mineral acid in the vinegar would prevent the ash from having an alkaline reaction or effervescing with acids. The presence of commercial acetic acid, added to tone up a weak vinegar, would give another colour to the Bunsen flame. "Glucose" in the vinegar would cause the residue, on being put in the flame, to emit the odour of burnt corn, and, as the last spark glows through the carbonized mass, usually to emit the garlic odour of arsenic, from the use of impure H_2SO_4 in making the glucose ; the presence of glucose in the residue is further shown by its reducing Fehling's solution.

Wine Vinegar is the product of the vinous and subsequent acetous fermentation of the grape-juice. It has the following composition :

Absolute acetic acid	4·00 to 7·00 per cent.
Total solids	1·00 ,, 3·00 ,,
Extractive	·35 ,, 2·16 ,,
Glycerine	·05 ,, ·10 ,,
Total ash	·15 ,, ·45 ,,
Potassium acid tartrate	·2 ,, ·75 ,,
Specific gravity	1·0116 to 1·0149

Genuine wine vinegar has a vinous odour and peculiar flavour, and contains cream of tartar and ethers from the wine. The colour varies from sherry to that of burgundy. The presence of a calculable quantity of cream of tartar is one of its chief characteristics. It contains not less than 4 per cent. of absolute acetic acid ; according to Allen, it is never less than 6 per cent. in good samples. The specific gravity varies from 1·0116 to 1·0149 ; if it falls below 1·0100, the presence of alcohol may be suspected, which is a rare occurrence.[1] The residue includes 1 per cent. or more of grape solids. The extractive matter varies from 0·35 to 2·16 per cent. Glycerine exists in traces from 0·05 to 0·1 per cent., but there is no constant relation between the proportion of glycerine and acetic acid. The total ash averages 0·15, and rarely exceeds 0·25 per cent.[2] Many substitutes are sold for the real article, consisting chiefly of dilutions of commercial acetic acid with a little sherry, malt vinegar, or ethers and water. These are distinguished by the absence of grape solids, and especially of cream of tartar, from the ash. The real thing is a beautiful condiment ; it should not be used for pickles, as in such a combination it loses its distinctive characters.

Artificial Vinegar may be made to represent any of the foregoing by mixing acetic acid with water, acetic and other ethers, and colouring the same with burnt sugar for malt, or other colourings for apple and wine vinegars. This is, however, distinguished by the absence of the characteristic flavour and aroma, and also by the absence of chlorides and phosphates from that representing malt vinegar.

[1] Ekenroth, *Zeit. für Anal. Chemie*, xxviii., part 2. [2] *Ibid.*

CHAPTER XXIX

CONDIMENTS AND SPICES

CONDIMENTS and spices of almost every name contain aromatic oils and substances of an extremely complex composition, mostly hydrocarbons and their derivatives. Upon these substances the taste, flavour, and aroma, as well as their effects, are dependent. "The proper use of these substances (condiments) is an important acquisition of the cook. Opinions differ as to the propriety of their use; but most medical men are in favour of their use in *moderation*, but urge against their *abuse* that they cause chronic catarrh of the stomach and chronic congestion of the liver from hyperæmia. It should be thoroughly understood that they are not foods in the proper sense of the term, but adjuncts to food. When properly used they arouse a flagging appetite, excite the gastric mucous membrane to secretion, and stimulate the torpid movements of the stomach and bowels. These properties show them to be suited to the middle-aged, the aged, and the feeble; *healthy individuals with normal digestion do not need them, and they should most certainly be withheld from children.*"[1] These substances fall into several groups, whose action is similar, and they are as follows:

1. *Stimulating Condiments:* Mustard, horse-radish, garlic, shallot, pepper, cayenne, turmeric, etc.
2. *Aromatic Spices:* Cloves, cinnamon, cassia, cardamom, ginger, mace, nutmeg, caraway, aniseed, cumin, etc.
3. *Sweet Herbs:* Thyme, mint, sage, basil, marjoram, savory, fennel, parsley, etc.

The first group is well represented by mustard, the most familiar of all condiments. As a class they owe their properties to a volatile oil which is formed, under the influence of an enzyme, by the decomposition or hydroylsis of another body. Their presence in our food excites the nerves of taste and smell, thereby increasing appetite, desire for and enjoyment of food. They produce a sensation of warmth in the mouth and increase the flow of saliva, and to that extent assist in the mastication and enjoyment of food. They produce a sensation of warmth in the stomach by increasing the circulation of blood through its coats, and at the same time promote a secretion of gastric juice, expedite the churning move-

[1] W. Tibbles, "Food and Hygiene," p. 212.

ments of the stomach, and generally aid in the digestion of food. The sensation of warmth relieves dyspepsia, cramp, spasms, hiccough. The same influence extended over the intestinal tract favours the local secretions, and stimulates the circulation and movements, flatus being expelled or absorbed, and the pain, colic or griping which arises from many of our vegetable foods is prevented or relieved.

They are therefore appetizers and stimulants to digestion, so long as they are taken in moderation ; but there is considerable evidence to show that an excessive consumption of them is deleterious ; that, while they increase the motor functions of the stomach, they progressively impair the secretory function, and finally hinder or inhibit the formation of hydrochloric acid. The constant stimulation of the gastric mucosa leads to chronic catarrh ; and the frequent flooding of the liver with blood from the alimentary canal, consequent upon the stimulation of the circulation, leads to portal congestion, chronic hyperæmia of the liver, and its sequelæ.

The aromatic spices are well represented by cloves and cinnamon. Like the former group, they excite the nerves of smell and taste, encourage appetite and a relish for food. The digestive secretions are promoted by their action, and therefore they assist in the digestion of the food. They likewise increase the flow of blood through the mucous membranes of the alimentary canal, create a sensation of warmth, thereby preventing or relieving flatulence, hiccough, cramp, spasms, colic, or the griping induced by food and other substances. The aromatic substances, on which their action depends, consist of materials allied to phenol, the camphors, resins, or balsams. They are therefore excellent antiseptics, and everywhere disinfect the alimentary tract. They also stimulate the blood-making organs, and especially increase the number of leucocytes in the blood. Their carminative action is useful in cases of nausea, vomiting, and intestinal catarrh ; and their astringency is valuable in diarrhœas of various kinds and in catarrh of mucous membranes of the alimentary and respiratory organs. Absorbed into the blood, these aromatic bodies reach the nervous system, where they act by relieving and preventing nervous depression, lowness of spirits, and hysteria ; they stimulate the action of the heart, at the same time relieving palpitation and pains in the cardiac region. Finally they are excreted by the skin, lungs, and kidneys, and everywhere act by stimulating and disinfecting these organs. Effects of their abuse have been observed, which are similar to those of the stimulant group.

The sweet herbs act differently from the former groups—at any rate in part. Instead of causing an agreeable sensation of warmth, by dilating the bloodvessels of the alimentary canal and increasing the circulation through them, the first effect of the active principles in these condiments is to contract the bloodvessels and produce a sensation of coldness, or rather of coolness. Their effect is in proportion to the coolness

produced. This depends upon the oils in the condiments, which contain stearoptenes, of which thymol and menthol are good representatives. Such condiments therefore are cooling and soothing in their effects, and prevent or relieve the flatulence, colic, or griping tendency, of our foods. They are also powerfully antiseptic. They may therefore be described as refrigerant, carminative, antiseptic; at the same time they are stimulating in their action by raising the arterial tension, and strengthening without quickening the cardiac beat.

Their effect upon alimentation is first of all to promote appetite and enjoyment of food by their flavour and aroma, for which purpose they are useful culinary agents, especially as sauces for animal foods, rich fatty foods, and for making soups, entrées, etc. Of the whole series, "mint sauce" is usually considered to have the most delicate or refined flavour, and is much valued as an accompaniment of lamb in its season. They do not promote gastric and intestinal secretion and movement; on the other hand, glandular activity is depressed, muscular movement and absorption are hindered or delayed to some extent. Nevertheless they are powerful antiseptics, and very proper accompaniments of rich foods, and especially high kept game. In *excess*, it was shown by Vladimirsky that they diminish the amount of free hydrochloric acid, and consequently the digestive power of the gastric juice; the motor activity of the stomach is also hindered; but *lactic acid* rises in proportion as the free hydrochloric acid diminishes.

Allspice, or Pimento: The dried berries of *Pimento officinalis* or *Eugenia pimento*, N.O. Myrtaceæ, a native of the Caribbee Islands, but cultivated in the East and West Indies. Being cultivated to a large extent in Jamaica, the name of "Jamaica pepper" has adhered to it, in spite of the fact that it is not a pepper at all. The tree is a handsome evergreen, having dense foliage, and attaining a height of 30 feet. It bears fragrant aromatic white flowers, which grow in racemes. The berries grow rapidly, and become moist and glutinous when ripe, and dry black and tasteless. They are, however, picked while green but fully grown, in which condition they have the maximum of flavour. The racemes are pulled, dried in the sun or in a kiln, and the berries pulled from the stalks. The berries are reddish-brown when dried, small, nearly globular, and consist of two "cells," each containing a kidney-shaped seed. They have a fragrant odour resembling a combination of cinnamon, cloves, and nutmeg, whence the name "allspice." Their taste is warm, aromatic, and pungent. They communicate their flavour to water and alcohol, and yield a volatile oil on distillation. They are used in domestic economy as an aromatic spice, being possessed of aromatic, stimulant, and carminative properties, which they communicate to various cordials and waters. The volatile oil, to which their properties are due, exists in the pericarp or shell of the berry, and is more abundant in the unripe than in their ripe state; whence small immature berries are often more aromatic than large

ones, and are therefore more highly esteemed. It forms 3 to 4·5 per cent. of the berries, and consists chiefly of eugenol. Besides volatile oil, they contain a green *fixed* oil, tannin, gum, uncrystallizable sugar, malic and gallic acids, saline and colouring matters, lignin, and moisture. The fixed green oil has a burning aromatic taste of pimento, and gives the acrid pungent flavour to the berry. All-spice is occasionally adulterated with *Myrtus pimentoides*, *Myrcia acris*, and other berries of the genus, which, however, have a different flavour and general characteristics.

Aniseeds : The fruit of *Pimpinella anisum*, N.O. Umbelliferæ, originally brought from Egypt and the Levant, but now grown all over Europe, but particularly in Malta, Spain, Germany, Bulgaria, and Russia. The seeds are a grateful aromatic and carminative. They have a fragrant odour and a sweet, warm, aromatic taste due to the volatile oil. The seeds are used in cookery, in making spices and cordials, and in medicine. The volatile oil, which forms 2·5 to 3·5 per cent. of the seeds, crystallizes at 50° to 59° F. ; it consists of 80 per cent. of anethol ($C_{10}H_{12}O$), a stearoptene, and 20 per cent. of a terpene. The same oil occurs also in Chinese aniseeds, the fruit of star-anise, *Illicium verum* or *I. anisatum*, N.O. Magnoliaceæ. The seeds are used for flavouring dishes, but the whole plant is aromatic, and with it the liqueur *anisette de Bordeaux* is flavoured.

Capers : The flower-buds of the caper-bush, *Capparis spinosa*, N.O. Capparidaceæ, which grows abundantly in the South of Europe, along the shores and on the islands of the Mediterranean, and in Syria. It is found growing wild on the rocks and walls about Rome, Sienna, and Florence, and is cultivated in France, Spain, Italy, and Majorca, where capers are of commercial value. The greatest supply is brought from Sicily, but those of Provence have the highest reputation for their flavour and keeping qualities. The plant begins to flower in the early summer, and continues to do so till the beginning of winter. The fresh buds are gathered every morning before they expand, and are pickled in strong white vinegar and salt. When the season closes, the buds are sorted according to their size and colour, the smallest and greenest being the youngest and having the finest quality. They are bottled in vinegar.

Capers are stimulant and antiscorbutic, and have a great reputation as a pickle and sauce. Their peculiar flavour is due to **capric acid,** which is present in notable quantity. Capers are sometimes adulterated by mixing the leaf or flower-buds of mallows and marsh-marigolds with them. The fruit of *Tropæolum majus* (nasturtium) is sometimes pickled and used as a substitute for them ; these seeds and the whole plant contain an oil which can be extracted with ether ; it consists of 85 per cent. of benzoyl-thio-carbamide, formed by the action of an enzyme upon a glucoside called *gluco-tropæolin*, a combination of tropæolic acid and glucose.[1] The liquor contained in a bottle of capers may contain copper, either by intention or

[1] Gadamer, *Archiv der Pharm.*, ccxxxvii. 111.

because they are sorted into sizes by being passed through copper-wire sieves. The copper acts as a mordant, and gives to the capers a permanently improved colour.

Capsicums (Chillies, **Cayenne Pepper**) : The fruit or pods of several species of capsicum, N.O. Solanaceæ. The large varieties are called "capsicums"; the small ones, when dried, are "chillies." They vary in size from a small pod to a large pod or berry of the size of a plum. The best-known varieties are—

1. *Capsicum annum*, or chillies, small pods ½ to ⅔ inch long, and of a deep orange-red colour. They are consumed largely in Guiana, Cayenne, and other tropical countries. In Europe they are chiefly used as an ingredient of pickling spice, and as "cayenne or red pepper." They have a hot, burning taste and aromatic odour. The name "chillie" is of Mexican origin. The chief sources of European supply are Zanzibar and the West Indies.

2. *C. baccatum*—the berry-making capsicum, called "bird pepper." They are small, red, very hot, and pungent.

3. *C. fructosum*, or goat pepper. These are also very hot.

4. *C. grossum*, or bell pepper. This is a West Indian species, bearing very large capsules. They form one of the chief condiments of Orientals, being eaten green or fresh, in curries and chutney. They are also pickled in brine or dried in the sun. They are used in Europe as an ingredient of sauces and pickles.

Composition of Cayenne Pepper.[1]

Moisture (=loss by drying at 100° C.)	8·90 to 9·90 per cent.
Ethereal extract	20·90 ,, 21·08 ,,
Alcoholic ,, ...	9·54 ,, 15·12 ,,
Woody fibre	17·96 ,, 25·30 ,,
Total ash	5·66 ,, 6·50 ,,
Insoluble ash	1·10 ,, ·16 ,,

Cayenne pepper consists of the powdered dry capsules ; but sometimes it is the powder of a *cake* formed of cayenne pods, wheaten flour, and yeast, which is baked into a hard, biscuit-like cake, more readily reduced to a powder than the pods alone. Pepper from the dry capsules or pods may be adulteraetd with horse-radish, turmeric, yellow ochre, and other matters.

The active principles are **capsaicin**, $C_{18}H_{28}NO_3$, a volatile alkaloid soluble in alcohol ; besides **capsicain,** an acrid substance, also an oleo-resin, and fatty matters soluble in ether.

Capsicum and the pepper derived from it is a diffusible stimulant ; it also promotes the secretion of gastric and pancreatic juices. As a condiment, a reasonably small quantity is of value in cases of atonic dyspepsia attended with flatulence, etc. ; it is of value to alcoholic subjects, but is more especially used by the residents of hot climates, to arouse appetite and relieve dyspeptic symptoms generally.

Cardamoms : The ripe fruit of a tall sedge-like plant, *Elettaria cardamomum*, N.O. Zingiberaceæ, native of the mountains of Mala-

[1] Kynaston, *Chemical News*, 1900, i. 109.

bar, and grown in the East Indies, Ceylon, and Java. It has been cultivated from time immemorial, but grows up spontaneously in the forests of Malabar after the removal of the undergrowth. The cultivated plants bear fruit in the fourth year, and continue to do so for several years. Gathered in November, the fruit is dried over a gentle fire, and afterwards separated from the foot-stalks and calyx by rubbing. The seeds are dark brown, of aromatic odour, warmth, and pungency. These properties depend upon a volatile oil, which can be obtained by distillation with water ; it is colourless, of strong aromatic odour, and camphoraceous but slightly bitter taste. The seeds contain 4·6 per cent. of volatile oil, 10·4 per cent. of fixed oil, 3 per cent. of starch, 1·8 per cent. of mucilage, 0·4 per cent. of yellow colouring matter, 2·5 per cent. of mineral substances, and 7·73 per cent. of lignin.

The chief commercial varieties of the seeds are—(1) Mysore : ovoid shape, nearly smooth, pale cream colour, 10 to 20 millimetres long ; (2) Malabar : shorter, plumper, not so smooth ; (3) Mangalore : larger, almost globular, rough or scurfy coat.

Cardamoms are used in cakes, curries, sauces, and cordials. There are other varieties than the official form described above—*e.g.*, the round cardamom (*Amomum cardamomum*), which has a strong aromatic and camphoraceous flavour, and is used in South Europe ; the Java cardamom (*A. maximum*), which has only a feeble aromatic taste and smell ; the Madagascar cardamom (*A. angustifolium*) ; and *A. aromaticum*, which is similar in shape and properties to the true cardamom.

Caraway Seeds : The fruit of *Carum carvi*, N.O. Umbelliferæ, found wild in many parts of Great Britain, and cultivated in Kent and Essex, as well as in Holland and other parts of Europe. The seeds are very agreeable, aromatic, and carminative ; chiefly used as a flavouring agent, to give taste and aromatic odour to various dietetic articles. The properties are due to an essential oil consisting of carvol ($C_{10}H_{14}O$), a ketone which forms 50 or 60 per cent., and the terpene *d*-limonene, or carven ($C_{10}H_{16}$), and a little carvacrol. Caraway-oil has S.G. 0·910 to 0·913, and optical rotation +77·30° to +80·0°.

Cassia, or Cassia Cinnamon, is the inner bark of *Cinnamomum cassia*, *C. aromaticum*, *C. loureirii*, and several other species of N.O. Lauraceæ, grown in China, Ceylon, Sumatra, and other Oriental countries. The colour, fragrance, and aroma, are similar to that of cinnamon. Some of the aforementioned barks are thin, and others are thick ; the thin barks resemble true cinnamon so closely as to be used as an adulterant of the latter. The chief constituent of cassia bark is 1 to 2 per cent. of volatile oil, which resembles that of cinnamon ; it contains from 80 to 85 per cent. of cinnamic aldehyde. The flower-buds of Chinese cinnamon, *C. aromatica*, furnish the cassia-buds of commerce. The bark of this tree is excellent ; and that of *C. Loureirii* is considered by some authorities to have a finer flavour than that of true cinnamon.

Cinnamon.—The true cinnamon is the inner bark of *Cinnamomum zeylanicum*, N.O. Lauraceæ, a native of Ceylon, but found all over India and the islands of the Eastern Archipelago, West Indies, and South America. The chief supplies come from Ceylon, Borneo, Java, Sumatra, the Mauritius, Jamaica, and Brazil. The trees are cultivated; branches up to $\frac{1}{2}$ inch in diameter are cut off. The bark is cut longitudinally and removed in strips; these are placed one above another in parcels 8 or 10 inches thick. They remain thus for twenty-four hours, during which time a species of fermentation takes place which facilitates the removal of the epidermis and green part of the bark. The inner bark, left free by this removal, is rolled into long cylinders, and dried first in the sun and later in the shade. This, however, is not the only way of obtaining the bark; it is sometimes dried in a store. The cultivated trees are strong enough to bear partial denudation after the fourth year, and the young small branches are stripped twice a year, at the monsoons.

The flavour and aroma of cinnamon is due to the essential oil, of which it contains 0·5 to 1·0 per cent., and which consists of 84 per cent. of cinnamic-aldehyde, 3 per cent. of eugenol, besides phellandrene, pinene, cymene, cymol, methyl-amyl-ketone, and various aldehydes.[1] The bark contains, in addition to the oil, sugar, gum, tannin, and lignin. It is aromatic, carminative, and astringent, and is much used as a flavouring agent in cookery, cordials, and medicine.

Adulteration of cinnamon is very common. The true Ceylon cinnamon is in long thin cylinders, of a light yellowish-brown colour, with dark spots and a slightly furrowed surface. The bark varies from 0·5 to 2 millimetres ($\frac{1}{50}$ to $\frac{1}{12}$ inch) in thickness, is smooth, pliable, but breaks into splinters; it has a sweetish, mildly aromatic taste and characteristic odour. Inferior qualities usually come from other countries than Ceylon; the bark is thicker, darker, and has a more or less acrid taste. Cassia bark (*C. cassia*) is the chief adulterant; it has a similar appearance, but is four times thicker than the true bark, is darker in colour, of coarser texture, breaks with a short fracture, and does not splinter. Cassia also lacks the sweetish taste of the genuine bark, and is not so mild; on the other hand, it has a biting and hot taste, a different flavour and aroma, and is not rolled into quills in the same way as cinnamon.

Oil of Cinnamon is obtained from the flowers, leaves, bark, and roots, of cinnamon. Bark which is too small for sale, the epidermis removed in preparing the bark, the leaves, etc., are reduced to a coarse powder, and macerated in brine or sea-water for two or three days, and then distilled. Two oils come over with the distillate—the oil of cinnamon, which is light and floats on the surface of the water; and a heavy oil, which goes to the bottom, and continues to be deposited from the distillate for several days. The finest oil is that distilled in China; it is of a yellowish-red colour, volatile,

[1] *Year-Book of Pharmacy*, 1902, 57.

pungent, and having the odour and aroma characteristic of cinnamon. It is much used for making waters and cordials. An *artificial* cinnamic aldehyde is manufactured from coal-tar, and is sometimes used to replace the oil in the manufacture of waters, cordials, and essences.

Chutney.—This condiment is formed of a mixture of spices and fruits, such as tamarind, guava, etc. There are various recipes for it, of which the following is an example : Mustard-seeds, 10 parts ; green ginger, 40 ; green chillies, 10 ; tamarinds, 40 ; butter, pepper, and salt, *q.s.* The mustard-seeds are roasted in butter, the chillies are minced, the ginger is ground, and all the ingredients are mixed together with a little pepper and salt.

Cloves : The dried flower-buds of the evergreen tree, *Eugenia caryophyllata* or *Caryophyllus aromaticus*, N.O. Myrtaceæ. The tree is a native of the Moluccas, but is cultivated all over the East Indies, to some extent in the West Indies, Africa, Brazil, and other tropical countries. The largest quantity comes from East Africa via Zanzibar. It is one of the ancient spices known to the Greeks and Romans. The tree grows to a height of 30 or 40 feet, and the flowers grow in racemes or clusters, the buds being first green, then white, and finally red. A tree is first plucked when it is four to six years old, the buds being plucked by hand when they are *red* and nearly ready to open ; and they are dried quickly in the sun or by the heat of a wood fire. The dried clove is of a reddish-brown colour, and has a characteristic shape (the calyx with a round prominence due to the unopened petals). The odour is distinct and unique ; the taste is aromatic, and is followed by a sensation of warmth. The product of different countries differs somewhat in size, colour, and other qualities.

Composition of Cloves.

Water	15 to 20 per cent.
Volatile oil	17 ,, 21 ,,
Oleo-resin	5 ,, 8 ,,
Gum, tannin, etc.	26 ,, 32 ,,
Fibre and ash	25 ,, 30 ,,

The use of cloves in domestic economy is well known. They are employed chiefly for their flavour, but they also possess stimulant, aromatic, antispasmodic, and antiseptic properties, and are the representative of the "aromatic spices." The taste, aroma, and other properties, for which cloves are prized, is entirely due to the volatile *oil of cloves*, with which the entire plant abounds. This is obtained by distilling coarsely powdered cloves and other parts of the shrub with water containing common salt (*e.g.*, brine or sea-water) in order to raise the temperature of ebullition, the water being put back and distilled again and again in order to exhaust the cloves. This oil consists of 85 to 90 per cent. of eugenol ($C_{10}H_{12}O_2$), a phenol, besides caryophylline, a sesqui-terpene ($C_{15}H_{24}$), furfurol, vanillin, amyl-ketone, methyl-benzoate, and

methyl-alcohol. Powdered clove is often adulterated with pimento, which likewise contains eugenol.

Coriander: The seeds of *Coriandrum sativum*, N.O. Umbelliferæ. The seeds are used as a flavouring agent. Coriander possesses the same properties as aniseed, caraway, and fennel, being an agreeable stimulant, aromatic, and carminative. The whole of the fresh plant, when crushed, emits a fœtid odour, but the dried fruit is very fragrant, and is used in making bread, cakes, confectionery, and liqueurs. The oil consists of 90 per cent. of coriandrol, and *d*-pinene; coriandrol yields citral on oxidation, and may be converted into geraniol.

Cumin: The seeds of *Cuminum cyminum*, N.O. Umbelliferæ, possess similar properties to coriander and caraway. They are much cultivated in Malta and Sicily; used largely as a flavouring. In Germany the seeds are frequently mixed in bread and cake, and in Holland they are used to flavour cheese. The chief constituent of the oil is cuminol, or cumic aldehyde.

Curcuma, or **Turmeric,** is the root or rhizome of *Curcuma longa*, N.O. Zingiberaceæ. It has an aromatic, peppery, but somewhat acrid taste, and possesses the same properties as ginger. It enters largely into the composition of **curry-powder,** and is otherwise used as a condiment. It consists of a peculiar colouring matter, *curcumin*, an odorous and acrid volatile oil, starch, gum, lignin, etc.

Curry-Powder.—There are numerous examples of this condiment, of which the following is a representative:

Capsicum	1·5 parts.
Ginger	2·0 ,,
Black pepper	3·0 ,,
Coriander	2·0 ,,
Cardamoms	·5 ,,
Cinnamon	2·0 ,,
Cloves	1·0 ,,
Turmeric	12·0 ,,

Mix.

Garlic: *Allium sativum*, N.O. Liliaceæ (see Onions). The bulbs are used as a condiment, being used alone, but more especially mingled with other substances, in entrées, sauces, etc. Garlic provokes the appetite, the muscular and glandular activity of the stomach. It possesses stimulant properties, quickens the circulation, excites the nervous system, the skin and kidneys. The whole plant, but especially the bulb, has a peculiar taste and smell, which is quickly communicated to the breath and perspiration of the consumer. This is due to an essential oil, usually stated to consist chiefly of allyl-sulphide (C_3H_5:S), or allyl-sulphocyanide (C_3H_5.N:C.S), which occurs in many cruciferous plants. Semmler,[1] however, says that neither garlic nor onions contain allyl-sulphide, but oil of garlic consists of—

[1] *Archiv. de Pharm.*, ccxxx. 434.

Composition of Oil of Garlic.

60·0 per cent. of $S_2:(C_3H_5)_2$—*i.e.*, di-allyl-bisulphide.
6·0 ,, $C_3H_5.S:Pr$—*i.e.*, allyl-propyl-sulphide.
20·0 ,, $C_6H_{10}O_3$.
10·5 ,, $C_6H_{10}S_4$.

Ginger : The rhizome of *Zingiber officinale*, N.O. Zingiberaceæ, a native of India, China, and the Moluccas, where it is cultivated assiduously ; transported thence to the West Indies, Africa, South America, and Australia, it forms also an important commercial product of those countries. European imports are chiefly from Jamaica, Indo-China, Bengal, Japan, and Africa ; the roots from the two first-named places are of the finest quality. In Jamaica the plants are set out in March or April, and flower in September ; seeds are formed in January, after which the leaves wither ; the roots are then dug up and trimmed, washed, boiled or scalded with boiling water to prevent germination, and rapidly dried ; so prepared, they constitute *unbleached*, dark-coloured, or black ginger. Unbleached or black ginger has a greyish wrinkled epidermis, with a brown underlayer and a yellowish interior. The dark epidermis contains a large amount of oleo-resin ; hence this kind is of more value than white or bleached ginger.

White or *Bleached Ginger* is prepared from the best selected roots, which are deprived of their epidermis and carefully dried in the sun, which gives them a beautiful white colour. But inferior grades of ginger are bleached by exposure to the fumes of sulphur, by dipping them in a solution of bleaching-powder or calcium sulphate, or in a mixture of chalk and water. Bleached ginger, being deprived of its epidermis, consists of pieces of smaller circumference than that of unbleached ginger ; they are also smoother and whiter, but less pungent, owing to the loss of oleo-resin in the removed epidermis.

Preserved Ginger is made from young succulent rhizomes, which are washed and boiled in syrup, some of the roots being afterwards *crystallized* or *candied* by drying them in the same way as candied fruits.

Ginger is a stimulant aromatic spice, much used in domestic economy. It also possesses carminative properties. It is of considerable value in enfeebled states of the alimentary canal, such as atonic dyspepsia, also in nausea, vomiting and diarrhœa, and atonic states of the bowels.

Composition.—It consists of oleo-resin, 2 to 5 per cent. ; volatile oil, 1 to 2·5 per cent. ; free acetic acid ; ginger starch ; nitrogenous matters, 7 per cent. ; lignin ; gum ; sulphur ; acetate of potash and other salts. The fragrance and aroma are due to the volatile oil, which is of a greenish-blue colour ; the pungency to the oleo-resin, a soft, acrid, aromatic substance, soluble in ether and alcohol. Unbleached ginger contains 4·6, and bleached only 4·1, per cent. of the oleo-resin or gingerol.[1] The volatile oil consists of a complex

[1] Davis, *Amer. Pharm. Jour.*, 1895, 500.

mixture of hydrocarbons, including camphene, zingiberene, phellandrene, citral, aldehydes, and ethereal salts. Ginger starch forms 50 per cent. of the root ; it consists of ellipsoidal granules, 12 to 30 μ long, which are very transparent, and therefore readily distinguishable from foreign starches, with which it may be adulterated. Pearmain finds that the ether extract (oil and resin) varies from 2·5 to 5·0 per cent. ; after such treatment the alcoholic extract (resins, etc.) varies from 2·7 to 3·4 per cent. ; total ash (not including sand), 3·1 to 5·0, soluble in hot water 1·8 to 2·7 per cent.

Grains of Paradise : The seeds of *Amomum melegueta*, N.O. Scitamineæ ; also called " Guinea grains " and " Melegueta pepper." The seeds are of a bright golden-brown colour, have an excessively hot taste, and are very aromatic. They are much used as a condiment in West Africa, where they are chiefly grown ; they are also grown in Demerara and other places in the West Indies. They have similar properties to black pepper, and are chiefly used in Europe to give artificial strength—*i.e.*, fiery taste to vinegar, beer, wine, spirits, and especially to gin. The pungency is due to an oily body called " paradol," and 0·5 per cent. of volatile oil.

Horseradish : The root of *Cochlearia armoracia*, N.O. Cruciferæ, which grows wild in Great Britain, is so well known as to require little description. It has a warm taste and pungent odour, promotes appetite and secretion of saliva, increases gastric secretion and motility, thereby stimulating the alimentary functions ; at the same time it is a carminative and antiseptic all along the canal. Horseradish sauce is therefore a valuable aid to the digestion of meat and various rich dishes. The virtues of the root arise from the volatile oil. The oil is obtained by distillation ; it is pale yellow or nearly colourless, heavier than water, but very volatile ; it has a pungent, acrid taste, is soluble in water and alcohol. It consists chiefly of sulphocyanate of butyl (C_4H_9:C·N·S), and, like the essential oil of mustard, with which it is allied, it is developed by the hydrolytic splitting of a glucoside by an enzyme. Containing a large amount of sulphur in an organized form, horseradish is one of the most valuable antiscorbutic condiments, and, in addition to the qualities already enumerated, it is of value in chronic rheumatism, sciatica, various dropsical conditions, and as a general stimulant and excitant in systemic and nervous debility.

Juniper : The berries of *Juniper communis*, N.O. Coniferæ, frequently found in England, in sterile places on chalky downs and rocky, mountainous places, where it exhales an aromatic odour. The " berries " are really small cones of the size of a pea, having a sweet pulp ; when dry they are black, and have a sweet-bitterish balsamic flavour. They are stomachic, increase the appetite, and facilitate digestion ; they also stimulate the skin and kidneys, and give to the urine an odour of violets.

The acids are formic, acetic, malic, and oxalic, alone or in combination with bases. The resins are a brown one, which separates out from an alcoholic solution, and a green one, which separates out

from an ethereal solution. The volatile oil gives the chief properties to the berries ; it consists of several hydrocarbons, including pinene and cadinene, and juniper camphor, a white crystalline compound. It has a warm aromatic taste and characteristic odour. It stimulates the kidneys and is excreted by them, and increases both the solids and water of the urine. The berries contain a large proportion of "sugar," and *German treacle* is made from them. The chief use of the berries is to give the peculiar flavour to Hollands and English gin, from which circumstance these spirits are called "geneva" or "gin," from *genièvre*, the French name of the berries.

COMPOSITION OF JUNIPER BERRIES.[1]

Water	29·44 per cent.
Organic acids	3·01 ,,
Volatile oil	·91 ,,
Resins	10·39 ,,
Pectin	·73 ,,
Juniperin	·37 ,,
Albumin	4·55 ,,
Sugar	29·65 ,,
Cellulose	15·83 ,,
Ash	2·33 ,,
	100·00

Mace.—See Nutmegs.

Mixed Spice.—The following examples are given by "The Practical Grocer," vol. ii., and other authorities :

1. Caraway-seeds 18, cinnamon 28, nutmeg 5, mace 11, rice flour 28, parts.
2. Caraway 15, cloves 6, coriander 30, sugar 19, rice flour 30, parts.
3. Caraway 14, cloves 5, cassia 14, cinnamon 6, coriander 1, ginger 1, mace 4, rice flour 50, parts.
3. Cinnamon 35, ginger 35, cardamom 15, nutmeg 15, parts.
5. Allspice 15, ginger 15, cardamom 15, nutmeg 5, rice flour 25, parts.
6. **Essence of Spice**:[2] Black pepper 64, turmeric 4, coriander-seeds 3, oil of pimento 3, parts; oils of nutmeg, cloves, cassia, and caraway, each 1 part; rectified spirit 125 parts.

Grind the seeds to a coarse powder, mix in the turmeric, dissolve the oils in the alcohol, mix all together; macerate one week, agitate daily, filter.

Mustard : A powder derived from the seeds of *Sinapis arvensis*, var. *nigra* and *alba*, N.O. Cruciferæ. Mustard was originally made in Durham, by a lady of that city, from the ground seeds of **charlock**, or wild-mustard (*Sinapis arvensis*), which grew plentifully in the district, and its reputation increased until it became a famous condiment throughout Europe. Mustard is now made from a mixture of the seeds of the black and white cultivated varieties ; but charlock seeds are still collected, and are used for purposes of adulteration. Black mustard is a native, and grows wild in the cornfields of England ; but white mustard is a native of Southern Europe, which has become naturalized in England. The finest qualities of both

[1] Donath, *Neues Jahrbey. der Pharm.*, xl. 37.
[2] *Year-Book of Pharmacy*, 1901, 241.

black and white mustard are grown in the eastern counties of England.

COMPOSITION OF MUSTARD—PERCENTAGES.[1]

	Whole Seeds.		Farina.	
	White.	Brown.	White.	Brown.
Moisture	8·66	8·52	6·04	4·83
Fat	26·53	25·54	35·16	37·05
Cellulose	9·69	9·01	5·79	2·80
Sulphur	·96	1·28	1·27	1·43
Nitrogen	4·51	4·38	4·73	4·75
Albuminoids	28·21	26·50	29·56	28·71
Myrosin and albumin	4·91	5·24	6·70	6·46
Soluble matter	26·83	24·22	33·94	31·94
Volatile oil	·07	·47	·03	1·44
Ash, total	4·63	4·98	4·28	4·93
,, soluble	·65	1·11	·44	·92
Potassium myronate	—	1·69	—	5·15

Starch is absent from both varieties; and, according to Sayre, there is no cellulose, but 25 per cent. of mucilage and albuminous matters. The *fixed oil* is the same in both varieties; it varies in proportion from 20 to 25, or even 37, per cent. The Canadian Inland Revenue Department fixed 35 per cent. as the standard of oil for medicinal mustard, and suggested that 30 per cent. should be the minimum proportion in other kinds.[2] It is of a yellow colour, mild taste, and consists of stearic, oleic, erucic ($C_{22}H_{42}O_2$), sinapolic ($C_{20}H_{38}O_2$), and behinic ($C_{22}H_{44}O_2$) acids in combination with glycerol. The *volatile* or essential oil of mustard does not exist ready-made, but it is formed under the influence of **myrosin,** an enzyme, from the active principle of mustard when the meal is moistened. The proportion of myrosin in white mustard-seeds is greater than in black seeds. The active principles and the changes they undergo are as follows: The active principle of black mustard is **sinigrin,** or potassium myronate ($C_{10}H_{18}KNS_2O_{10}$); it is soluble in water and warm alcohol, and crystallizes in rhombic prisms. Under the influence of myrosin, the sinigrin is split up into glucose, potassium, acid sulphate, the *volatile oil* (allyl-thiocarbamide or allyl-iso-sulphocyanate, $C_3H_5{\cdot}N{:}C{\cdot}S$ or C_4H_5NS), which forms 0·5 per cent. of the seeds, and an *alkaloid* which is sinapin sulphocyanate ($C_{16}H_{24}NO_5{\cdot}C{:}N{\cdot}S$), besides a small quantity of crotonitrite and free sulphur—thus :[3]

$$\underset{\text{Sinigrin.}}{C_{10}H_{18}KNS_2O_{10}} = \underset{\text{Glucose.}}{C_6H_{12}O_6} + \underset{\text{Potassium acid sulphate.}}{K_2SO_4} + \underset{\text{Volatile oil.}}{C_4H_5NS} + \underset{\text{Alkaloid.}}{C_{17}H_{24}N_2SO_5}.$$

[1] Piesse and Stansell; *cf.* Thorpe's "Dictionary," vol. ii., p. 626.
[2] Bulletin 19, Revenue Department, Ottawa, Canada, 1890.
[3] Sayre, *Amer. Jour. Pharm.*, 1895, 339-532.

The active principle of white mustard is **sinalbin** ($C_{30}H_{44}N_4S_2O_{18}$), a glucoside, which is split up, under the influence of myrosin, into the same alkaloid, glucose, sinapin sulphate ($C_{16}H_{25}NSO_9$), and a volatile oil bearing the name of ortho-hydroxy-benzyl sulphocyanate—$C_6H_4\begin{cases}OH\\CH_2\cdot CNS\end{cases}$—thus :[1]

$$\underset{\text{Sinalbin.}}{C_{30}H_{44}N_4S_2O_{18}} = \underset{\text{Glucose.}}{C_6H_{12}O_6} + \underset{\text{Sinapin sulphate.}}{C_{16}H_{25}NSO_9} + \underset{\text{Alkaloid.}}{C_{16}H_{24}NO_5CNS} + \underset{\text{Volatile oil.}}{C_6H_4\begin{cases}OH\\CH_2\cdot CNS.\end{cases}}$$

The seeds are crushed between rollers and powdered ; the powdered material is sifted twice, thereby dividing it into "mustard" and "dressings." The first sifting divides the powder into *impure mustard* and first quality of dressings ; the impure mustard is again sifted, and results in a division into second quality of dressings and *pure mustard*. Pure mustard is the only genuine mustard, but inasmuch as the seeds vary in quality the flour also varies in quality.

The condiment depends for its properties, especially the aroma and pungency, upon the volatile oil, which, as we have seen, arises from the action of the enzyme myrosin upon the active principles (sinigrin and sinalbin). Now, black mustard does not contain enough myrosin to hydrolyze all its sinigrin ; white mustard, on the other hand, contains an excess of myrosin. It follows, therefore, that the strongest mustard is obtained by mixing the two seeds together, which is usually done. Pure mustard varies in strength according to the proportion these seeds bear to one another in the mixture, from which arises the circumstance that the strength of commercial brands of *pure* mustard varies, and they are sold under names such as "pure," "extra quality," "superfine," or "double superfine."

Adulterations.—Pure flour of mustard contains no starch ; but a very large number of commercial brands are not pure : they are diluted with 10 per cent. or more of starch derived from rice or wheat flour. It is claimed by the advocates of such compounds that the mixture is an advantage, by reducing the pungency of the finer qualities of mustard and improving their keeping power. It is a fact that a compound of black and white mustard with 10 per cent. of starch may be stronger than an unadulterated mustard derived chiefly from white seeds. There are, besides starch, various other commonly used adulterants. Charlock or wild-mustard seeds (*S. arvensis*), which grow abundantly in Durham and other counties, are used. Compound mustards frequently consist of a low proportion of mustard flour combined with starch, turmeric, or Martius' yellow, to give colour, and horseradish, ginger, or cayenne pepper, to give flavour and pungency. The diluents used are starch, wheat flour, fine oatmeal, rice flour, rape or linseeds,

[1] Sayre, *Amer. Jour. Phar.*, 1895, 339-532.

and occasionally clay or plaster of Paris; 20 per cent. of gypsum has been discovered. The colouring matters found at various times are turmeric, Martius' yellow, ochre, gamboge, methyl orange, and other aniline dyes. Allen gives an account of one firm who for months made their "mustard" solely of rape-seed, wheat flour, and cayenne pepper; and the writer knows of another mustard which contains a large proportion of horseradish, to which is added a proportion of malt flour, with the view of mixing in it a diastatic ferment as a digestant of the carbohydrates. The Canadian Government suggests that mustard should be considered adulterated if it contains more than 30 per cent. of starch or less than 22 per cent. of fixed oil.

Nutmeg and Mace.—The nutmeg-tree, *Myristica fragrans*, *M. moschata*, *M. fatua*, and other varieties (N.O. Myristicaceæ), is indigenous to the Moluccas and neighbouring islands, but is cultivated also in the Banda Islands, Isle of Bourbon, Java, Sumatra, the Mauritius, Martinique, and other parts of the East and West Indies and Madagascar. The tree attains a height of about 30 feet, and has a large branching head, resembling a pear-tree in foliage and general appearance. The flowers are insignificant, the males and females being on separate trees. The fruit is round or oval, and resembles a small peach, green at first, yellow when ripe. It consists of four parts: the external covering is a thick, tough, fleshy substance resembling that of a walnut; when the fruit is ripe, this envelope opens and exposes the arillus, or **mace,** reticulated, of a beautiful blood-red colour, and closely surrounding a thin hard shell, or *testa*, which encloses the **nutmeg**, or kernel. The nutmeg consists of a large whitish endosperm, covered by a thin dark brown perisperm, which is numerously folded and penetrates the endosperm, thereby producing the appearance which is characteristic in a section of nutmeg.

A plantation of nutmeg-trees is cultivated from the seeds, and they begin to produce flowers in the eighth or ninth year. But, as the sexes are distinct, the trees are cut down when they are two years old, and grafted with cuttings from selected female trees; only one or two male trees are left in the grove to insure fecundation. The ripe fruit is gathered by hand, the pulpy husk stripped off, and the mace detached. The latter soon loses its bright red colour when dried by exposure to the sun; it is usually sprinkled with sea-water or brine to render it pliable. The nuts are first sun-dried, and then smoked until the kernels are shrivelled and loose, and the shells are brittle enough to be easily broken. The kernels, being removed from the shells, are dipped in lime-water two or three times to prevent the depredations of insects; they are again dried, and divided into grades, small round ones being considered of finer quality than large oval nuts.

Composition.—Bussé[1] found the composition of nutmegs to be as follows: Fat 31·1 to 40·5, volatile oil 8 to 10, nitrogenous matters and

[1] *Pharm. Woch.*, xix. 150.

lignin 30 to 50, moisture 1 to 5, and ash 4 or 5, per cent. The fat or concrete oil consists chiefly of myristicin or myristic acid ($C_{14}H_{28}O_2$), a stearoptene, combined with glycerine to form the trimyristicate of glyceryl. The volatile oil, or *oil of nutmeg*, consists of a terpene, myristicin, and myristicol. The following is given by Power and Salway[1] as its composition :

Camphene	80 per cent.	
Dipentene	8·0	,,
Iso-eugenol	2·0	,,
Geraniol	6·0	,,
Myristicin	4·0	,,
Myristic acid	·3	,,
Saffrol	·6	,,
Eugenol	Small quantities.	
Pinene		
Linalool		
Borneol		
Terpineol		
Acetic acid	Traces.	
Formic acid		
Butyric acid		
Octoic acid		

The fat, called *nutmeg butter*, is obtained by applying pressure to the kernels between hot plates ; it is of a yellowish colour and agreeable odour. The fat of genuine mace is of a yellowish-brown colour ; that of Bombay mace is light yellow. The *volatile oil* is obtained by distilling powdered nutmegs with water ; it is a pale straw-coloured liquid, soluble in ether and alcohol, having the pungent taste and odour of nutmegs.

Nutmeg is aromatic, stimulant, and stomachic, much used and of great value as a flavouring for various foods. A small quantity is usually sufficient to flavour any food required by one person. In large doses nutmeg is narcotic, poisoning having occurred through the mastication of a portion of a nut ; this is due to the essential oil. The medicinal dose of nutmeg is from 0·3 to 1·25 grammes, beyond which limit it is dangerous by sometimes producing stupor, delirium, a sense of oppression in the chest, headache, thirst, etc. ; fatal consequences have followed the consumption of a whole nutmeg.

Mace is also a stimulant, carminative, and valuable flavouring agent ; its excessive use is apt to produce narcotic effects similar to those of camphor.

Pepper : The dried unripe fruit of *Piper officinarum*, called "long pepper," and *P. nigrum*, or black pepper, N.O. Piperaceæ. The peppers are almost entirely confined to the tropics, and especially to Asia and America ; some are found in Cape Colony, but they are rare in other parts of Africa.

Black and White Pepper are both the fruit of the same tree, *P. nigrum*, a climbing plant which grows wild in the forests of Malabar and Travancore, and is cultivated throughout India,

[1] *Chemical News*, 1907, ii. 315.

Siam, Indo-China, Java, Borneo, Sumatra, the Philippine Islands, and the West Indies. The greatest quantity of pepper is, however, produced in the regions of Penang, Johore (near Singapore), and the island of Rio ; Singapore is the principal emporium for pepper in the East. The names of commercial varieties indicate their source. White and black pepper are merely due to a difference in the treatment of the berries, from which results a difference in the composition as well as the colour.

The plant is a rambling shrub which requires supporting in the same way as a vine ; the trees are propagated by cuttings, begin to bear fruit after they have grown three or four years, and produce two crops a year. The fruit grows on a spike, or like a bunch of red currants, each berry being the size of a pea, green at first, then red, and finally black when quite ripe. They are gathered before they are ripe—in fact, as soon as those at the base of the spike turn red. They are dried in the sun, and afterwards trodden or beaten on mats to detach them from the stalks. The dried fruit constitutes **Black Pepper,** and the best varieties are those of Penang, Tellicherry, and Malabar.

White Pepper consists of berries which have been decorticated. The fruit is allowed to become quite red, or even black, before it is gathered ; it thereby loses some of its pungency, but attains a finer flavour and aroma than black pepper. The berries are carefully selected, only the finest being used for this purpose. After being plucked, they are kept indoors for a few days, until the pulpy matter becomes softened by fermentation or putrefaction. They are then rubbed together by hand to remove the pericarp and pulp, being afterwards washed, blanched, and dried in the sun. The chief sources of white pepper are Penang and Singapore, but the finest berries are those of Tellicherry. Sometimes white pepper is prepared by *decorticating* the black peppercorns—*i.e.*, by grinding off the outer rind or pericarp after they have been dried. Such berries are sold as *decorticated pepper*, and as a rule are deficient in flavour and pungency.

Ground Pepper is rarely the produce of a single variety of the berry ; like coffee and tea, it is usually the product of several kinds blended together. A common mixture consists of equal parts of Penang berries to give strength, Malabar to give flavour and aroma, and Sumatra to give colour. The composition of household pepper varies as follows :

Water	10·00 to 15·0 per cent.
Piperin	3·00 ,, 9·0 ,,
Oleo-resin	·75 ,, 3·2 ,,
Volatile oil	·50 ,, 1·0 ,,
Albuminoids, starch, and cellulose	55·00 ,, 86·0 ,,
Ash	·80 ,, 5·0 ,,

The chief active ingredient in pepper is **piperin** ($C_{17}H_{19}NO_3$), a crystalline alkaloid substance, common to all the pepperworts, which yields *piperidin* and *piperic acid*. The proportion of piperin

varies in berries of different varieties, but is usually from 5 to 9 per cent. It can be obtained and its percentage ascertained by mixing finely powdered pepper with twice as much slaked lime, mixing it to a paste with water, and boiling for fifteen minutes. It is then evaporated to dryness on a water-bath ; the residue is powdered, and exhausted with ether, from which the piperin is recovered by evaporating the ether, washing it with alcohol, and recrystallization. It is in the form of colourless transparent crystals or prisms which are tasteless, but an alcoholic solution has a pungent taste like pepper. The *volatile oil*, 1 to 2·3 per cent. contributes flavour, has a mild taste and odour of pepper ; it is obtained by distillation, and consists of terpenes, including phellandrene. The *oleo-resin* is a dark green substance, having a hot, pungent, peppery taste, and contributes to the pepper the character of pungency. The starch of pepper is the natural constituent of the berry, and exists in a greater proportion in white or decorticated than in black pepper. The proportion of ash is important ; in black pepper it varies from 4 to 6 per cent., but genuine white pepper only contains 1 to 3 per cent. Should any sample of white pepper contain more than 3 per cent., it must be held as adulterated, especially if the ash includes more than 0·6 per cent. of chalk or carbonate of lime.

The berries are adulterated by inferior berries of the same species, also by other pepperworts—*e.g.*, *Pimento officinalis ; Piper trioicum*, an extremely pungent berry, native of the Circars, and imported from Madras ; *Cocobryon capense*, from the Cape of Good Hope ; also *Peltobryon longifolium* and *Serronia jaborandi*, from South America. White pepper is adulterated by berries bleached by lime, whitewash, or clay, which can be rubbed off ; sometimes their colour is improved by a mixture of chalk, baryta-water, and rice starch, with a trace of chrome. *Ground pepper* is adulterated by the *hulls*, or parts removed from the berries when making white peppercorns ; they contain no piperin. Long pepper, horseradish, mustard, chillies, and other spices which contain no piperin, are also used. "Black pepper dust," containing 30 to 40 per cent. of mineral matter, is also sold for purposes of adulteration. Two powders resembling black and white pepper, but composed of the seeds of the vetch, are sold in France for this purpose under the names of *Le Griffon* and *Le Mito ;* they contain no piperin.

Composition of Le Griffon.[1]

Protein	17·60 per cent.
Fat	4·10 ,,
Extractives	62·77 ,,
Moisture	12·40 ,,
Ash	3·05 ,,

Another adulterant, known as *poivrette*, consists of the powdered stones of olives. The hulls of mustard, cotton, and linseeds, are also used for the same purpose.

[1] F. Jean, *The Analyst*, xxx., January, 1905.

COMPOSITION OF BLACK AND WHITE PEPPERCORNS—PERCENTAGES.[1]

Commercial Varieties.	Ash.	Ethereal Extract.	Piperin.	Oleo-Resin.
Black : Singapore	3·5 to 4·5	8·76 to 9·73	6·58 to 7·68	1·08 to 2·60
Tellicherry	3·8 ,, 4·8	7·26 ,, 8·85	5·91 ,, 6·82	·70 ,, 2·80
Allippy	4·7 ,, 4·8	9·47 ,, 9·65	6·75 ,, 7·50	1·95 ,, 2·72
Trang	3·8 ,, 3·9	8·44 ,, 8·83	5·12 ,, 5·61	3·22 ,, 3·32
Lienburg	3·6 ,, 4·0	8·70 ,, 9·48	5·98 ,, 6·59	2·20 ,, 3·20
Lampong	5·0 ,, 5·5	8·76 ,, 10·61	7·00 ,, 8·30	1·16 ,, 2·30
Sumatra	4·0 ,, 4·3	9·22 ,, 9·28	6·68 ,, 7·00	2·28 ,, 2·54
Acheen	4·0 ,, 4·7	9·20 ,, 10·10	7·10 ,, 7·96	2·10 ,, 2·50
White : Coriander	·8 ,, 1·0	7·90 ,, 11·68	6·81 ,, 9·00	1·06 ,, 2·68
Singapore	1·0 ,, 1·2	8·20 ,, 8·78	6·78 ,, 7·26	1·00 ,, 1·67
Penang	2·1 ,, 2·8	6·80 ,, 7·20	5·74 ,, 6·76	·44 ,, 1·30
Decorticated	·8 ,, 1·9	6·60 ,, 7·64	6·25 ,, 7·64	·24 ,, 1·39
Hulls (or parts removed)	·7 ,, 1·9	5·00 ,, 8·93	none	5·00 ,, 8·93

[1] J. W. Gladhill, *Amer. Jour. Pharm.*, 1904, 171.

Long Pepper is the fruit of *Piper officinarum* (*Piper longum*) or *Chavica roxburghii*, a native of India, the Philippine Islands, Brazil, and Peru. It consists of the female spikes, bearing very small berries closely packed together; the whole averages 1½ inches long and ¼ inch thick. The fruit is gathered in January before it is ripe, and dried. The berries are not separated from the stalk. Like black pepper, it contains piperin (6 per cent.), volatile oil, and oleo-resin, together with starch, albuminoids, etc. The proportion of piperin is lower than in black pepper, and the oil has a disagreeable odour, for which reason this kind of pepper is seldom used alone. It is a constituent of pickling spice, and used as an adulterant of ground pepper. The chief sources of supply are Penang and Singapore.

Pickles consist of various kinds of vegetables, such as onions, gherkins, kidney beans, cauliflower, cabbage, samphire, walnuts, etc., pickled in vinegar and various spices, such as pepper, chillies, cloves, allspice, mace, etc. They are very appetizing morsels, and have a genuine condimental value.

Pickles may contain copper, and used very frequently to do so, from the mode of their manufacture. It used to be stated in cookery-books that the vinegar should be boiled in a brass or copper pan; the following are examples—"*To pickle Gherkins:* Boil the vinegar in a bell-metal or copper pan; pour it boiling hot on the cucumber . . ." "*To make Greening:* Take a bit of **verdigris** the size of a hazelnut, finely powdered, ½ pint of vinegar, a bit of alum, and bay-salt. Put all in a bottle and shake it; let it stand to clear. Put a teaspoonful into whatever you wish to be green."

Salt: **Sodium Chloride** ($NaCl_2$).—This condiment has been used from time immemorial. It occurs in immense underground deposits in various parts of the earth, forming "rock-salt" in the keuper marls of the triassic formation. In many places a saturated brine, containing about 25 per cent. of sodium chloride, is formed on the top of the salt-beds, owing to the percolation of water through the earth's strata. As a result of this formation, brine-springs occur in many places. Chloride of sodium also exists in large proportion in sea-water.

Composition of Brine and Salt—Solids per Cent.

	Brine.			Salt.	
	Northwich.	Stoke Prior.	Droitwich.	From Brine.	From Sea-Water
Sodium chloride	25·199	25·491	22·455	97·35	89·35
,, sulphate	·143	·595	·392	1·13	—
Calcium sulphate	·393	·262	·385	·83	1·50
Magnesium carbonate ..	·110	·033	·033	·03	·39
,, chloride	—	—	—	·07	·93
,, sulphate	—	—	—	—	3·14

Domestic salt may therefore be made in several ways: 1. By dissolving the rock-salt, purifying and filtering the solution, and evaporating it by the aid of heat. 2. Concentration of brine from the springs. The chief seats of salt manufacture in England are in Cheshire, Yorkshire, and Worcestershire; at Stassfurt in Germany; Wieliczka and Stebrük in Austria; in New York, Michigan, and Louisiana, in the United States. The brine is evaporated in large iron pans at a temperature of 107·5° C. 3. Evaporation of sea-water. In Sicily and some other countries salt is made in enormous quantities by concentration of the sea-water to the point of crystallization, purification, filtration, and recrystallization.

Sauces.—There are sold numerous liquid condiments which are highly esteemed by a host of consumers for their appetizing properties. Many of these sauces, or relishes, consist of a basis of vinegar, with Indian soy, mushroom ketchup, walnut ketchup, cayenne pepper, allspice, garlic, and other condiments and aromatic spices, to give flavour, pungency, and aromatic properties. A notable example is *Worcestershire Sauce*, which is composed of the following ingredients:

Soy	1 quart.
Malt vinegar	7 pints.
Lime-juice	¾ pint.
Tamarind	1 pound.
Chillies	1¼ ounces.
Cloves	1¼ ,,
Garlic	3 ,,
Shallots	6 ,,
Anchovies	3 ,,

. These substances are prepared by peeling and bruising the garlic and shallots with the anchovies. They are then mixed with the vinegar, soy, and spices, boiled together for twenty minutes, allowed to get cold, and strained.

There are many other examples; most of the ingredients have been described in the foregoing pages. **Soy** is a liquid preparation of soy beans (see Legumes), which is prepared by boiling the beans with salt, reducing them to a pulp with wheat or barley meal, and allowing the mixture to ferment. After three or four weeks the liquid is poured off and clarified, forming a thick dark brown liquid, used as a basis for various sauces. An imitation, called **English soy,** is made by heating together 10 parts treacle, 16 parts extract of malt, 4 parts mushroom ketchup, and 9 parts common salt; it is allowed to stand twenty-one days, and afterwards clarified. **Mushroom ketchup** is a sauce made by covering mushrooms with common salt for three days, then removing the juice by expression, and boiling it with chillies, allspice, ginger, mace, etc. It is used for flavouring gravy and making sauces, etc.

Walnut Ketchup is made by pickling green young walnuts in vinegar and salt for eight days; the liquor is then expressed and boiled with spices, such as shallots, garlic, horseradish, ginger, cloves, nutmeg, mace, and allowed to macerate a short time before straining.

SWEET HERBS.—These include the ordinary herbs used in domestic cookery, and are treated under one heading as a matter of convenience. The following belong to N.O. Labiatæ: Common mint, thyme, sage, sweet marjoram, basil, sweet basil, and savory. There are in addition parsley and fennel, of N.O. Leguminosæ, bay-leaf, cherry-laurel, and a few others. Their fragrance, aromatic, carminative, and antiseptic properties, are all due to aromatic oils.

Common Mint, garden mint, or spearmint (*Mentha viridis*), is largely used for culinary purposes, and especially as mint sauce. The oil, upon which its flavour and properties depend, contains pinene ($C_{10}H_{16}$), a stearoptene ($C_{10}H_{20}O$), and a liquid ($C_{10}H_{14}O$) which is isomeric with carvol.

Thyme (*Thymus vulgaris*) grown in gardens is a native of South Europe, and is not the same as the wild-thyme (*T. serpyllum*) found abundantly on the moors and mountains of some parts of Great Britain. Both varieties contain the same oil, which gives the fragrance and aroma to the plant, but the cultivated plant contains more than the wild variety. Oil of thyme contains pinene ($C_{10}H_{16}$), cymol or cymene ($C_{10}H_{14}$), and 25 to 42 per cent. of thymol ($C_{10}H_{14}O$).[1] On making an extended analysis of oil of thyme, Labbé found it yielded the following :[2] Menthene 15, cymene 21, linalool 5, borneol 8, hydrocarbon isomeric with pinene 17, and a carvacrol-containing residue 4, per cent.

Sage (*Salvia officinalis*) : The ordinary garden plant. The aromatic oil has the following composition :[3] Salviol ($C_{10}H_{16}O$) 40, hydrocarbon ($C_{10}H_{19}$) 20, another hydrocarbon of same formula 20, a camphor ($C_{10}H_{16}O$) 10, cedrene ($C_{15}H_{24}$) 10, per cent., and a trace of cymene ($C_{10}H_{14}$).

Sweet Marjoram (*Origanum marjoranum*) is a native of North Africa, a sweet fragrant and aromatic herb cultivated in most gardens for culinary purposes. The oil consists of 40 per cent. of terpinene, some terpineol, with small quantities of acetic and other organic acids.[4] Bruylants found that it consists of 5 per cent. of terpene, 85 per cent. of a dextro-rotatory mixture of camphor and borneol, and 5 per cent. of resin. Cretan oil of marjoram consists of 50 per cent. of carvacrol, a little phenol, and the rest of terpenes.[5]

Sweet Basil (*Ocymum basilicum*) : A native of India and Africa, cultivated in England and Europe as an aromatic herb for seasoning soups and various dishes with its peculiar flavour, resembling cloves. The oil yields pinene, cineol, camphor, and methyl-chavicol, the latter, again, splitting into anethol and anisinic acid.[6]

Savory : Summer Savory (*Satureia hortensis*) and Mountain Savory (*S. montana*). Both species are grown in gardens as aromatic herbs for flavouring soups, entrées, and other made dishes. They have a powerful aromatic odour and a warm, rather bitter

[1] Thorpe's "Dictionary of Applied Chemistry," vol. iii.
[2] *Bull. Soc. Chim.*, xix. 1009. [3] Attfield's "Chemistry."
[4] Biltz, *Berl. der Deutsch. Chem. Ges.*, xxxii. 993.
[5] Brit. Pharm. Codex, p. 219. [6] *Archiv. der Pharm.*, 1897, ccxxxv. 175.

taste. The leaves are sometimes nearly covered with small vesicles containing the oil upon which the properties depend. The oil consists of 50 per cent. carvacrol, 20 per cent. cymene or cymol, 30 per cent. of a terpene and a phenol which differ slightly from carvacrol.[1]

Bay-Leaf: The leaf of the laurel or sweet bay (*Laurus nobilis*, N.O. Lauraceæ), a native of the Mediterranean countries, but grown in England in shrubberies and sheltered gardens. The leaves have an agreeable odour, a bitter aromatic taste, and are used for flavouring custard, blancmange, etc. They contain a fixed oil which can be expressed, and an essential or volatile oil obtained by distillation. The oil of bay-leaf yields **myrcene** (a terpene), eugenol, chavicol, citral, and phellandrene.[2]

Cherry-Laurel Leaves (*Cerasus lauro-cerasus*, N.O. Rosaceæ) have a taste and flavour resembling that of bitter almonds; they are used to flavour custards, blancmange, and puddings. According to Lehmann, they yield 1·38 per cent. of prussic acid.[3] The chief constituent of the leaves is the glucoside lauro-cerasin, which is hydrolyzed by emulsin into dextrose, hydrocyanic acid, and benzaldehyde.

Fennel (*Fœniculum capillaceum*, N.O. Umbelliferæ): A native of Europe, and naturalized in England; used in sauce for heavy kinds of fish—salmon, mackerel, etc. It has similar properties to other aromatic spices. The oil contains anethol, fenchone, dextropinene, methyl-chavicol, phellandrene,[4] and other bodies.

Parsley (*Petroselinum sativum*, N.O. Umbelliferæ) is a native of Europe and the East, and was brought to England from Sardinia in 1548. Nearly all the wild-parsley in Europe consists, according to De Candolle, of "escapes" from cultivation. It is much used in culinary preparations. All parts of the plant contain an oil, to which its flavour and properties are due. The plant also contains **apiin** in the leaves, a peculiar substance readily extracted by water, and gelatinized on boiling; this pectinous substance dissolved in alcohol yields a crop of crystals. The crude oil, which is most abundant in the seeds, contains **apiol** or **apiolin,** a dark oily liquid, yielding a stearoptene which crystallizes in needles, besides a substance analogous to myristicin, small quantities of apiolic acid, tetra-methyl-apionol, and tri-methyl-gallic acid.[5] Apiol is said to predominate in German and myristicin in French parsley. The main use of parsley is to make a sauce; like many other aromatics, it is scarcely eaten in sufficient quantity to produce its specific effects.

Essence of Sweet Herbs is frequently sold to flavour soups, entrées, and other culinary preparations. The following is a good example: Take of thyme, 4 parts; winter savory, 4 parts; sweet marjoram, 4 parts; sweet basil, 4 parts; grated lemon-peel, 2 parts; celery-seeds, 1 part; alcohol, 50 parts; bruise them all, macerate in the alcohol for seven days, and filter.

[1] Watts's "Dictionary of Chemistry."
[2] *Pharm. Rundschau.*, xiii. 60.
[3] *Year-Book of Pharmacy*, 1874. 35.
[4] *Ibid.*, 1902, 101.
[5] *Gazz. Chim. Ital.*, xxx. 240.

PART V

BEVERAGES

CHAPTER XXX

TEA, COFFEE, AND COCOA

Tea.

Tea consists of the young shoots and leaves of *Thea chinensis*, *Thea assamica*, and various hybrid species of the genus Camellia, N.O. Ternstrœmiacæ. It grows in tropical and subtropical regions, where the rainfall is not less than 60 inches per annum, and in some of the tea-growing districts is nearly double that amount. The tea which is now found growing wild in Assam and Burmah is believed to be the progenitor of the existing varieties There is no certain evidence of its having been found wild in China, although it has been cultivated there for many centuries. Fortune, who carefully inquired into the cultivation of tea in China, does not mention the wild plant; but Fontanier says it grows abundantly in Manchuria. It is probable that it grows wild in South-East China, where naturalists have not yet penetrated.[1] Louvier says tea is also found growing wild in Cochin-China. It may be concluded, therefore, that the tea-plant grows wild in the mountainous regions which separate India from China.

An oft-quoted legend is said to account for its origin. A priest, who came from India into China in A.D. 519, having succumbed to sleep when he wished to watch and pray, in a moment of anger cut off his eyelids, which were changed into a shrub—the tea-tree—whose leaves were eminently calculated to prevent sleep. But tea was certainly known to the Chinese before A.D. 519, and it was probably not brought from India. It is true that reliable authorities for its *cultivation* prior to that date have not been found. But the "Pentsao" (2700 B.C.) mentions tea, and so does the "Rye" (300 or 600 B.C.); and the commentator of the latter work in A.D. 400 gave details of the plant and its infusion. Its use in China is therefore very ancient—probably 4,000 or 5,000 years. Its cultivation was introduced into Japan in the thirteenth century, although it was not until some centuries later that it was brought to England—in fact, it was brought to Europe in 1610 by the Dutch East India Company.

Writing in his Diary in 1660, Pepys says: "I sent for a cup of *tee*, a

[1] De Candolle, "Origin of Cultivated Plants," p. 119.

China drink, of which I had never drunk before." In 1664 the East Indian Company considered a gift of *two pounds* of tea to the Queen of England a rare gift. When first introduced for sale, it cost *ten guineas* a pound in London, and the duty in 1689 was five shillings a pound. It is now sold at a price within reach of the poorest person, and in Great Britain is consumed to the extent of six pounds per head per annum. Until the year 1862 nearly all the tea consumed in Great Britain was imported from China. About that time Indian or Assam tea began to arrive; and although the importation of China teas continued to increase until 1879, their use has since declined, until at the present day they form little more than one-tenth of the total consumption.

Source.—The teas consumed in the United Kingdom are derived at the present time from India and Assam, 55·6 per cent.; Ceylon, 33·3 per cent.; and China, 11·1 per cent. The *annual exports* of tea from the chief countries where it is grown at the present day are as follows: China, 300,000,000 pounds; British India (Assam and Bengal), 190,000,000 pounds; Ceylon, 150,000,000 pounds; Japan, Java, Straits Settlements, Fiji, Mauritius, Caucasus, Brazil, South Carolina, Natal, etc., small quantities only. In India and Ceylon about 1,000,000 acres of land are occupied in its cultivation.

Manufacture.—The conditions which favour the growth of tea are opposite to those which favour the vine; the shrub will not bear frost or drought. No wine-growing country produces tea for exportation. The vine grows in China, but the manufacture of wine is unimportant; on the other hand, the climate is adapted to the growth of tea. After China, Japan, and Assam, it is in Ceylon, Java, and Brazil, that tea is largely grown, and in these places wine is little cultivated; while in dry regions, such as Australia and South Africa, grapes grow freely and wines are exported.

Under cultivation tea-plants grow to a height of 3 or 4 feet; but when allowed to grow naturally—that is, without picking and pruning—they may attain a height of 30 or 40 feet, and the stem may be 12 or 15 inches in diameter. There are in China two species of tea—*Thea bohea*, named after the Bohea Mountains, and *Thea viridis;* while *Thea viridis assaminensis* is the stock indigenous to India. As a matter of fact, however, it has been proved that there is only one species, comprising several varieties, from which all kinds of green or black tea are made. Most of the teas grown in India are hybrids produced by crossing the indigenous with the Chinese variety. The leaves of Assam tea are long, thin, membranous, and often undulated; while those of the China shrub are short, thick, coriaceous, and generally straight. The hybrids, however, bear smaller leaves than the indigenous Assam shrubs, and are more hardy than those of China. The result of crossing the Assam tea with *Thea viridis chinensis* is an improvement as regards cultivation, but the effects of crossing with the Bohea variety is doubtful, and sometimes held to be injurious.

The plants are grown from the seeds in nursery beds, and are planted in their permanent position when about 4 inches high, in

rows 4 feet apart, and with 4 feet between each plant—that is, about 2,000 to 2,500 plants to an acre. When one and a half years old the shrubs are about 2 feet high, and are then cut down to 10 or 12 inches. At three years old they are again cut down to 15 inches. This severe pruning causes the shrubs to spread and produce a great quantity of young shoots. The mature tree is about 3 feet high.

The picking commences when the shrub is three years old. Each plant "flushes"—that is, it sends out young shoots four times a year; and at each "flush" the young leaves and shoots are picked off. But the leaves are picked off somewhat irregularly, as much as fifty times a year in some plantations, and only twenty times in others. The leaf-buds are carefully separated from the shrub with the finger and thumb. The best Chinese and Japanese teas are obtained from the *first* flush of leaves, but this is not so in the case of Ceylon and Indian teas, where the shrubs are systematically plucked about every fortnight. One hundred pounds of fresh leaves yield about twenty-five pounds of tea. The tea is black or green according to the mode of treatment.

Black Tea.—The mode of manufacture differs somewhat in each country.

1. In China—(*a*) *Withering:* The leaves are *withered in the sun* on mats or trays.

(*b*) *Fermentation.*—They are then collected together in a cool building, where they are tossed about until they are flaccid and soft. After this treatment they are allowed to remain undisturbed in a heap for about twelve hours until they attain a slightly reddish tinge and a somewhat fragrant odour. These changes are brought about by the action of enzymes.

(*c*) *Rolling and Roasting.*—After fermentation they are roasted for five minutes in a shallow pan over a wood fire, and then rolled by hand upon a rattan cane table. This process breaks up the cells and fibres of the leaves. Some manufacturers have the leaves rolled before they are roasted.

(*d*) *Exposure to the Sun.*—They are now once more exposed to the sun out of doors on rattan or bamboo frames for three hours.

(*e*) *Roasting and Rolling.*—When they are dry enough the leaves are roasted and rolled a second time.

(*f*) *Drying and Rolling.*—They are then spread upon sieves to a depth of 1 inch, and dried in a stove, and afterwards rolled again. They are dried and rolled alternately three times. Finally they are sifted and dried again at a reduced heat.

2. In Japan the *withering* only lasts one hour; the leaves are then *rolled* into small balls and allowed to *ferment*, being exposed to the sun during this time, but covered with a cloth. This exposure lasts from forty to sixty minutes when the temperature is 40° C. Too short a time does not get rid of the raw flavour; too long a time leads to the development of a sour taste; the right moment to stop the process is known by the colour of the leaves

inside the ball. The leaves are rolled a second time, dried in the sun, and afterwards *fired* in a furnace wherein the temperature is 65° C., and gradually raised to 80° C. The *firing* is finished when the leaves are brittle enough to break by a slight pressure. Red leaves are then picked out by hand.

3. In Assam, Bengal, and Ceylon, the leaves are (*a*) *withered* by being put on wire trays and exposed to the sun, or, in large factories, in a room about 40° C., free currents of air being drawn through and over them by machine-driven fans. When the leaves are sufficiently flaccid, or soft and yielding, like an old kid glove, they are ready for rolling.

(*b*) *Rolling.*—They are now rolled by hand or machinary in order to rupture the sap-containing cells. The use of machinery is better than the old-fashioned hand method ; it is quicker and more thorough. The leaves are fed between two tables of wood, actuated by cranks, which give them a circular motion, the tables rotating in opposite directions. The rolling compresses the leaves into little lumps.

(*c*) *Fermentation.*—As soon as the rolling is finished, the little rolls are slightly moistened, and exposed to the air in a layer about a foot thick, for the process of fermentation. This is considered the most critical time in tea manufacture. During the process the tea loses its raw smell and acquires a fine flavour. The balls stand until the fermentation is complete, the quality and flavour of the tea depending upon its being stopped at the right moment. There are no fixed rules as regards the time. In hot weather it may occupy only twenty minutes ; in cool or wet weather it may take two or three hours. It is known by the leaves becoming a light copper colour, and of aromatic, astringent odour. If stopped too soon the tea is raw ; if allowed to go on too long it becomes sour and is spoilt. Processes (*b*) and (*c*) are repeated twice in some manufactories.

(*d*) *Firing.*—The leaves are collected, spread out and dried as soon as possible after the satisfactory termination of the fermentation. They are dried or "fired," to stop fermentation and to harden the leaves, in a chest of firing drawers consisting of trays of fine wire gauze, which can be heated all at once. In some places the leaves are passed on an endless band through an oven at 200° F., from which they emerge black and crisp after a short exposure. Finally the tea is assorted by machinery, the smaller and finer leaves being separated from those of a larger growth.

Green Tea.—As already stated, green tea merely differs from black tea by the mode of its preparation, which also differs somewhat in different countries. It is unfermented. It is prepared as follows :

1. In China, according to Knapp's "Chemical Technology," the leaves are (*a*) *withered* either in a pan over a fire at a temperature of 160° F. or by steaming them. In the latter method they are spread on bamboo trays over a boiler, where they remain for an

hour or two. They are then heaped on tiled floors, either out of doors or in the shade. They thus get rid of the raw flavour, but preserve their colour.

(*b*) *Roasting.*—They are then roasted over a wood fire until they become moist and flaccid. About ½ pound of leaves at a time is put into an iron pan over the fire and rapidly stirred.

(*c*) *Rolling.*—They are next rolled into balls, by which means the leaf cells are broken, the juices liberated, spread over the leaves, and a fine aroma produced. They are now allowed to remain undisturbed for a few minutes, during which time they cool down and "sweat."

(*d*) *Second Roasting.*—They are then roasted again over a charcoal fire for one to one and a half hours, being gently moved about. At the end of this roasting the green colour is fixed, being dull at first and gradually becoming brighter.

(*e*) *Sorting.*—Finally the tea is sifted to free it from dust and impurities, being sorted, graded into different sizes by the use of larger or smaller sieves, and submitted to a third roasting.

2. In Japan[1] similar methods are used. The leaves are withered by exposure to steam, a ventilating fan being used to remove moisture and steam as it passes through them. They are then alternately rolled and roasted three times. A charcoal fire is used, and the temperature of the leaves at the two first roastings is maintained at 75° to 85° C., but in the last roasting only from 65° to 75° C.

3. In India and Ceylon[2] machinery is used almost exclusively, thereby insuring greater uniformity and cleanliness. The leaves are fresh-gathered twice daily, and submitted to the following processes, being alternately rolled and exposed to the sun four times:

(*a*) *Drying.*—The leaves are dried at a low heat.

(*b*) *Roasting*—They are then roasted in pans over a fire at 160° F. (82° C.), being constantly stirred for seven minutes.

(*c*) *Rolling.*—They are then rolled and dried in the sun alternately four times.

(*d*) *Second Roasting.*—They are again submitted to the same degree of heat in open pans, and stirred as before.

(*e*) *Beating.*—After this they are put into bags and *well beaten*, being then allowed to remain undisturbed all night.

(*f*) *Third Roasting.*—They are now roasted and stirred at 160° F. once more, the temperature being gradually dropped to 120° F.

(*g*) *Sorting.*—Finally they are sifted, sorted, and picked.

Changes in the Leaves during Preparation.—The leaves are softened by withering or steaming, the leaf cells and fibres are broken by rolling, the sap and cell juices are liberated, spread over the tissues, and finally dry up. The fresh leaves contain 75 per cent. of moisture, the finished product only 5 to 9 per cent. During

[1] Kozai, "Tea and its Manufacture," Bulletin 7, College of Agriculture, Japan.

[2] Bannister, the Cantor Lectures, 1890.

the fermentation of black tea certain changes occur by which the colour is turned from green to black, an increase in the amount of essential oil occurs, and bitterness is developed. At the same time some of the tannic acid is oxidized and rendered less soluble, whence it follows that an infusion of green tea contains more tannin than that of black tea while the latter has more colour. The principal agent in the fermentation and colouring of the tea is an *oxydase* or enzyme which exists in the leaves. This oxydase occurs in greatest quantity in the unopened tip-leaf of the shoot, but it diminishes with the growth and expansion of the stalk and its leaves. The proportion of this enzyme present in a given sample bears some relation to the proportion of phosphates in the soil whereon it is grown ; it increases in amount during the *withering* of the leaves, and those leaves which contain the highest proportion make the finest-flavoured tea.[1] Formerly green tea was made to a large extent in the same way as black tea, and afterwards *faced* with indigo or Prussian blue ; but artificially coloured tea is rarely placed on the market at the present day, or only to a comparatively small extent.

Nomenclature.—Tea varies in quality according to the country, and even the district, in which it is grown, and the age of the leaves when they are picked. The leaves of a young shoot vary in size from the tip down to the stem, from which arises a special nomenclature. Thus we have—

1. **Flowery Orange Pekoe**, derived from the *tip-leaf*, which is practically an unopened leaf-bud.

2. **Orange Pekoe** consists of the next leaf to the tip, and is therefore a small and only partially-grown leaf. These two form the finest tea, as the leaves have the least fibre and contain the most juice.

3. **Pekoe** consists of the next leaf on the stem, and is therefore a little larger than the former.

4. **Souchong** consists of the next leaf in order upon the stem, and is therefore somewhat larger than either of the former.

5. and 6. **Congou** and **Bohea** consist of the largest leaves next to the stem, but these are now seldom picked. The term Bohea has practically disappeared from commerce, while Congou signifies the great care that is needed in the treatment of the leaves to produce good tea. In China the leaves 1, 2, and 3, are all used in Pekoe teas, the larger leaves constituting Souchong. In the retail trade Pekoe and Souchong merely mean unblended tea, and Congou blended tea.

China Teas.—These are undoubtedly the most delicately flavoured teas. They are green and black and have little astringency, but are deficient in " body."

1. **Green.**—The green teas mostly come from Northern China and Japan, very little being exported from other countries. The principal varieties are—

[1] Mann. *Jour. Asiatic Soc.*, Bengal, 1901, ii.

(*a*) *Young Hyson* (Yu-Chien—*i.e.*, before the rains) ; it consists of the leaf-buds and the first leaves picked in April. It gives a clear pale liquor, somewhat pungent and of strong, sharp flavour.

(*b*) *Gunpowder* is carefully selected Hyson, flavoured by addition of leaves of the sweet-scented olive (*Olea fragrans*). It yields a clear pale-straw-coloured liquid, with delicate flavour, but inclining to bitter.

(*c*) *Imperial*, consists of a larger leaf than either of the foregoing, and is seldom sent to Europe.

(*d*) *Twankay* is a low quality of green tea, giving a muddy liquor of somewhat rough taste and coarse flavour.

2. **Black.**—(*a*) *Pekoe*, consisting of the youngest leaves and leaf-buds, as indicated above, picked in April, and sometimes flavoured with orange, rose, or jasmine flowers.

(*b*) *Monings*, consisting of a small delicate leaf from the North of China. It has a peculiar malty flavour, and yields a soft, smooth beverage.

(*c*) *Kaisows* are teas grown in Southern China. The original teas of this district had a reddish colour—hence the name. They have more "life" in the cup, but have not such a full flavour as Indian teas of the same name.

(*d*) *Oolong* teas are from Formosa ; they give an infusion which is pale, pungent, and slightly bitter. They are chiefly used for blending.

(*e*) *Souchong* teas have a delicate flavour, and are said to be the finest black teas.

(*f*) *Scented Orange Pekoe* is from the district of Canton. It yields an infusion of aromatic flavour, but pale and strong. It is chiefly used in blending to give bouquet.

(*g*) *Scented Caper* is from the same district, has similar characteristics, gives a similar infusion, and like it is chiefly used for blending. It should be noted, however, that it is an unfermented tea, and occupies a position between the black and green varieties.

Indian Teas are mostly of the black variety.

(*a*) *Assam* teas are Flowery Pekoe, Orange Pekoe, Pekoe-Souchong, Souchong, Broken Pekoe, Broken Souchong, Dust, etc. Assam tea gives an infusion which is more remarkable for strength than flavour, of high colour, having considerable body and astringency, and somewhat harsh to the palate. The Pekoe teas, however, are fine, and yield a light-coloured liquor of delicate flavour. Broken Souchong gives a dark liquor, thicker than that from whole leaves, but not so strong. These teas are largely used for blending.

(*b*) *Darjeeling teas* are some of the finest Indian product, and are better suited for use without blending than Assam tea. The leaf is small and regular, has a pleasant aroma, and yields an infusion of lighter colour and less astringency, but of more pleasant fragrance, than Assam, and the best samples are said to be equal to China tea of the finest quality.

Tea-Blending.—Black tea, as it is used in the household, is nearly always a combination of Chinese, Indian, and Ceylon teas. The art of tea-blending has gradually developed and become an important part of the business of a tea-dealer. The mixture should be so blended than an infusion of the leaves is of a reddish-golden colour, having body, not bitter to the taste, but slightly astringent and aromatic. The leaves of good tea will not be completely unrolled *after five minutes'* infusion, but they should be evenly extracted and have a uniformly coppery colour. The commercial value of tea depends largely upon the flavour, aroma, body, and strength, of the infusion. The bouquet, flavour, and pungency, depend chiefly on the amount and quality of the ethereal volatile oil; body and "strength" upon resins, gum, pectin, albuminoids, and tannin.

The Scenting of Tea.—Caper, scented Orange Pekoe, and Gunpowder teas have a flavour and aroma communicated to them by mingling therewith the flowers of *Chloranthus inconspicuus, Olea fragrans, Gardenia florida,* and *Jasminum sambuc.* The fresh flowers are strewn among layers of tea-leaves before they are roasted, and afterwards sifted out; or the flowers are dried, powdered, and sprinkled over the leaves.

The **Adulteration of Tea** is practised very much less than formerly. The method consists in (*a*) mixing foreign leaves (*i.e.*, of other plants) with tea-leaves—*e.g.*, beech, elm, horse-chestnut, plane, bastard plane, fancy oak, willow, poplar, hawthorn, sloe, etc.; (*b*) exhausted tea-leaves, coloured, faced and glazed, and rolled to represent fresh tea; (*c*) artificial colouring of green tea by Prussian blue, indigo, or graphite (blacklead), mingled with kaolin or Chinese clay, and occasionally gypsum (calcium sulphate).

Spent Tea.—It is illegal, under Sections 30 and 31 of the Food and Drugs Act, 1875, to sell tea which is spent or exhausted.

The Detection of Spent Tea-Leaves or Coffee.—Nestler gave the following simple direction for the detection of caffein in tea, coffee, maté, guarana, or kolanut: A few leaves or grains of the substance examined is placed in a watch-glass and covered with another watch-glass, and placed on a wire gauze support, about 7 centimetres above a source of heat. The upper cover-glass will soon show numerous droplets of a condensed liquid; in ten minutes fine needle-shaped crystals of caffein appear in them, in fifteen minutes a crop of crystals sufficient for microscopical examination will be formed. If the leaves or other substance has been exhausted no crystals will be obtained. Another writer says the above is a very delicate test; a tea-leaf weighing 0·001 gramme gave distinct crystals after heating for ten minutes, but none could be got from spent tea-leaves. It is called the "sublimate test."

The Composition of Tea-Leaves.—Although green and black tea are produced from leaves of the same shrub, their composition is not quite the same. This difference arises from the mode of preparation. The most notable difference is in the amount of

tannic or gallo-tannic acid, which diminishes from 13 per cent. in fresh leaves to 10 or 11 per cent. in green and barely 5 per cent. in black tea ; there is an increase in the proportion of volatile oil and amido-nitrogen due to fermentation. These differences are well shown in the following table of analyses by Kozai :[1]

COMPOSITION OF TEA-LEAVES BEFORE AND AFTER PREPARATION.—PERCENTAGES.

	Fresh Leaves before Treatment.	Made into Green Tea.	Made into Black Tea.
Crude fibre	10·44	10·06	10·07
,, protein (N × 6·25) ..	37·33	37·43	38·90
Total nitrogen	5·97	5·99	6·22
Albuminoid-nitrogen ..	4·11	3·94	4·11
Amido-nitrogen	·91	1·13	1·16
Caffein-nitrogen	·96	·93	·96
Caffein (thein)	3·30	3·20	3·30
Ethereal extract	6·49	5·52	5·82
Other nitrogen-free extract..	27·86	31·43	35·39
GALLO-TANNIC ACID	**12·91**	**10·64**	**4·89**
Ash	4·97	4·92	4·93
Soluble in hot water ..	50·97	53·74	47·23

The analyses of tea by J. F. Geissler,[2] on p. 788, show the extent of the variation of the chief constituents in the Chinese and Indian teas.

The following analyses of China teas, given by Bannister,[3] in some respects more extended than the foregoing, were made of teas purchased at a good price :

COMPOSITION OF CHINA TEAS—PERCENTAGES.

	Green (Hyson).	Black (Congou).
Water	5·96	8·20
Caffein	2·33	3·24
Albumin	16·83	17·20
Nitrogenous extractives ..	7·05	6·79
Dextrin	·50	—
Pectin, pectic acid	3·22	2·60
Tannin	27·14	16·40
Chlorophyll, resin	4·20	4·60
Cellulose	25·90	34·00
Ash	6·07	6·27

The most important components of tea, as regards their physiological effect, are the caffein (thein), volatile oil, and tannin. The amount of tannin varies from 5 to 20 per cent., there being more

[1] *Bulletin No. 7 of College of Agriculture, Japan ;* also Thorpe's "Applied Chemistry," vol. iii., art. "Tea."

[2] *The Analyst*, 1884.

[3] Cantor Lectures, 1890.

VARIATIONS IN THE COMPOSITION OF TEA.—PERCENTAGES.

	Moisture.	Soluble Extract.		Insoluble Leaf.	Tannin.	Thein.	Ash.		
		Half-hour Infusion.	Total.				Soluble.	Insoluble.	Insoluble in HCl.
China green tea (six varieties) :									
Minimum	5·39	30·20	43·30	44·60	11·87	1·52	2·02	2·11	·210
Maximum	7·78	44·70	50·00	49·61	19·11	2·86	5·02	6·38	·660
Average	6·43	36·74	46·56	47·05	14·57	2·02	3·28	3·61	·490
China black tea (Congou, eleven varieties) :									
Minimum	7·65	23·48	27·48	54·50	8·44	1·70	2·28	1·90	·320
Maximum	9·15	32·14	37·06	63·85	13·89	2·87	3·52	3·86	1·310
Average	8·37	28·40	34·45	57·20	11·54	2·37	3·06	2·68	·425
Indian tea (six varieties) :									
Minimum	5·56	37·80	41·32	48·53	13·04	1·80	3·24	1·93	·137
Maximum	6·19	39·66	45·64	53·07	18·86	3·30	3·68	2·22	·296
Average	5·81	38·77	42·94	51·24	14·87	2·70	3·52	2·12	·178
Assam Pekoe-Souchong,[1] average	—	—	43·54	—	21·46	1·50	4·30	1·28	—

[1] Green, *Chemical News*, 1884.

in green than in black tea. Various named varieties were found by Allen[1] to contain the following amount of tannin per cent.: China tea—Gunpowder, 12·95; Moning, 11·76; Pekoe-Souchong, 9·90; Kaisow, 11·35. Assam — Whole leaf, 10·08; broken leaf, 11·33. Ceylon Pekoe—Whole leaf, 13·01; broken leaf, 12·31. Java Pekoe, 12·93. The amount of tannin or gallo-tannic acid sometimes exceeds these amounts; it has reached 39 per cent. in Young Hyson (*Allen*), and 42 per cent. in Caper (*Wigner*). It has been observed that the tip and outer edge of the leaves contain considerably less tannin than the rest, and this portion of the leaves is nearly all broken off in the manufacture of tea and separated in the dust. Properly prepared dust, free from extraneous matter, is therefore valuable for invalids.

The ethereal oil averages about 0·5 per cent.; it is a yellow oil, having a strong odour of tea, a specific gravity lower than that of water, and it solidifies on cooling.

The proportion of thein or caffein varies from 1·35 per cent. (*König*) to 4 per cent. (*Allen*). The proportion in the varieties of tea named has been found to be as follows:

AMOUNT OF THEIN IN VARIOUS TEAS.

China Teas.	
Young Hyson	4·29 per cent.
Gunpowder, low quality	3·18 ,,
,, good quality	4·98 ,,
Congou	2·93 ,,
Bohea	3·21 ,,
Moning	3 74 ,,
Kaisou	3·41 ,,
Indian Teas.[1]	
Pekoe	3·86 to 4·74 ,,
,, picked	4·62 ,,
,, broken	3·95 to 4·81 ,,
Orange Pekoe	4·89 ,,
Mixed tea	3·87 ,,
Assam, low quality	3·03 ,,
,, good quality	4·83 ,,
Ceylon Teas.[2]	
Pekoe: Hardenhuish	4·24 ,,
Venture	3·66 ,,
Morton	4·15 ,,
Broken: Penrhos	4·96 ,,
Radilla	4·30 ,,
Orange Pekoe: Strantheties	4·33 ,,
Nahahua	4·29 ,,
Venture	3·66 ,,
St. Clair	4·09 ,,
Broken	4·26 ,,
Pekoe-Souchong: Woodstock	3·57 ,,
Salsay	3·43 ,,
In hairs from leaves	2·57 ,,

[1] "Commercial Organic Analysis," vol. iii.
[2] Paul; *cf.* Bannister, *loc. cit.*

Estimation of the Caffein in Tea, Coffee, etc.—The following method was recommended by Markownikoff[1]: Boil 15 grammes of powdered tea with 15 grammes of calcined magnesia in 500 grammes of water for some time. Filter the decoction; wash the residue and filter it again. Evaporate the filtrate to dryness with a little calcined magnesia. Then exhaust the dry residue with hot benzol, filter it, and evaporate the solution to dryness. The caffein is left behind in a pure state; weigh it and estimate the proportion. A simpler method is to infuse tea in four times its weight of water; add one part of milk of lime to the drained liquor, evaporate it to dryness over a water-bath; extract the caffein from the deposit by chloroform, evaporate, wash in water, filter and crystallize it; weigh and estimate the amount.

Composition of Tea Infusion.—Prior to the introduction of China tea into Europe, a hot infusion of various leaves formed a familiar beverage. Sage-leaves (dried) were much used for this purpose in England, and it is said they were carried as an article of commerce to China by the Dutch, to be there exchanged for Chinese tea-leaves, which have since supplanted them. An infusion of tea is made by pouring fresh-boiled water upon the tea-leaves in a teapot. The character of the infusion necessarily depends upon the quantity and quality of the leaf, upon the water, its temperature and duration of infusion. The quality of the leaf depends on its source and mode of preparation. The quantity depends upon its weight; some teas are rolled more tightly than others, and consequently they do not unroll so quickly or so speedily become extracted. "A tea-spoonful of tea for each person, and one for the pot," is a time-honoured rule, but a most uncertain rule, because of variations in the measure and weight of the tea. Thus, a caddy spoonful weighs from 45 to 90 grains (3 to 6 grammes), according to the manner in which the tea is measured and the way in which it is rolled. A tea-taster uses the same weight always, frequently a new sixpence, which weighs 1½ grammes; this weight of tea is infused in 100 c.c. of boiling water, and definitely uniform results are thus obtained. **Tea-tasting** has become an important part of the blender's art, for the commercial value of the tea depends on the flavour, aroma, body, and strength, of the infusion.

The infusion contains caffein (thein), tannin, and volatile oil, besides colouring matter, dextrin, gum, resin, pectin, albuminoids, and other extractives, upon which the "body" and "strength" of the infusion depend. The important constituents, however, are the caffein, tannin, and oil. As a general rule it may be stated that practically all the thein and oil are extracted by an infusion of five minutes' duration; but the tannin is not so quickly dissolved out, and more is extracted in proportion to the duration of the infusion. These points are well brought out in the following tables:

[1] *Ber. der Deutsch Chem. Ges.*, ix. 1312.

COMPOSITION OF TEA INFUSION—PERCENTAGES.

	Duration of Infusion.			
	5 Minutes.	10 Minutes.	20 Minutes.	40 Minutes.
Total extract	21·78	25·38	26·81	28·14
Thein	1·11	1·30	1·16	—
Tannin	6·85	8·52	11·73	16·32
Nitrogen, total	1·11	1·16	1·11	1·04
Ash	3·52	4·09	4·15	4·48

	Number of Samples.	Time of Infusion.	
		5 Minutes.	10 Minutes.
China tea : Tannin	8	3·06	3·78
China tea : Thein	8	2·58	2·79
Ceylon tea : Thein	6	3·15	3·29
Ceylon tea : Tannin	6	5·87	7·39
Indian tea : Thein	12	3·63	3·73
Indian tea : Tannin	12	6·77	8·09

The first table is by W. Green,[1] who infused 3·5 grammes of tea in 422 c.c. of boiling distilled water, and covered the pot with a cosy. The second table is by Dittmar,[2] but no account is given of the proportion of tea or the kind of water used to make the infusion. The table is useful as showing the amount of tannin in the infusion of different kinds of tea. The following table is also useful in showing the influence of temperature upon the extraction of tea-leaves. Kellner infused 90 grammes of green tea in distilled water at 50° C.—that is, warm water; he used ½ litre of water for each infusion of the leaves, which lasted five minutes; the liquor was then poured off, another ½ litre of warm water poured over the leaves, and, after five minutes' infusion, this also was poured off and a third lot of water added to the leaves. Finally a fresh quantity of the same kind of tea was taken and infused with boiling water. The results of his analyses are given in the table on p. 792.

After careful examination, Hutchison[3] found that the amount of caffein (thein) in a teacupful of tea varied from 0·73 to 1·21 grains, and the tannin from 0·89 grains in a teacupful made from fine Moning to 4·2 grains in a teacupful made from Moyune Gunpowder tea; or, as an average, an ordinary cupful of tea, after five minutes' infusion, contains 1 grain of caffein and 2 or 3 grains of tannin.

It is certain, however, that not only the temperature but other characters of the water influence the strength of the final product. If

[1] W. Green; *cf.* Thorpe's "Applied Chemistry," vol. iii., p. 804.
[2] Dittmar, *ibid.*
[3] "Food and Dietetics," p. 306.

the water contain too much lime, it will not extract some of the constituents of the leaves so well. On the other hand, soft water is too flat and extracts the bitter principle, which is undesirable. The best water for making "tea" is a moderately hard and well-aerated water, such as that from a hill spring or running stream. It should be poured on the leaves *immediately it boils*; prolonged boiling causes the water to become flat, and therefore it does not make good tea. As practically all the thein and ethereal oil are extracted in five minutes, there is no necessity to infuse it any longer; in fact, prolonged infusion causes loss of aroma and dissipation of the volatile principles, but extracts tannin, bitter principle, and colouring matter, which are better left behind. The proper mode of making tea is to pour upon the leaves *all* the water which is to be used, and after proper infusion to pour it off into another teapot, thereby avoiding the extraction of tannin and the other undesirable constituents.

INFUSION OF TEA MADE WITH WARM AND BOILING WATER COMPARED.

	Water at Temperature of 50° C. (106° F.).				Boiling Water.
	First Infusion.	Second Infusion.	Third Infusion.	Average.	
Total dry matter ..	8·430	7·600	5·690	7·240	15·340
Thein	·910	·740	·750	·800	1·330
Tannin	4·490	4·070	3·970	4·180	7·090
Protein	·528	·476	·452	·486	1·061
Nitrogen-free extract	1·820	1·830	·820	1·290	5·080
Total ash	1·590	1·330	·450	1·290	2·110
,, potash.. ..	·535	·533	·216	·428	1·384

Coffee.

As an article of food, coffee was only introduced within comparatively recent dates. It was wholly unknown to the Greeks and Romans. It has been in use in Abyssinia from time immemorial, but as a beverage has been traced to the Persians, who began to use it in 875. It came into great repute in Arabia Felix about 1454, and soon after in Egypt and Syria, and thence it passed into Constantinople in 1511, and the first coffee-house was opened there in 1551. The "Popular Encyclopædia" says: "The early history of coffee is obscure. Its use is said to have been introduced from Abyssinia into Persia, and thence to have been sent, in the fifteenth century, to a Mohammedan priest at Aden, who, having found that its use cleared the intellect, was exhilarating, and at the same time prevented drowsiness, recommended its use to his dervises, with whom he passed the night in prayer. From Aden it was communicated to Mecca, where first the pilgrims and then the rest of the people used it; from Arabia it passed over to Cairo

in Egypt, where in 1511 its use was prohibited from a belief that it was intoxicating and inclined to things forbidden in the Koran. But the Sultan Causan having removed the prohibition, the use of coffee passed along the coast of Syria to Constantinople." The dervises again raised a clamour against its use, saying it was not of the number of things created by God for food. It has in consequence had a vicissitudinous history, marked by prohibitions and relaxation of prohibitions, according to the power or otherwise of the priests and the whims of political rulers. It is, moreover, used immoderately by the Turks and most other people in Mohammedan countries.

The introduction of coffee into Europe occurred in the seventeenth century. Its first mention is by Anderson, who says that coffee was brought to England by Nathaniel Canopus, a Cretan, who made it his common beverage while a student at Baliol College, Oxford, in 1641. The "Dictionary of Dates" says the first coffee-house in England was kept by Jacobs, a Jew, in Oxford, in the year 1650. An English merchant brought from Turkey a Greek servant named Pasquet, who opened the first coffee-house in London in 1652 ; he afterwards went to Holland and opened the first coffee-house there (*Anderson*). Coffee was first introduced into France in 1662, by Thevenot the traveller. In 1671 an Armenian named Pascal set up a coffee-house in Paris. He met with little success ; however, he was succeeded by other Armenians and Persians who kept coffee-houses, but like him were unsuccessful ; indeed, it was not until an ingenious Frenchman conceived and carried out the plan of fitting up elegant and spacious rooms as resorts for the fashionable, where coffee was supplied, as well as tea, chocolate, and other beverages, that coffee passed from the region of obscurity to the realms of fashion, and became one of the chief beverages of the people.

The history of its cultivation is equally interesting. Native of Abyssinia, and probably of Arabia, it is now cultivated in hot climates over nearly the entire globe. The tree was conveyed from Mocha in Arabia to Holland in 1616 by the Dutch East India Company, who traded at the Arabian ports along the Red Sea. In 1690 the Dutch Governor-General of India caused some ripe seeds to be sent to Java, where they were planted, grew, and produced fruit ; thence a single plant was sent home to the Botanical Gardens at Amsterdam. This tree continued to thrive in its new home, and plants grown from its seeds were sent to the Dutch colony in Surinam in 1718. In the course of the next ten years it was introduced by the English into Jamaica, by the French into Martinique, and thence to the entire European colonies in the tropics. From Java it was conveyed to Sumatra, Celebes, and the Philippines, and more recently to Malabar, Mysore, and Ceylon. The first coffee produced in Brazil was the fruit of seeds sent by a Franciscan monk to his confrères in 1774. Thus, from the berries sent from Arabia to Holland in 1616, and thence to Java in

1690, all the coffee now produced is descended, excepting the comparatively small amount grown in Arabia.

Coffee is the fruit of a shrub, genus **Caffea**, N.O. Rubiaceæ, of which there are numerous species—thirty according to Fraehner, or as many as sixty according to some botanists. The most important species, however, are *Caffea arabica* and *C. liberica.*

Caffea Arabica is a shrub which grows 15 to 25 feet high, and bears a white blossom, which is followed by yellowish-red fruit turning to dark crimson, whence the tree is not unlike a cherry-tree in appearance. There are, however, several varieties, one of which (*C. leucocarpa*) bears white fruit. The fruit of the ordinary variety, however, is dark red when ripe, oval in shape, of the size of a cherry, and has two divisions, each of which contains a single seed, or "bean," surrounded by a delicate but tough, parchment-like membrane, called the "silver skin," and embedded in a glutinous pulp. It is cultivated in Arabia, Abyssinia, Natal, the East Indies, Java, Sumatra, Malabar, Ceylon, Central America, the West Indies, and Australia. The conditions most favourable for its cultivation are an elevation between 1,000 and 4,000 feet above sea-level, a temperature between 60° and 80° F. in the shade, and a moist climate. The varieties mostly cultivated in Brazil—which produces about two-thirds of the world's supply of coffee—are the *Café nacional* and *C. botacatu* (also called Amarell or Bourbon coffee); the former yields 70 to 75 and the latter 25 to 30 per cent. of the Brazilian harvest.

Caffea Liberica, or Liberian coffee-tree, is larger than the former. It grows to 30 or 35 feet high; the berries are larger and the seeds coarser than those of the Arabian species, but they are said to be improving in quality under cultivation. This species also flourishes at a lower level than the Arabian species, growing freely on the slopes of lower hills and even on ground near the sea-level. It is cultivated extensively in Ceylon, Dominica, and to a less extent in other places, its chief value being that of flourishing at a lower altitude than the other species.

Caffea Stenophylla is a species indigenous to Sierra Leone. It yields coffee of an excellent quality, said to rival the finest Mocha. The amount at present produced is small, but attempts are being made to introduce it into British colonies for cultivation.

The consumption of coffee in the United Kingdom is exceedingly small in comparison with the amount consumed in other civilized countries. In Great Britain the consumption of coffee per head is only 10 ounces per annum; in the United States it amounts to 9 pounds per head per annum, in Holland and Belgium to 16 pounds per head per annum. Only a very small amount of the world's coffee comes from Arabia, as shown by the table on p. 795.

The Sources and Kinds of Coffee.[1]—**Arabian**—Mocha. **African**—Abyssinia, Sierra Leone, Nyassaland, etc. **East Indian**—Ceylon,

[1] "The Practical Grocer," vol. ii., p. 67, and Bannister's Cantor Lectures, 1890.

Java, Mysore, Neilgherry, Naidoo-Batum, Coorg. **West Indian**—Jamaica, San Domingo (including Hayti, Jacmel, Jeremie, Port-au-Prince), Porto Rico, Cuba, New Granada. **Central American**—Costa Rica, Guatemala, Mexico, Nicaragua, Columbia, Honduras, etc. **South American**—Brazil (Rio Janeiro and Santos), Venezuela, and Ecuador.

ANNUAL PRODUCTION OF COFFEE.

Brazil	540,000 tons.
Venezuela, etc.	70,000 ,,
Java and Sumatra	59,000 ,,
St. Domingo and Hayti	35,000 ,,
East Indies	35,000 ,,
Columbia and Ecuador	23,000 ,,
San Salvador	15,000 ,,
Mexico	14,000 ,,
Costa Rica	11,000 ,,
Nicaragua	9,000 ,,
Jamaica	4,000 ,,
Arabia	1,000 ,,
Ceylon	950 ,,
German colonies	707 ,,

1. **Mocha Coffee.**—This yields the finest coffee in the world. Genuine Mocha coffee is grown only in Arabia and in the district of the Yemen, the highest quality of all being that grown in the neighbourhood of Mecca. A considerable amount of so-called Mocha coffee, however, comes from Guatemala and other countries; this, however, is not the same, a difference existing between them which is due to the soil and climate. There are two subvarieties —"short berry" and "long berry." The *long berry* is yellowish-grey in colour, oblong, somewhat flat, and yields a rich mellow-flavoured liquor. The short berry is small, hard, and roundish in shape, of a yellowish-green or yellowish-brown colour, and gives a liquor which is rich and mellow like the former, but is cleaner and has a more delicate flavour and aroma. It is exceedingly doubtful whether any beans which arrive in England are of genuine Mocha growth, the long greyish beans being probably of Indian origin, the short green or brownish beans being from Abyssinia or America. Palgrave[1] says that a very inconsiderable portion of the coffee grown in Arabia ever arrives in Europe; "Arabia itself, with Syria and Egypt, consume two-thirds, and the remainder is absorbed by Turkish and Armenian œsophagi. Nor do these last get for their share the best or purest. Before reaching the harbours of Jaffa, Beyrouth, or Alexandria, the Mokhan bales are sifted and resifted, even while in transit, and whatever they have contained of the small, hard, rounded, semi-transparent, greenish-brown berry—the only one really worth roasting and pounding—has been carefully picked out by experienced fingers; and it is the less generous residue of opaque, flattened, whitish grains which alone go on board for shipping. So constant is this selecting pro-

[1] "Central and Eastern Arabia," i. 424.

cess that a gradation as regular as the degrees on a map may be observed in Mokha—that is, genuine Yemen—coffee, even within the limits of Arabia itself." As it is transported from mart to mart, it is sifted time after time. As it passes from hand to hand, the genuine Mokha is diminished, and substitution occurs, until that which actually leaves the port, marked "Mokha," for Europe and the West, "is often no more like the offspring of the Yemen plant than the logwood preparations of a London fourth-rate wine-seller resemble the pure libations of an Oporto vineyard." Most of the coffee sold even at Mocha, excepting as a favour to well-known people, is of Abyssinian, East Indian, or American origin. Abyssinian coffee is the larger, longer, flatter, and greyish-yellow or whitish-yellow bean referred to above; it is an excellent species of somewhat different flavour, and less heating than genuine Mocha, and is preferred by some people to that of the Yemen. *With this kind*, says Palgrave, "in Eastern opinion and taste, stops the list of coffee and begins the list of beans." In the latter "the products of India rank first and foremost; those of America, in the opinion of Orientals, hold the very last rank."

2. **East Indian Coffee.**—The **Mysore** berries, called "Natives," are large, plump, and heavy, of a bluish-grey or green colour, and have more or less of the "silver skin" adherent to them. They yield a strong, clean liquor of fine flavour. Much Mysore coffee also comes from Java and Ceylon. **Neilgherry** "Plantation" berries are of a delicate greenish colour, and give a similar liquor of good flavour. **Naidoo-Batum** berries are large and plump, and have some of the "silver skin" adherent to them. They also yield an excellent beverage. **Coorg,** although yielding a liquor of good flavour, is devoid of body. Speaking of the East Indian varieties, Palgrave says: "This class supplies almost all the coffee-drinkers from Darfah to Basrah, and thence to Bagdad and Mosoul; Arabs, Persians, Turks, and Kurds, have no other beverage. To one accustomed to what the Yemen supplies, the Indian variety is tolerable, or even agreeable. But for one freshly arrived from Nejed or Kaseem it is hardly potable." **Java** berries are large and oblong; their colour varies from pale yellow or green to whitish-grey; they yield a strong, clear beverage. **Ceylon** coffee is of two kinds—"Native" and "Plantation." The former are of a pale green tint, the latter of a bluish tint and fair size. They yield a clear liquor, smooth, full-flavoured, and of fair body. They are used for blending.

3. **West Indian.**—The **Jamaica** berries are of a medium size, oblong, and varied in colour: grey to blue, with intermediate shades of bluish-green, yellowish-green, or even yellow. Their quality is also varied. The finest Jamaica Blue Mountain berries rival the Mysore Plantation product in their agreeable flavour and odour. Inferior kinds yield a thin liquor, but even these are clean and have a delicate flavour. The **St. Domingo** berries somewhat resemble the commoner and pale-coloured Jamaica beans, but the liquor is

rougher. **Cuban** berries are small and have a red streak, but they yield a strong liquor. **New Granada** coffee consists of small beans of a greenish or grey, approaching to silver, colour ; they yield a strong liquor.

4. **American Coffee.**—**Brazilian** coffee comes from two districts—Rio Janeiro and Santos. Rio beans are "washed" and "unwashed"; they have a peculiar flavour, and are used chiefly for blending. "Washed" berries are bluish in colour, and yield a good coffee. The small round beans, sifted out from the larger and flatter ones, are called "pea-berries," and are often passed off as Mocha or Java coffee. The beans from Santos are larger than those of Rio, and of a pale yellow or greenish colour ; they yield a liquor of good aroma. **Guatemala** beans are mostly pale, and yield a mild-flavoured liquor. **Costa Rica** berries are large, plump, bluish-green or grey, and yield a strong but rather coarse-flavoured liquor. The other American beans are similar, being large or medium-sized, and of oval shape, but their colour varies considerably. Palgrave says : "American coffee holds, in the opinion of all Orientals, the very last rank. The deterioration of [the quality of] this product in the New World from what it is in the Old is no less remarkable than that which occurs in rice and tea, and is of an ambiguous character."

Frauds in the Sale of Coffee-Beans.—Some varieties of beans are far more valuable than others, and methods of "faking" the inferior so as to pass it as a superior article have been adopted. Thus, Santos coffee is made to pass as Java produce, which is worth 25 per cent. more, by washing the beans, decolorizing them with lime-water, washing again, drying them rapidly, and slightly roasting them or colouring them with azo-orange dye.[1]

Coffee in the United Kingdom.—The coffee consumed in Great Britain is derived from the East and West Indies and American sources. Individual varieties of coffee, however, have characteristics of their own, some being stronger, others milder, or having more flavour, a pleasanter aroma, or more body. Coffee as sold in the shops is usually a mixture of several kinds. Those mostly used in the United Kingdom are from East India, Jamaica, Costa Rica, Guatemala, and Central America generally ; they are preferred to the Brazilian berries because they yield a milder beverage, although some of the latter are often blended. "The Practical Grocer" says that in such mixtures "Rio is used to give strength, Santos mildness ; Mysore, Mocha, Jamaica, or Sumatra, for flavour ; Mexican or Venezuelan, for body, etc. A high-class blend is made of Mocha, Jamaica, Blue Mountain, Mysore, and Ceylon Plantation. A medium quality is made of Mysore, Costa Rica and New Granada blend. Cheaper ones of East Indian and Costa Rica ; or Costa Rica and Columbian ; etc." The blender has to make a special study of each kind of bean and of various combinations.

[1] L. Padé, *Bull. de Soc. Chem. de Paris*, 1887, xlvii. 7.

The Manufacture of Coffee.—*Preparation of Berries for the Market.*—There are two methods. 1. *Dry Method :* This is the original mode of preparation, and is that still carried on in Arabia, Abyssinia, etc. The fruit is gathered and dried in the sun ; the external part, representing the pulp and parchment-like membrane, is afterwards removed by crushing the dried fruit between rollers, drying again, and winnowing ; the berries are then polished. 2. *The Wet Method :* In all modern factories the modern method is used. The fruit is " pulped "—*i.e.*, the fleshy portion is removed by machinery, leaving the berries surrounded by the parchment-like envelope. They are now put into tanks for a period of twelve to fifty hours, according to atmospheric conditions, to undergo *fermentation.* The tanks are filled up with water in some establishments, in others no water is added ; in either case spontaneous fermentation takes place, and some saccharine matter is removed from the exterior. They are removed from the tanks, washed and dried. They are dried in the sun, being exposed to its heat for several days, during which time they are frequently turned over ; or they are dried in a rotating machine through which warm air is driven. In either case it is desirable that the parchment-like envelope should not be broken at this stage, but become dry and brittle. In this condition they are usually transported to the place of shipment, and are there " hulled " before exportation. In order to do this, they are exposed to the sun for some time, passed between rollers to crack the envelope, and the parchment or " silver skin " separated by winnowing. The beans are then polished and graded into various sizes. When freshly hulled the beans are of a light colour, but speedily assume that which is characteristic of the variety, unless they are exposed to damp, when they assume a mottled-grey tint and are damaged.

Composition of Coffee—Percentages.[1]

	Green Mocha.	Jamaica Plantation.	Ceylon Plantation.	Rio Janeiro (Washed).	Costa Rica.	Malabar.	East Indian.
Gum, sugar, etc. . .	22·60	25·30	23·80	27·40	20·60	25·80	24·40
Caffein	·64	1·43	1·33	1·14	1·18	·88	1·01
Fat	21·79	14·76	14·87	15·97	21·12	18·80	17·00
Tannic, caffeo-tannic acid . .	23·10	22·70	20·90	20·90	21·10	20·70	19·50
Cellulose	29·90	33·80	36·00	32·50	33·00	31·90	36·40
Ash	4·10	3·80	4·00	4·50	4·90	4·30	—
Potash	2·13	1·87	—	—	—	—	—
Phosphoric acid . .	·42	·33	·27	·51	·46	·60	—

The above table does not show the moisture, which varies from 6 to 15 per cent. ; and albuminoids, which vary from 6·15 to 13·5 per cent. Twenty-four samples of undressed Mysore coffee analyzed

[1] Levisic, *Archiv. de Pharm.*, series 3, viii. 294.

by Commaille[1] contained—Moisture 6·3 to 15·7, fat 12·68, caffein 0·42 to 1·31, and ash 3·88, per cent.

The *ash* yielded on two analyses by Ludwig[2] the following composition : K_2O=14·13—44·03 ; Na_2O=5·84—5·85 ; CaO=8·64—4·89 ; MgO=8·14—8·01 ; Fe_2O_3=16·54—1·96 ; Al_2O_3=2·78—0 ; SiO_2=1·65—0·37 ; P_2O_5=8·3—21·24 ; SO_3=15·28—1·64 ; Cl, trace —0·98.

Changes due to Roasting.—Before being used coffee is roasted and ground. During this process various changes in the composition occur, and the excellence of the future beverage depends on the skill and care now exercised. If it is too little roasted, the beverage is devoid of flavour and aroma ; if too much roasted, it has a burnt and acrid taste. During roasting the berry swells from the formation of gases in the interior ; a large amount of water is driven off (equal to 12 to 20 per cent. of its weight). There is also a loss of organic matter, including 10 per cent. of the fat and 21 per cent. of the caffein ; if the coffee is too much roasted, the destruction of caffein is even greater. The cellular elements containing fat and albumin are ruptured ; sugar is lost by transformation into caramel, and some of the starch is transformed into dextrin. An aroma is developed by the production of **caffeol** ; carbonic, palmitic, and acetic acids are given off, together with pyrrol, hydroquinone, and methylamine. It is sometimes roasted at a temperature of 390° to 480° F. ; but it is better roasted at 210° F., because the aromatic substance is volatile and would be driven off by great heat ; a little butter is commonly added before roasting, to assist in bringing out the flavour and aroma ; and the infusion is more fragrant when coffee is used immediately after roasting it. The loss of weight in roasting amounts to 17 or 19 per cent. of the total substance. The dealers sometimes fraudulently make good this loss by restoring the weight, the roasted beans being exposed to steam, and afterwards coated with palm-oil, glycerine, or vaseline, to prevent evaporation. Such beans, instead of being hard and brittle, are elastic and horny to the teeth.[3] The practice of this fraud is now rarer than formerly.

Variations in Composition.—According to Balland,[4] the nitrogenous matters vary from 6·15 to 13·58 per cent. ; they consist of legumin or casein, albumin, globulin, proteoses, etc. ; the fat varies from 3·98 to 11·6 per cent. ; the cellulose from 8·6 to 16·1 per cent. ; the saccharine matter, 9 to 10 per cent. ; caffein, 0·5 to 2·05 per cent. ; ash, 2·1 to 3·7 per cent. ; and water, 7 to 13·5 per cent. The amount of soluble substance is as follows : According to Commaille,[5] twenty-four samples of Mysore coffee on an average yielded to cold water 24·97, hot water 37·20, 60 per cent. alcohol 23·15, per cent.

The albuminoid, albumin, proteoses, fat, and cellulose, form the hard portion of the seed, and together make a total of half the

[1] *Moniteur Scientif.* (3) vi. 779. [2] *Archiv. de Pharm.*, series 3, i. 482.
[3] *Chemical News*, 1887, ii. 24.
[4] *Journal of the Chemical Society* (6), xx. 543. [5] *Monit. Scient.*, vi. 779.

berry. The mineral salts or ash consists largely of potassium carbonate and phosphate, with smaller quantities of magnesia and lime. *Caffeic acid* is a yellowish substance which, when heated, has an odour of coffee, and is considered to play an important part in the production of caffeol. *Caffeone* or *caffeol* ($C_8H_{10}O_2$) gives the characteristic flavour and aroma to coffee, and is its principal aromatic substance. It originates during the roasting of coffee. It is a brown oily liquid, a single drop of which will fill a room with the odour of coffee ; and a mere trace gives the characteristic aroma of coffee to a quart of water. Being volatile, some of it is lost by overroasting the berries. **Caffein** is the substance which contributes to coffee its chief physiological activity. It is identical with thein. The average proportion in all commercial varieties is only 1·2 per cent. This is only one-third of the amount contained in tea ; nevertheless, a cup of coffee always contains as much of the active principle as there is in a cup of tea, because so much more material is used to make the beverage. Hutchison[1] found that a cupful of coffee made of 2 ounces of coffee to 1 pint of water contained 1·7 grains of caffein and 3·24 grains of tannin ; that a teacupful of tea contained from 0·73 to 1·21 grains of caffein and 0·89 to 4·2 grains of tannin, or an average of 1 grain of caffein and 2 or 3 grains of tannin ; whence it is concluded that a teacupful of *café noir* contains rather more caffein than the same amount of tea, and *café au lait* contains about the same amount of caffein as ordinary tea infusion. But coffee contains more " body " from the presence of dextrin, saccharine, and colouring matters, than is contained in the corresponding infusion of tea.

Composition of Coffee before and after Roasting.[2]

	Mocha.		East Indian.	
	Raw.	Roasted.	Raw.	Roasted.
Moisture	8·98	·63	9·64	1·13
Caffein	1·08	·82	1·11	1·05
Saccharine matter	9·55	·43	8·90	·41
Caffeic acid	8·46	4·74	9·58	4·52
Alcoholic extract (nitrogenous and colouring matter)	6·90	14·14	4·31	12·67
Fat and oil	12·60	13·59	11·81	13·41
Legumin	9·87	11·23	11·23	13·13
Dextrin	·87	1·24	·84	1·38
Cellulose and insoluble colouring matters	37·95	48·62	38·60	47·42
Ash	3·74	4·56	3·98	4·88

The roasted and ground coffee is usually mixed with chicory and put into tins immediately. The great desideratum of the dealer is to prevent the loss of the normal fragrance. This is attempted

[1] " Food and Dietetics," p. 310.

[2] Bell's " Foods," i. 43.

in some cases by "glazing" the coffee with a mixture of equal parts of Irish moss, gelatin, and isinglass, combined with sugar and eggs. Other dealers use simply a mixture of eggs and sugar or caramel. The effect of these mixtures is to absorb the aroma of the coffee or prevent its evaporation, while at the same time they give "body" to the infusion.

Overroasting coffee is sometimes a fault of trade coffee-roasters, to give a deeper colour and fictitious strength to the liquid. During the process an empyreumatic product is generated, which causes highly roasted coffee to disagree with the stomach, and renders dyspeptic people unable to take it in consequence of the heartburn and flatulence it induces. Highly roasted coffees, though *de facto* imparting a deeper colour to the liquid, are *less strong* and have a corresponding less aroma than the pale roasted berry; the light roasted coffee of the Turkey and West Indian berry is the acme of perfection, and a wholesome and grateful beverage.[1]

Making Coffee.—The amount of roasted coffee required to make a good infusion is 2 ounces to 1 pint of water. English people as a general rule do not use enough. The water should be freshly boiled, and used just at the boiling temperature, or only at 210° F. A good mixture is 50 per cent. of Mocha and 50 per cent. of Plantation coffee, with a *trace* of chicory. When much chicory is used in the mixture, the infusion may be strained and reboiled, as thereby the bitter flavour of chicory is destroyed. An earthenware coffee-pot is the best; it should be dried and warmed, the coffee put at the bottom, the boiling water poured over it; allow it to stand two minutes, then stir it thoroughly; put it into a warm place for six or eight minutes while it settles; pour it into the cup with sugar and boiled milk to suit the palate.[2] The infusion contains 60 to 96 per cent. of the caffein in roasted beans, according to the mode of making the infusion.[3]

The Adulteration of Coffee.—Numerous articles have been used from time to time to mingle with coffee, and thereby increase the profit obtained from a given weight of berries. These articles are chiefly as follows:

1. *Roots:* Chicory, dandelion, burdock, turnips, beetroot, carrots, parsnips, mangold-wurzels.

2. *Seeds:* Acorns, rye, malted barley, peas, beans, lupin-seeds, date-stones.

3. *Miscellaneous:* Figs, locust-beans, burnt sugar, biscuits, oak-bark tan, artificial "berries," etc.

Some of these substances must have a little more attention. None of them are injurious to the consumer, but they are poor substitutes for coffee, and the sale of them in place of the genuine article amounts to a fraud.

Chicory is the substance most commonly employed as an adul-

[1] *British Medical Journal*, 1896, ii. 1082.
[2] "The Practical Grocer," vol. ii.
[3] Katz, *Archiv. d. Pharmazie*, 1907, cclii. 42.

terant of coffee. It is the root of wild-endive or succory (*Cichorium intybus*), N.O. Compositæ. It is cultivated in Yorkshire, Surrey, Bedford and other counties of England, but much more largely in Holland, Belgium, Germany, and Northern France. The roots are fleshy and white. After being dug up, they are washed, sliced, and dried in a kiln; they are roasted, with about 2 pounds of lard to each hundredweight, before being used. The following, according to Wolff,[1] is the mean composition of numerous commercial samples:

Composition of Roasted Chicory.

Moisture	12·30 per cent.
Nitrogenous matters	6·00 ,,
Inulin	5·90 ,,
Lævulose and dextrose	11·10 ,,
Caramel	13·40 ,,
Cellulose	9·10 ,,
Ash	5·80 ,,
Salts	1·90 ,,
Sodium chloride	·22 ,,
Iron	·12 ,,
Soluble in water	60·10 ,,

Chicory contains no caffein or tannin, and no aromatic oil like that of coffee; between it and coffee there is no analogy—it is merely a diluent; but it gives to coffee additional body, sweetness, slight bitterness, and much colour. The colour arises from the presence of caramel, which is produced from sugar during the roasting of chicory. Fresh raw chicory contains 3·5 per cent. of sugar; dried raw chicory contains from 25 to 35 per cent., but roasted chicory only 10 to 18 per cent. (including 7 to 14 per cent. dextrose), the rest being converted to caramel; sugar is, however, sometimes added to chicory by the dealer. Genuine roasted coffee contains only 1 or 2 per cent. of saccharine matter; hence this property is much increased by the addition of chicory. There is no legal limit to the amount of chicory which may be added to coffee, and the greatest fault arises from the adulteration or the reduction of the percentage of caffein and caffeol. **French coffee,** as various mixtures sold in tins are called, consists of an admixture of coffee, chicory (30 to 70 per cent.), burnt sugar (caramel), and sometimes other vegetables. In such a mixture the chicory may be recognized in various ways: (1) The microscope reveals its presence by the coarse areolar tissue and the long dotted ducts which are characteristic of chicory; coffee, on the other hand, presents, an irregular network of fibres containing the dark angular masses and oil globules which make up the substance of the berry, and the oval cells which are seen in the testa. (2) Another method of detection is as follows: Sprinkle a little of the coffee upon the surface of some water in a glass vessel; chicory rapidly sinks, and each particle speedily becomes surrounded by an amber-coloured cloud, which diffuses in streaks through the water until the whole is yellowish-brown.

[1] *Anal. de Chim. Anal.*, 1899, 157-193.

Meanwhile the particles of coffee float on or near the surface, owing to the presence of oil globules and gases developed during roasting. When the coffee is pure, no material coloration of the water is produced under fifteen minutes. (3) The quantity of chicory mingled with such coffee as the former is determined by the specific gravity of the infusion—thus : A 10 per cent. solution is made by infusing 1 ounce of coffee in 10 ounces of boiling water ; if it be pure coffee, the infusion will have S.G. = 1009 ; if it be all chicory, the infusion will have S.G. = 1024 ; if it is half and half, the S.G. will be 1016 ; and so on. It should be noted that pure coffee and pure chicory may be sold separately without any liability or legal restriction ; but a *mixture* of coffee and chicory should bear a label which states the composition of the mixture, according to the Sale of Food and Drugs Act. When roasted or ground, imported chicory is charged the same duty as coffee ; but raw chicory is charged at a lower rate of duty.

Beetroot (*Beta vulgaris*) is used as an adulterant both of coffee and chicory. Roasted beetroot contains more sugar than roasted chicory. It has the following composition :[1] Water 5·03, nitrogen 1·63, fat 0·7, sugar 34·69, ash 7·89, soluble in water 49·5, per cent. The presence of beetroot in coffee or chicory is recognized by the microscope and the large amount of sugar per cent.

Roasted Grain, Malt, etc., are also detected by microscopical examination and the tests for starch. Roasted barley, sold as "cereal coffee," has the following composition : Starch and dextrin 67·19, fat 1·04, ash 2·04, per cent. It contains no caffein, but 35 per cent. of extract soluble in water.

Substitutes for Coffee.—A great variety of substances have been used as substitutes for coffee or chicory. Sometimes the coffee consists wholly of chicory or of roasted malt, or dried and roasted figs. The composition of some of these is compared with that of Ceylon coffee in the following table by Duchacek :[2]

COFFEE SUBSTITUTES—PERCENTAGES.

	Ceylon Coffee.	Malt Coffee.	Fig Coffee.	Chicory Coffee.
Moisture	1·96	2·07	7·83	5·99
Soluble in water	26·06	41·93	70·99	67·67
Sugars	1·43	1·73	35·70	18·23
Dextrins	·90	15·83	2·30	1·40
Caffein	1·12	nil	nil	nil
Fat	15·05	5·24	3·07	2·23
Ash	3·65	3·19	4·47	5·88

The use of roasted cereals (previously soaked in beer, etc.), peas, beans, peanuts, almonds, buckwheat, etc., as substitutes for coffee, is far less common than formerly ; but dandelion roots, gombo, acorns, cassia-nuts, and even artificial berries, are used.

[1] *The Analyst*, 1904, xxix. 279. [2] *Annal. de Chim. Anal.*, 1904, 292.

Artificial Roasted Coffee.—Coreil[1] examined a sample of "roasted coffee," which was manufactured by *moulding* a mixture of flour, husk of wheat, potato, bean flour, and gum. It contained none of the elementary constituents of true coffee. Sometimes mixtures are formed containing the inner shell of coffee fruit, a dried sample of which was found by Beld von Bitto[2] to have the following composition: *Composition of inner shell of coffee fruit*—Nitrogen 6·19, fibrin 66·29, nitrogenous extractives 23·26, fat 1·29, **caffein** 0·35, ash 2·96, per cent.

Spurious Coffee.—A manufactory of spurious coffee existed at Lille in 1891. The raw material consisted of 15 kilos of chicory, 35 kilos of flour, and 500 grammes of sulphate of iron. This was made into a paste and pressed into the shape of coffee-beans, the lustre of which was imitated by coating them with oil, while the iron sulphate produced an imitation of the natural colour.

Dandelion Coffee. — The roots of *Taraxacum officinale*, when roasted and ground, make an infusion which is well flavoured, aromatic, and is sometimes used as a substitute for coffee. The roots contain inulin and levulin (an isomeride of inulin), and mannite in the juice. According to Dragendorff,[3] roots collected in October contain 24 per cent. of inulin; those collected in March contained only 1·7 per cent. of inulin, but associated with it was 19 per cent. of levulin and 17 per cent. of uncrystallizable sugar. They contain no starch. The roasted roots yield 65 per cent. of their weight to water, and make an infusion of high specific gravity.

Gombo Coffee. — The dried fruit of gombo or okra is used to some extent as a coffee substitute. The ripe seeds are roasted, ground to a fine powder, and mixed into a paste with milk or sweetened water, to form a substance resembling chocolate. It is agreeable to the palate, and has the aroma of the seeds. A beverage made from it is said to be superior to that made from an inferior quality of coffee.

Date-stones, when roasted and ground, are used as an adulterant of coffee; but they only contain 10 per cent. of soluble material, and yield a liquor of lower specific gravity than most coffee substitutes.

"**Black Coffee.**"—The nuts of *Cassia occidentalis*, N.O. Leguminosæ, a shrub grown in the tropical regions of Asia, Africa, and America, when roasted and reduced to a powder, yield an agreeable infusion which is very similar to coffee. The material is sold as "black coffee."

Acorn Coffee.—The fruit of the Spanish oak-tree is a dietetic article in Spain, Portugal, and Corsica. They are very sweet; when torrefied and ground, they form a good substitute for coffee, 15 grammes (two teaspoonfuls) being necessary, however, to form a cupful of satisfactory strength. The composition of roasted acorns is: Carbohydrates 60 to 70, fat 3, ash 2, soluble in water 50, per

[1] *Jour. de Pharm. et de Chemie*, 1897, vi., No. 3.
[2] *Jour. Lander-vers.*, 1904, lii. 93.
[3] *Chemical News*, 1891, ii. 153.

cent. As there is a regular demand for more or less of this substitute in some districts, any shortage of the supply of "sweet acorns" is usually made up by substitution of the acorns of the ordinary oak. The latter are buried in the earth for some time, and there undergo a fermentation which induces certain changes, including the destruction of the bitter principle. The bitter principle can also be extracted by grinding the acorns, and soaking them six or eight times in succession in cold soft water, and drying them immediately afterwards. But the loss of substance is too great, and amounts to 25 per cent. Solstein therefore recommends that the acorns be reduced to a paste with milk, and allowed to ferment. The bitterness is thus entirely eliminated, and loss is avoided. Acorn meal prepared in this manner costs only fourpence per kilo; it therefore makes a very cheap substitute for coffee, and is enjoyed by many people, although it lacks the caffein and fine aroma.

Coffee Extracts and Essences.—These liquids are usually concentrated infusions, made by digesting coffee and chicory with water in a percolator, the liquid being afterwards concentrated by evaporation *in vacuo* and mixed with caramel. A common formula is 4 parts of coffee and 2 parts of chicory for the infusion, and 1 part of caramel or burnt sugar in the finished product. Coffee extract or essence is a convenient form for the rapid preparation of the beverage; but as a rule such liquids lack the fine aroma of fresh coffee, and a notable deficiency in the proportion of caffein shows that there is sometimes a lack of coffee in the mixture. But other substances besides coffee and chicory are used. The amount of soluble extract in roasted coffee is 22, in chicory 70, acorns 50, barley or malt 35, figs 65, dandelion root 67, per cent. The specific gravity of 10 per cent. infusion of coffee = 1·0070, chicory = 1·020, acorns = 1·020, barley = 1·016, figs = 1·025, dandelion = 1·030.

Cocoa.

The introduction of cocoa into Europe occurred in 1520, when it was brought from Mexico by Columbus. It was therefore known to Europeans fully a century before tea or coffee were brought by the Dutch. But, although it was known so much earlier than tea and coffee, it is only during the last two generations that its consumption has become popular, the great increase in the demand for it being largely due to the enterprise of a few manufacturers.

Cocoa is derived from the seeds of *Theobroma cacao*, Linn., N.O. Byttneriaceæ. There are fifteen to eighteen species of this tree, all belonging to tropical America, principally to the hotter parts of Brazil, Guiana, and Central America. The common cacao, *T. cacao*, is a small tree, wild in the valleys of the Amazon and Orinoco. Many early writers indicate that both *wild* and *cultivated* trees existed at the time of the discovery of America, from Panama to Guatemala.[1] The exact area in which the tree is

[1] De Candolle's "Origin of Cultivated Plants," p. 314.

now found wild is disputed by botanists. It was introduced by the Indians into Mexico, *before the discovery of America*, for the custom of drinking chocolate, which is a Mexican name, was then general. It was carried by the Spaniards to the Philippine Islands in 1674 and 1680. The Spaniards also introduced it into Europe. The *T. bicolor*, which is a native of New Granada, is found growing side by side with the common cacao in American plantations, but it is not so valuable or so highly esteemed.

The Manufacture of Cocoa.—The fruit of *T. cacao* is a pod of 7 to 12 inches in length and 3 inches or more in width, and somewhat resembles a cucumber in shape. It contains a pulp in which are embedded a number of seeds about the size of a haricot bean. It is from these seeds that cocoa and chocolate are prepared. The pods are cut from the trees by pruning-knives, and piled in heaps under the trees, where the seeds are removed. The seeds or beans are exposed to the sun for three or four days, being spread upon a platform of bamboo and palms, and turned over occasionally to dry them uniformly. They are then taken to the "sweating-house," where a species of fermentation takes place; they are put into boxes or barrels, and covered with plantain leaves, in a close room for four to seven days. The fresh beans are of a crimson colour, somewhat oily and disagreeable to the taste. During fermentation their temperature rises to about 140° F.; some water and carbon dioxide are given off; the colour changes from crimson-red to dark brown; they lose their disagreeable and somewhat bitter flavour, and develop the aroma and flavour so highly prized in chocolate. They are then turned out, picked over, and rubbed to remove any adherent pulp or foreign matter, and spread on a tray and covered with red earth for another day to complete the fermentation. The red earth absorbs the moisture given off, together with mucilage or slime, and gives to the beans a red colour. Finally they are again rubbed, spread upon trays, and dried in the sun, care being taken that they do not become shrivelled.

The composition of the raw unshelled beans, according to Weigmann,[1] is as follows: Water 7·5 to 8·27, fat 44·6 to 46·6, carbohydrates 19·4 to 26·45, theobromine 1·6 to 1·3, ash 3·16 to 4·91, nitrogen 2·16 to 2·46, per cent.

Roasting the Beans.—In the after-part of the manufacture of cocoa, the beans are *roasted* either by direct heat over a coke fire, or dried by the indirect heat of superheated high-pressure steam; they thus become hard and brittle. They are then passed through a machine which cracks the hard thin skin, or "husk," and the latter is then removed by winnowing.

Cocoa-Nibs.—The beans are split by the machine, and the product constitutes cocoa-nibs. This is the pure form of cocoa; but the nibs require to be ground or boiled to obtain the proper ingredients from them.

[1] König's *Chemie*, i. 1019.

Flake Cocoa.—Usually, however, the cocoa-nibs are ground between hot rollers. The heat breaks down the thin-walled polygonal cells and dissolves out some of the fat, and reduces it to a semifluid pasty condition. A considerable proportion of the fat is now removed by hydraulic pressure ; the remainder of the material is run into moulds, and forms flat pieces or irregular masses called " flake cocoa," which differs from the former in the smaller proportion of fat. It is from this that prepared cocoas are made.

Rock Cocoa.—Sometimes the cocoa is mixed while fresh from the press, and therefore in a soft and plastic condition, with a quantity of starch and sugar. This mixture constitutes the rock cocoa of commerce.

Composition of Commercial Cocoas (Bell)—Percentages.

	Fresh Beans (shelled).	Nibs.	Flake Cocoa.	Rock Cocoa.	Prepared Cocoa.	Cocoatina.
Moisture	7·6	2·6	5·5	2·6	5·0	3·5
Fat	49·9	51·8	28·2	22·6	24·9	24·0
Added starch ..	nil	nil	nil	17·6	19·2	nil
,, cane-sugar	nil	nil	nil	32·2	23·0	nil
Non-fatty cocoa ..	42·5	45·6	66·3	24·8	27·9	72·5

Of these numerous varieties, Caracas cocoa is considered to be the finest, and Trinidad cocoa to rank next to it. The variations in composition are as follows :

Fat.—The natural cocoa-bean contains from 36 to 55, or an average of 43, per cent. of fat ; but a considerable part of this is removed from prepared cocoas, which only contain from 23 to 33 per cent. of fat.

Protein.—The nitrogen in cocoa varies from 1·75 to 2·25 per cent., equivalent to 11 to 14 per cent. of protein. But the nitrogen is not all protein ; Cohn found that the protein averages only 7·9 per cent., the remainder being amides or extractives. Wigner says, indeed, that only 21 per cent., and Stutzer that only 32 per cent., of the nitrogen is in the form of true protein, the rest being amides. These statements, however, do not agree with the analyses of Ridenour (see table on p. 808), who found that the albuminoid varied from 7·5 to 12·6 per cent., and the extractives from 5·8 to 13·5 per cent. Heisch also found the albuminoid to vary from 7·5 to 13 per cent. Such a close agreement in their results is important, and they show in their analyses that the protein and amide nitrogen are about equal. The protein is chiefly albumin, and, according to Bell, amounts to 6·30 per cent. soluble, and 6·96 per cent. insoluble, albumin.

Theobromine varies from 1·0 to 2·65 per cent. ; it accounts for a little of the non-protein nitrogen. It is the active principle of cocoa, and is di-methyl-xanthin, $C_7H_8N_4O_2$; its relation to caffein is well known

COMPOSITION OF COMMERCIAL VARIETIES OF COCOA—PERCENTAGES.

Roasted and Unroasted Beans.

Source:[1]	Bahia.	Surinam.	Java.	Trinidad.	Ariba.	Caracas.	Granada.	Roasted Trinidad.	Tobasco.	Machalle.	Roasted Caracas.	Maracaybo.	Average.
	1	2	3	4	5	6	7	8	9	10	11	12	13
Fat or butter ..	42·10	41·00	45·40	43·60	43·30	36·80	44·10	41·80	50·90	46·80	37·60	42·2	42·90
Theobromine ..	1·08	·93	1·16	·85	·86	1·13	·75	·95	1·15	·76	·76	1·0	·97
Albuminoids ..	7·50	10·50	9·25	11·90	10·10	10·50	9·70	12·00	7·80	12·60	12·30	11·5	10·50
Glucose	1·00	1·20	1·20	1·30	·42	2·70	1·80	1·40	·90	1·60	1·70	1·0	1·40
Saccharose	·51	·35	·51	·32	6·37	1·50	·55	·28	2·70	·46	·51	1·3	1·20
Starch	7·50	3·60	5·10	4·90	1·50	3·80	6·20	5·70	3·50	1·35	6·00	1·6	4·20
Lignin	7·80	3·90	6·10	5·60	4·60	3·20	5·50	5·80	6·40	5·90	9·00	7·1	5·90
Cellulose	13·80	16·20	13·80	13·00	14·00	16·30	13·40	19·60	12·50	11·30	11·60	17·3	14·40
Extractive	8·90	13·50	8·90	8·30	9·00	12·70	9·70	5·80	9·20	9·00	9·20	6·7	9·30
Moisture	5·90	5·50	5·10	6 30	5·90	6·60	5·20	2·60	1·50	5·80	5·60	5·6	5·10
Ash	3·60	3·00	3·30	3·60	3·70	4·30	2·70	3·70	3·00	4·10	50·0	4·1	3·70

Roasted Beans.

Source:[1]	Caracas.	Trinidad.	Surinam.	Guayaquil.	Granada.	Bahia.	Cuba.	Para.	Trinidad Nibs.
	14	15	16	17	18	19	20	21	22
Fat or cocoa-butter	48·40	49·40	54·40	49·80	45·60	50·30	45·30	54·00	50·44
Theobromine	—	—	—	—	—	—	—	—	·84
Albuminoids	11·14	11·14	11·14	13·03	12·40	7·40	8·67	12·66	13·26
Glucose	32·19	32·82	28·35	30·47	35·70	35·50	39·41	26·33	2·17
Saccharose									—
Starch									4·20
Lignin (husk)	13·80	15·50	15·50	11·50	14·60	9·60	12·00	8·50	—
Cellulose									6·40
Moisture	4·32	3·84	3·74	4·14	3·90	4·40	3·72	3·96	5·23
Ash	3·95	2·80	2·35	2·50	2·40	2·60	2·90	3·05	2·75
,, soluble in water ..	2·15	·90	·80	·75	·60	·90	·95	1·40	—
,, ,, in HCl	1·80	1·90	1·85	1·75	1·80	1·70	1·95	1·65	—
H_3PO_4 in ash	1·54	·93	1·23	1·87	1·35	1·26	1·13	1·00	—
Nitrogen	1·76	1·76	1·76	2·06	1·96	1·17	1·37	2·00	—

[1] Analyses 1 to 13 by Ridenour, *Amer. Jour. Pharm.*, 1891, 207; 14 to 21 by Heisch, *Year-Book of Pharmacy*, 1878, p. 222; and 22 by Professor Bell.

Starch varies from 5·78 to 15·13 per cent. (Ewell), or to 19·0 per cent. according to Müter; Wanklyn found an average of 10 per cent., and König 9 per cent. According to Ridenour, the starch varies from 1·5 to 7·5 per cent.; saccharose from 0·35 to 2·7 per cent.; glucose (dextiose), 1·0 to 2·7 per cent.; cellulose, 11 to 16 per cent.

Tannin.—The astringent matter of cocoa is somewhat different from that in tea and coffee. The proportion varies from 4 to 6·7 per cent., and averages 5 per cent. Part of the tannin in the raw beans becomes changed during analysis into cocoa-red. *Cocoa-red* is a pigment; it does not exist in the fresh beans, but arises from tannin in the seed by a process of oxidation. Roasted beans contain about 4 or 5 per cent. of tannin, and 2 to 2·75 per cent. of cocoa-red.

Mineral Matters.—The ash reaches a rather high proportion, amounting to 2·5 to 4·0 per cent. in raw and from 3·5 to 5·0 per cent. in roasted beans. The percentage composition of the ash, according to Bell,[1] is as follows: Silica 0·03, sodium chloride 0·55, soda 0·62, potash 27·07, magnesia 19·47, lime 4·66, alumina 0·07, ferric oxide 0·21, CO_2 2·78, SO_3 3·87, P_2O_5 40·64, per cent.

Prepared Cocoa.—Cocoa is, by reason of its composition, a nutritious food, and, although not so stimulating, it is more sustaining than tea or coffee. In its natural condition, however, cocoa is too rich in fat, and somewhat indigestible. In order to make it acceptable to the stomach, it is roasted and ground and the quantity of fat reduced. The reduction of the fat is brought about (1) by submitting the heated cocoa to hydraulic pressure, or (2) by mingling the roasted and ground cocoa with starch and sugar. *In the latter method it is obvious that no fat is removed, but the cocoa is diluted;* the former method is therefore the best one to adopt, and is that most in use at the present time. The following tables show the composition of numerous prepared cocoas:

Composition of Prepared Cocoas (Hutchison)—Percentages.

	Moisture.	Fat.	Nitrogenous (N×6·25).	Starch, Sugar, Tannin, etc.	Ash.
Cadbury's Cocoa Essence ..	3·9	25·2	20·9	45·2	4·8
Fry's Pearl Cocoa	7·3	15·8	4·3	71·2	1·4
,, Pure Cocoa	5·6	25·6	19·7	43·2	5·9
Van Houten's Pure Cocoa ..	3·0	28·0	20·5	39·7	8·8
Vi-Cocoa	6·3	26·9	17·0	43·8	7·0
Schweitzer's Cocoatina ..	4·3	28·2	19·4	41·8	6·3
Rowntree's Elect Cocoa ..	6·5	25·5	18·0	42·2	7·8
Epps's Prepared Cocoa ..	4·9	15·1	6·7	71·8	1·5
Suchard's Cocoa	4·7	33·2	18·6	36·7	6·8

[1] Bell's "Foods," i. 86.

In the following table the composition of various prepared cocoas is compared with that of cocoa-nibs, flake and rock cocoa.

Composition of Commercial Cocoas (Bell)—Percentages.

	Cocoa-Nibs (Finest Trinidad).	Flake Cocoa.	Rock Cocoa.	Prepared Cocoa.	Iceland Moss Cocoa.	Cocoa Extract.	Cocoatina.	Chocolatine.	Chocolat de Santé.
Moisture ..	2·60	5·49	2·58	4·93	5·47	5·76	3·52	4·40	1·44
Fat	51·77	28·24	22·76	24·94	16·86	29·50	23·98	29·60	22·08
Non-fatty cocoa	45·63	66·27	24·90	27·89	23·74	64·74	72·50	66·00	13·27
Added starch ..	none	none	17·56	19·19	24·70	none	none	none	2·00
,, sugar ..	none	none	32·20	23·03	29·23	none	none	none	61·21

In prepared cocoa the fat usually varies from 25 to 33 per cent., as much as 30 to 50 per cent. of the amount in cocoa-nibs having been removed. The Society of Analysts fixed 20 per cent. as the *minimum* amount of fat which prepared cocoa should contain ; if any sample contains a smaller amount than that, it is exceedingly probable that such a low percentage is due to dilution of the cocoa with starch and sugar instead of removal of fat by heat and pressure. Some prepared cocoas contain a considerable proportion of added starch and sugar ; there may be 25 per cent. of added starch, and 30 or 35 per cent. of cane-sugar. These adulterations of cocoa are by no means injurious ; but the added starch and sugar dilutes the cocoa, which in consequence contains less of the essential ingredients and is less invigorating. The starch added to such preparations is usually potato starch, arrowroot, *tous les mois* (*Canna edulis*), corn starch, or some other cereal starch. Natural cocoa only contains 4 to 7 per cent. of starch ; prepared cocoa may have 20 to 25 per cent. of starch, which is recognizable under the microscope, each variety of granules having the characteristic marking and size. The natural starch of cocoa consists of exceedingly small, nearly spherical granules, smooth, unmarked, and having a small central hilum. The amount of sugar in natural cocoa does not exceed 2·5 per cent., most of which is dextrose ; in prepared cocoa the saccharose or cane-sugar amounts to 20 or 35 per cent.

In preparations where the natural fat is not reduced, a proportion of alkali is usually added, such as ammonia, potash, or soda, which have the effect of saponifying the fat, reducing greasiness, darkening the colour, and apparently increasing the strength of the cocoa. It also has the effect of softening the cellulose and making the cocoa more easily digested. Formerly cheap cocoas contained various colouring matters, such as Venetian red, umber, peroxide of iron, or even brickdust.

The cocoa essences and extracts are popularly supposed to be stronger than other preparations of cocoa. They are no stronger than other cocoas, unless they have been fortified by the addition

of some other article containing stimulating properties, such as kola. This is shown by the analysis (No. 6) of Cadbury's cocoa by Hutchison given in the table of prepared cocoas, and that in the table of cocoa essences.[1] The other part of the table shows the composition of five samples of cocoa essence analyzed by E. G. Clayton ;[2] the starch in Nos. 4 and 5 was not quite all cocoa starch, and in No. 4 some of the caffein and all the maltose were of extraneous origin. One preparation of cocoa on the market was made with the idea of replacing *beer* in the diet of working men and women, and its originator endeavoured to combine cocoa, kola, and malt, in such proportions as to be at once palatable and invigorating. A similar **malted cocoa** was found to contain—Moisture 8·44, protein 12·09, fat 20·40, minerals 4·00, per cent.[3] The mixture contained malt diastase unimpaired in the form of malt extract, and was therefore a decided addition to digestive foods.

Composition of Cocoa Essences—Percentages.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Water	4·62	3·22	3·59	5·33	4·28	3·80
Fat	33·11	32·69	30·50	22·30	27·46	28·12
Theobromine	1·82	·93	·88	·83	2·69	·95
Caffein	·08	·02	·42	·66	·16	—
Starch	5·63	6·56	—	5·06	—	4·20
Proteins	15·56	14·31	14·19	19·50	12·12	21·34
Maltose	—	—	—	1·64	—	—
Cellulose	5·65	9·29	6·97	5·59	4·21	36·65
Cocoa-red, tannin, dextrin, etc.	27·82	25·15	37·35	32·47	42·77	
Ash	5·71	7·83	6·10	6·62	6·31	4·94
Soluble in cold water :						
Total	17·90	17·20	14·56	18·25	—	—
Organic	15·10	12·30	10·48	13·29	—	—
Ash	2·80	4·90	4·08	4·96	—	—

Chocolate consists of the cocoa-beans, sweated, fermented, and roasted in the usual way for the preparation of cocoa ; but the cocoa-nibs are ground in a heated mill, and as much as possible of the fat exhausted by pressure. The residue is mingled while in a soft and plastic condition with 30 to 60 per cent. of cane-sugar, 5 to 10 per cent. of sweet almond, 1·0 to 1·5 of vanilla, 0·5 of cinnamon, and 0·2 of clove. The proportion of sugar and flavourings varies to a considerable extent, and this variation constitutes the chief difference in the best kinds of chocolate. Chocolate, however, varies considerably in quality ; many of the inferior kinds contain very little genuine cocoa ; on the other hand, they may consist

[1] *The Analyst*, 1890, xv. 119. [2] *Chemical News*, 1902, ii. 51.
[3] *The Lancet*, 1902, ii. 1703.

of the *husks* of cocoa-beans, obtained after roasting them, ground to a fine powder, mingled with sugar, sometimes coloured, and the odour and flavour of chocolate added to it by an ingenious combination of cocoa-fat. **Vanilla,** which is so largely used in the manufacture of cocoa and chocolate, is the fruit of *Vanilla aromatica et planifolia,* an orchid having thick and fleshy leaves, which grows upon cocoa and other trees. It is a native of Brazil, but is cultivated in most places where cocoa-trees are grown.

Composition of Chocolate—Percentages.

	Moisture.	Protein.	Fat.	Sugar, etc.	Ash.
Chocolate[1]	1·44	13·27	22·08	63·21	—
Milk chocolate[2]	1·10	11·18	31·50[4]	53·82	2·40
,, ,, [3]	1·10	6·42	24·90	66·34	1·24
Peptonized milk chocolate[3]	3·31	12·09	34·20	51·89	4·00

Substitutes for Tea, etc.

Prior to the introduction into Europe of China tea and coffee, various leaves of plants or trees made into an infusion, or *tisane,* were used as beverage. One of the most commonly used was sage-leaves (*Salvia officinalis*), which were even sent to China to be exchanged for the Chinese product. Others are as follows:

Khât is the tea of Arabia, where it has been used from time immemorial. It consists of the leaves of a shrub (*Catha edulis,* N.O. Celastrinæ) which grows wild in Abyssinia, and is cultivated there and in Arabia. An infusion or decoction is made of the dried leaves, and consumed as a beverage. The leaves, both green and dried, are chewed by the natives, just as coca-leaves are chewed in America. They form an article of commerce of some importance to the Arabs. The twigs and leaves of the shrub are made up into bundles of varied size and quality. There appears to be no special mode of preparing them, like the leaves of tea or berries of coffee; they are simply dried like a herb. The leaves contain an active principle called *katin,* which is closely allied to caffein. The use of the "tea" is said to produce effects similar to those of coca—viz., wakefulness and capacity for bearing strain with a minimum of fatigue; it is a powerful stimulant to the nervous system, and a moderate consumption of the "tea" produces an exhilaration analogous to that produced by Chinese green tea.

Maté, or Paraguay tea, consists of the leaves of a species of holly (*Ilex paraguayensis,* N.O. Aquifoliaceæ), which grows abundantly in the forests of Paraguay, Brazil, Chaco, and other places. Maté has been used, as the Chinese use tea, from time immemorial by

[1] Bell. [2] *The Lancet,* 1902, ii. 1135. [3] *Ibid.,* 1703.
[4] The fat is one-quarter milk-fat, three-quarters cocoa-fat; the sugar is combined cane-sugar and milk-sugar in like proportion.

the inhabitants of the above-named countries, its use having been derived from the aborigines. The plant is cultivated, but as yet the production is by no means equal to the consumption, which is said to be more than 8,000,000 pounds per annum. The mode of preparing Paraguay tea is much simpler than that of Chinese tea, as the leaves are not gathered separately, nor are they fermented or rolled. The young branches and twigs are cut off the tree, and placed on hurdles over a fire until they are properly dried or "roasted"; the leaves are then removed by beating a heap of the branches, and powdered or cut into small pieces. The natives make the infusion in a gourd, and drink by drawing it through a *bombilla* or tube into the mouth. The composition of the dried leaves, according to Katz,[1] is as follows: Moisture 9·38, nitrogen 2·05, albuminoids 10·75, caffein 1·15, fat and resin 6·57, tannin 7·74, mineral ash 7·24, per cent.; soluble in water, 31·18 per cent. The salts contain a high proportion of manganese and magnesium. The proportion of caffein[2] varies from 0·5 to 1·85 per cent., and therefore resembles that of coffee. It also contains 0·77 per cent. of a yellow oil, having an aroma like that of the plant, which appears to increase the stimulating properties of the plant.[3] Maté is the favourite beverage of the South Americans, who attribute to it innumerable virtues.

Guarana, or Brazilian cocoa, consists of a preparation made in South America from the seeds of *Paullinia sorbilis*, N.O. Sapindaceæ. The seeds are roasted, ground, and made into a stiff paste with water, formed into cylindrical rods and dried in the sun. It contains 5 per cent. of **caffein** besides tannin, sugar, starch, and dextrin, and is therefore much stronger than ordinary tea, coffee, or cocoa.[4] As a beverage, 15 to 60 grains infused in boiling water makes a stimulant and restorative beverage, the properties being almost entirely due to caffein.

Kola, or goora-nut, is the product of *Cola acuminata*, an African tree of N.O. Sterculiaceæ. It forms a highly stimulating beverage, while the nut itself is highly prized as a condiment by the natives of Africa, the West Indies, and Brazil. The average composition of ten varieties of kola-nut is as follows,[5] according to Uffelmann and Börner:

Composition of Kola-Nut.

Water	13·50 per cent.
Nitrogen, total	1·53 ,,
Caffein and theobromine	2·08 ,,
Fatty bodies	1·35 ,,
Starch	45·40 ,,
Cellulose	7·00 ,,
Tannin	3·79 ,,
Other non-nitrogenous matters	18·21 ,,
Mineral ash	2·90 ,,

[1] *The Analyst*, 1897, xxii. 251. [2] Byasson, *Jour. de Chim. Méd.*, i. 11.
[3] *The Analyst*, September, 1905.
[4] *Year-Book of Pharmacy*, 1877, 133.
[5] *Zeit. f. Angew. Chem.*, 1894, 716.

The active principle in kola-nuts is **kolanin,** a glucoside. The fresh undried nuts contain very little kolanin; it is developed by fermentation under the influence of an enzyme—*laccase*—whose action is favoured by a combination of warmth, light, moisture, and air. The kolanin in turn is broken down by the enzyme into kola-red, caffein, and tannin. Dried Dahomey and Congo nuts contain the most kolanin, and caffein and theobromine are developed from it—equivalent to one-fifth its weight.

A beverage is made from kola-powder by mixing a teaspoonful into a paste with a little water, then adding ½ pint of water and boiling it for five minutes in an open pan; it is poured into a jug, allowing five minutes for it to clear; the liquor is then poured off and made palatable with sugar and milk or cream. Various elixirs and wines are also prepared which contain it. The stimulating and invigorating effects of kola are undoubted; it increases the power of enduring mental and physical strain, or it removes the sense of fatigue after such strain. These effects are acknowledged by the medical faculty, but the opinion upon its secondary effects is not unanimous, some maintaining that it has no evil effects whatever, and others that it has deleterious effects like those of narcotics. The stimulating effect of kola is similar to that of tea, but more enduring, which Boa[1] attributes to the slower absorption of its active principles.

Coca, the leaves of *Erythroxylon coca,* N.O. Erythroxylaceæ, is included here because of the similarity of its action to that of tea, kola, etc. The natives of Bolivia and Peru cultivate this shrub for its leaves, *which they chew.* This is a very ancient custom, which has spread into the elevated regions where the shrub does not live. The annual consumption of coca-leaves in South America is said to exceed 100 million pounds. The physiological action places them in the same category as tea, coffee, and kola. But the alkaloids are different; they are *cocain, iso-atropyl cocain,* and *ecgonin,* combined with an aromatic substance named *hygrin,* coca-tannin, and coca-wax. It is less exciting than either tea or coffee, but its action on the heart is greater, while the mental faculties are less stimulated by it. The South American usually chews it with a trace of lime or chalk, when it appeases hunger and removes the sensation of fatigue. The leaves of commerce are by no means so active in this respect as freshly dried leaves. The properties are virtually those of cocain, but they possess a slight astringency and are more stimulating.

The proportion of cocain can be estimated thus: extract the leaves with water at a temperature of 80° C., precipitate the solution with acetate of lead; filter; wash the precipitate in solution of sodium sulphate to precipitate the lead; add soda to excess; filter, evaporate the filtrate to dryness, wash the crystals in ether, and again in alcohol. It may also be obtained by extracting the leaves with a 2 or 5 per cent. solution of sulphuric acid, precipitating by

[1] *Pharm. Jour.,* 3rd series, xxii. 841.

excess of sodium carbonate, purification of crystals by ether or alcohol, and recrystallization.

Other leaves which are used as substitutes for tea are the leaves of *Cliffortia*, N.O. Rosaceæ, called "Dorn-thée" at the Cape; the leaves of a leguminous plant of South Africa, called *Borboma*, yields "Stekel-thée"; and the leaves of *Cyclopia*, another leguminous plant of South Africa, yields "Bush-tea," which has an aroma like China tea. "Hottentot" or "Caffer" tea consists of several species of *Helichrysum*, N.O. Compositæ; it has an agreeable aroma, and is a favourite with the natives. Madagascar tea, or "Fahum," consists of the leaves of an orchid; "Labrador" tea is the leaves of *Ledum latifolium*.

The Dietetic Value of Tea, Coffee, Cocoa, etc.

The action of these beverages is due to the volatile oil, alkaloids, and tannin.

1. *The volatile oil* is not the same in each of these substances; neither is their flavour or effects. The oil of tea dilates the blood-vessels of the surface, flushes the skin with blood, and stimulates the sweat-glands. It warms the body when it is cool by increasing the circulation through the skin; it cools the body when it is warm by causing a radiation of heat from its surface and an increased evaporation of moisture. The oil of coffee causes more or less contraction of the arterioles and capillaries, and cools the surface of the body by reducing the circulation through the skin.

2. *The alkaloids* are **caffein** in tea, coffee, kola, maté, guarana; **katin,** an allied body, in khât; **theobromine** in cocoa; **cocain** in coca; etc.

Caffein (thein) is absorbed unchanged into the circulation, and it acts upon nervous and muscular systems, its chief effect being upon the nervous system. *The brain is stimulated*, there being an increase in the reflex excitability, and a shortening of the time occupied in nervous processes; this results in the clearness of intellect, the removal of languor and drowsiness, which follow a cup of strong coffee or tea. This wakefulness and increased quickness to respond to stimuli result in the ability to perform an increased amount of intellectual work, whence has arisen the statement that tea and coffee are the beverages of the brain-worker. They enliven the spirits, arouse thought, clear the perceptive faculties, and stimulate imagination. The effect of caffein was demonstrated by Benz, who experimented on animals rendered comatose by alcohol; the coffee combated the paralyzing effect of alcohol so that the animals could be roused; indeed, coffee has long been used as an antidote to alcohol, opium, and other narcotics which induce coma. It is true that large doses of coffee or caffein cause a species of narcotism, but there are differences in this respect according to the individual or species of animal. In the lower animals it affects all the spinal centres simultaneously to such a degree that tetanic convulsions may occur. In man it does not affect the spinal centres very much;

the sensory and motor peripheral nerves are not affected at all in ordinary cases ; but the respiratory movements become deeper, and the heart beats more powerfully, thereby showing its influence on the medullary centres.

The action of caffein on the heart is twofold : (1) It acts through the medullary centre, and increases the force and frequency of the heart, and thereby the blood-pressure ; (2) it acts upon the muscle itself, which it stimulates to increased exertion—thus it strengthens and lengthens the cardiac contraction, and shortens the period of dilatation and rest ; in poisonous doses it acts so powerfully as to stop the heart in systole. A cup of hot tea or coffee therefore increases the force and frequency of the heart, raises the blood-pressure, flushes the skin and kidneys with blood, promotes an increased secretion of urine and removal of waste products.

Upon the muscles caffein also has a direct action : tea and coffee alter the character of the muscle curve, and the contraction is more easily executed. An increase of muscular power after taking tea or coffee is shown by the ergograph ; this, however, is only temporary, like the increase of blood-pressure ; the muscular power first rises and then falls. The temporary increase of power is due to the abolition of the sense of fatigue ; for Schomberg[1] has shown that when the muscles are completely exhausted caffein is unable to bring about a reaction.

Metabolism is but little influenced. It was formerly thought that the stimulation of the body to increased exertion was due to some influence upon the tissues, whereby the tissues were spared, the chemical changes reduced or slowed down, and the body able to do its work with less food. This, however, is not so ; for, experiments show that under the influence of caffein there is actually a slight increase of tissue destruction rather than diminution, owing to the stimulation to activity, and a slight increase of temperature. The fact is, tea and coffee are stimulants—they are not foods ; they do not prevent starvation, although they lessen the feeling of hunger. They neither build up tissues nor provide them with energy. They deaden the sense of fatigue, and by so doing enable the worker to continue his exertions longer than he otherwise could do ; at the same time they stimulate muscular and nervous activity ; and by promoting the circulation they increase mental activity, induce wakefulness, and remove from the tissues some of the waste products which cause the feeling of fatigue.

The *nutritive value* of a cup of tea or coffee depends very largely upon the cream or milk and sugar which are added to it. The two lumps of sugar which most people add to an ordinary cup of tea weigh 3 drachms, contain 11 grammes of carbohydrate, and yield 45 calories or units of heat ; and something may be added for the teaspoonful or two of cream. When coffee is made with boiled milk the nutritive value is much increased.

Habit materially weakens the stimulating effects of tea, coffee,

[1] *Archiv f. Anat. u. Physiol.*, 1899, supplement, p. 289.

etc.; but at the same time an *excess* of tea is deleterious by its influence upon the nervous system. Common symptoms are indigestion, heartburn, flushing of the face, excessive nervousness, irregularity of the heart, palpitation, neuralgia, headache, insomnia, and other nervous troubles. Green tea is more likely to produce a train of nervous symptoms than black. The consumption of coffee to excess is not only followed by insomnia, but also by numbness or formication, loss of power of groups of muscles, pain in the back, liver complaint, etc. The tannin in these infusions has a tendency to retard digestion by coagulating albumin, and thereby promoting flatulence and dyspepsia; wherefore they should not be taken immediately after a meal containing meat.

Cocoa.—The *nutritive value* of cocoa is greater than that of tea or coffee. A breakfastcupful of cocoa ready for consumption, made of two teaspoonfuls of cocoa (=3 drachms), two lumps of sugar, and an ounce of boiled milk, contains, in grammes—Protein 3·75, fat 4·75, sugar 10·01, starch 0·50, theobromine 0·095 (=1½ grains), tannin, dextrin, etc., 3·66, ash 0·50, and has a heat value of 120 to 125 calories. The proportion of theobromine is small, but not negligible, inasmuch as a breakfastcupful contains about 1½ grains. Theobromine, although it has similar diuretic effects, due to increased blood-pressure, has not the same value as caffein. Cocoa is less stimulating, but more nutritive and sustaining than coffee, by virtue of the greater proportion of protein, fat, and sugar, in the mixture. The stimulating power of one of the popular cocoas has been increased by adding kola to it. Kola contains a considerable quantity of caffein, and therefore possesses a proportionate stimulating power. Its action on the nervous system is just as great as that of cocoa is little; therefore the stimulating effect of cocoa can be made equal to that of tea or coffee. Kola has the power of temporarily increasing the muscular power, of abolishing the sensation of fatigue, and thereby sustaining the body under prolonged muscular exertion. It is doubtful whether the use of kola by Western people should be encouraged; many people suggest that it has deleterious results. The same things were asserted, however, about tea and coffee in the early days of their use. The only thing, therefore, is to make observations among the people who use it, to watch its physiological effects, and see in what way these differ from those of coffee and tea, and to judge of its value thereby.

ABSORPTION OF COCOA.

Consumed daily.	Nitrogen absorbed per Cent.	Fat absorbed per Cent.	Carbohydrate absorbed.	Authority.
110 to 120 grammes	54·0	95·4	100·0	Cohn.
98 grammes ..	42·0	94·5	—	Weigmann.

With regard to tea and coffee, it may be said that practically the whole is absorbed. With regard to the time occupied in their absorption, the following observations were made by Hutchison:[1]

TIME OCCUPIED IN ABSORPTION.

200 c.c. (1½ teacups)	of tea were absorbed in	..	..	1½ hours.
,, ,, ,,	of coffee ,, ,,	..	..	1¾ ,,
,, ,, ,,	of cocoa made with water were absorbed in	..	..	1¾ ,,
,, ,, ,,	of cocoa made with milk were absorbed in	..	..	2½ ,,

The Influence of Tea, Coffee, and Cocoa, on Digestion.—(*a*) *Salivary digestion* is hindered, but Aitchison Robertson found that coffee had less influence than tea, and cocoa none at all. Some observations by Roberts,[2] which have been confirmed by others, show that an infusion of tea has a marked inhibitory effect on salivary digestion. When 5 per cent. of an ordinary infusion of tea is present in an artificial digestion mixture, no transformation of starch occurs. The tea appeared to have quite as strong effect when infused for only two minutes as when it is infused for half an hour. Roberts considers the inhibition is due to the presence of tannin, and is prevented by the addition of a pinch of bicarbonate of soda. It is probable that the diastatic enzymes are precipitated by the action of even a small proportion of tannin.

(*b*) *Gastric Digestion.*—Tea and coffee retard gastric digestion, but the inhibitory power of tea is greater than that of coffee, and Indian tea more effective than China tea. The inhibition is due to the tannin and essential oil; caffein does not hinder, but is regarded as favouring, digestion. Coffee has less retarding influence than tea, when an infusion is made of the same strength, according to Schultzenstein;[3] but inasmuch as an infusion of coffee is usually stronger than an infusion of tea, it may be regarded as having an equal inhibitory action. This requires a little explanation. The proportion of tannin in black tea is 5·0 per cent., in green tea 10·0 per cent., and in coffee the tannin and caffeo-tannic acid equal 20 per cent. The tannin of tea is evidently more easily soluble in hot water than that of coffee, for Hutchison found that a cup of tea contained from 0·9 to 4·2, or an average of 2 or 3 grains of tannin, and a cup of coffee, made with 2 ounces of coffee to 1 pint of water, contained 3·25 grains of tannin. Roberts, however, considered that the retarding influence of tea and coffee was only half due to tannin; the rest is due to the volatile oil.

The presence of milk in tea and coffee removes the influence of tannin to a great extent by the union of the tannin with proteins of the milk. It is also to be observed that these beverages do not exert the same influence on all foods alike—*i.e.*, their digestion is not retarded to an equal degree. Roast beef, white of egg, ham,

[1] "Food and Dietetics," p. 317. [2] "Digestion and Diet," p. 120.
[3] *Zeit. f. Physiol. Chem.*, 1894, xviii. 131.

and salt beef, are much less affected than fowl, lamb, and bread, according to Fraser.[1] This investigator also observed that there is a greater production of gas under the influence of tea than under coffee or cocoa. Tea reduces the acid-absorbing power of the proteins ; coffee also reduces it, but to a lesser degree ; while cocoa actually increases it. These reasons show why coffee should be preferred to tea by persons suffering from flatulent dyspepsia, and cocoa by those who have hyperacidity.

Cocoa interferes with digestion in another manner : it deposits a fine powder upon the food, and thereby prevents the access of the gastric juice ; but this is soon obviated in natural conditions. The fat of cocoa is rather difficult of digestion, and may likewise exercise an inhibitory influence by coating the food ; but the proportion is not great in a cup of the beverage.

There are several practical deductions to be made from these observations. Under ordinary conditions the delay in digestion due to the essential oil and tannin are not of great importance. Indeed, Roberts regarded this slight delay as being rather beneficial than otherwise, by compensating for the too rapid digestion of foods prepared according to modern refinements—*e.g.*, fine white flour and bread. But when the digestive functions are feebly performed, tea (especially green tea) may be sufficient to upset the balance by interfering with the digestion of meat, fish, and other protein foods. Tea and coffee should be avoided at all meals of which proteins, especially meat and fish, form a part. The tannin in these beverages may irritate the mucous membrane of the stomach, and thereby assist in the causation or duration of chronic gastric catarrh. In chronic catarrh of the stomach coffee is more injurious than tea ; but when the gastric ailment arises from atony of the organ or feeble action of its ferments, coffee is preferable to tea, and cocoa is better than either. When flatulence is a marked feature coffee is the best ; when acidity prevails cocoa is the best beverage.

[1] *Jour. Anat. and Physiol.*, 1898, xxxii. 615.

CHAPTER XXXI

MALT LIQUORS[1]

Malt Liquors are beverages prepared from an infusion of malt and hops ; they are commonly called **Beer,** but this is a generic term including ale, beer, stout, porter, etc. **Malt** is a grain, usually barley, which has been made to germinate in order to obtain the transformation of starch into saccharine matters, after which it is dried in a kiln ; 100 parts of barley produce about 92 parts of air-dried malt. The changes which occur during malting are considered under that heading.

Historical.—The manufacture of beer—that is, of fermented liquors prepared from grain—is of great antiquity. Evidence of its use for more than 2,000 years is found in ancient writings. The discovery of the art of brewing has been ascribed to Gambrinus, the son of Marcus, King of the Germans, who lived 1730 B.C. But Herodotus attributes it to the ancient Egyptians, who claim to have been taught by the god Osiris. He says they consumed a fermented liquor made from barley, which, however, was little inferior to wine. Antilochus the satirist, who lived about 700 B.C., and Æschylus, about 500 B.C., described ale as *the wine of barley*. Xenophon says it was used by the inhabitants of Armenia. Diodorus Siculus mentions beer in his history. Pliny says the nations of Western Europe made an intoxicating beverage of corn and water, and that it was used in Spain, Gaul, and other provinces of the Roman Empire. The Spaniards called it *ceria* and *celia*, but in Gaul and Germany it was called *cerevisia*. Our Teutonic ancestors probably brought the custom with them into Britain. But Isodorus in the fifth century describes the mode of making beer by the ancient Britons as follows : "Grain is steeped in water until it germinates ; it is then dried, ground, infused with water, and fermented. It makes a pleasant and intoxicating drink." Ina, King of Wessex, in 680 found it necessary to formulate regulations for *ale-booths*. Numerous laws and regulations have been made by successive Kings ever since then to govern the price of the beverage and levy a tax upon it for State purposes. Excise duties are now payable upon all malt liquors manufactured for sale, but sufficient ale for the private use of the family can be brewed by any person without a licence or payment of Excise duty.

The term **Beer** is at the present day a generic name for the whole of the malt liquors produced by fermentation ; it includes the following and other kinds :

[1] The following books have been consulted by the author : (1) Southby's "Practical Brewing"; (2) Thausing's "Malt and Beer"; (3) Sykes's "Principles and Practice of Brewing"; (4) Moritz and Morris's : "Science of Brewing"; (5) Hansen's "Studies in Fermentation"; (6) Effront's "Enzymes"; (7) Jörgensen's "Micro-Organisms of Fermentation."

Ale is any liquor made by the fermentation of infusion of malt, in which sense it is synonymous with beer. It is usually made from malted barley, but any grain—wheat, rye, oats, rice, or maize—malted or unmalted, can be used; but other substances which contain, or are capable of transformation into, saccharine material (beetroot, parsnips, potatoes, beans, sugar, molasses, glucose, etc.) are sometimes used to replace or supplement barley malt. It is, however, usually understood that ale is a pale brown liquor, brewed from lightly dried malt and hops, containing more or less undecomposed saccharine matter and dextrins in the form of extract of malt, and certain other characteristics which undergo modification by maturation and age. Analyses show them to have the following composition :

COMPOSITION OF ALE AND BEER.

Water	88·0000 to 92·000	per cent.
Alcohol, by weight	3·5000 ,, 7·000	,,
,, equal to proof spirit	7·8500 ,, 15·500	,,
Nitrogenous matters	·3500 ,, ·850	,,
Extract, including— Maltose, 1 to 4 per cent. Dextrin, 3 to 6 per cent. Hop extract, resin, 1 to 1·25 per cent. Cellulose, colouring matter	5·0000 ,, 10·000	,,
Secondary products (higher alcohols)	·0209 ,, ·077	,,
Free organic acids :		
Volatile : Carbonic[1]	·2200 ,, ·250	,,
Acetic	·0200 ,, ·040	,,
Succinic	·0400 ,, 1·000	,,
Fixed : Lactic	·0200 ,, ·050	,,
Malic, tannic, etc.	·1400 ,, ·320	,,
Glycerin	·2000 ,, ·250	,,
Mineral substances	·2000 ,, ·450	,,

The volatile acid is usually reckoned in terms of acetic acid, and the fixed acid as lactic acid.

Ale and beer are usually prepared by the *infusion method* in England, and are fermented with ordinary or top-fermentation yeast (*Saccharomyces cerevisiæ I.*). A good sample, when first poured into a glass, should appear as *cloudy as milk*, clearing slowly as the gas in solution rises to the surface of the liquid ; it should then be clear and bright, free from floating particles and sediment, have bubbles of gas adhering to the glass, and bear upon its surface a tenacious creamy foam.

Mild Ale should have just a perceptibly bitter taste, but at the same time a soft taste and palate-fulness.

Brown Ale is made from malt which is dried or roasted at a higher temperature.

Beer is stronger, darker, well fermented, contains less saccharine substances and more alcohol than ale.

Table Beer is a considerably weaker liquor than the former ; it contains more saccharine matter and less alcohol

[1] Equal to about 2 cubic inches per fluid ounce.

Scotch Ale is stronger; it contains 8 or 9 per cent. of alcohol and 10 per cent. of malt extract.

Pale Ale is made from pale or lightly dried malt and the finest and palest hops. It contains about 14 per cent. of extract of malt and 6 or 7 per cent. of alcohol. It should have a bitter taste, due to the flavour of the hops, and the aroma of the latter should be perceptible on pouring the liquid into a glass. It should possess the other qualities of a good ale already indicated, especially brilliancy and sparkle. Average pale ale is inclined to *dryness*, but it contains a fair percentage of dextrin or malto-dextrin. The hops used for pale ale should be the choicest East Kent, Farnham, or Worcester hops. *East India Pale Ale* combines the pale colour, flavour, and bitterness (usually in excess), of pale ale, with the dryness and maturity of beer.

Stout and **Porter**, also called "black ales," have the same characteristics as ale, with the additional flavour of caramelized materials. In some types the liquor is characterized by "dryness"; in others a luscious fulness is considered indispensable. The malt used is black, brown, or amber-coloured. *Porter* is a dark brown liquor, formerly brewed from dark or high-dried malt, but now frequently made of amber or pale coloured malt, with a sufficiency of dark malt to give it a flavour, and coloured with *caramel* or burnt sugar. It contains from 7 to 8 per cent. of extract and about 5 per cent. of alcohol. *Stout* is a rather stronger kind of porter, and contains 6 or 7 per cent. of alcohol. In London porter is often called "beer."

Small Beer.—Formerly the liquid obtained from the "grains" by "sparging" was fermented separately, and produced a beverage of low alcoholic strength, but containing some saccharine material and malto-dextrin. The proportion of alcohol varied from 1·25 to 2 per cent. Such beer is never produced now, as the "smalls" is mingled with the "sweet-wort."

Lager Beer is the Continental beverage. It is prepared by the *decoction system*, fermented by bottom-fermentation yeast (*S. cerevisiæ II.*), and contains 9 to 10 per cent. of extract and 4 or 5 per cent. of alcohol. The following is the mean of several analyses by Sir Charles A. Cameron:

Composition of Lager Beer.

Water	89·49 per cent.
Alcohol (by weight)	4·34 ,,
Maltose	2·04 ,,
Dextrin	3·34 ,,
Albumin and other proteins	·40 ,,
Acids (reckoned as acetic acid)	·12 ,,
Ash	·27 ,,

It is a light, wholesome, palatable, strengthening, and mildly stimulating beverage. It contains only a moderate amount of alcohol, enough to preserve the liquid and little more. It combines the nutritive qualities of malted barley with the tonic properties of

hops. Being slightly alcoholized, lager beer cannot be exposed to the air very long ; it would become flat and acid.

Bavarian Beer is of this type ; it is the beverage of a large number of Continental people. It possesses excellent qualities, has a rather bitter taste, a fine aroma, and peculiar flavour derived from the casks. It does not turn sour, owing to its being fermented at a low temperature by the bottom-fermentation process. The wort is fermented, in vessels having an extensive surface, and cellars whose temperature ranges from 45° to 50° F., for three or four weeks. Instead of forming a foam on the surface, as in top-fermentation, the yeast sinks to the bottom as a viscid sediment, or *Unterhefe*—that is, bottom-yeast, consisting of *S. Cerevisiæ II.* There are two chief brewings, called " winter beer " and " summer beer." The latter is brewed in December, January, and February, and stored in air-tight cellars for consumption in summer.

Bock Beer is a stronger variety of lager beer, having a darker colour and sweeter taste ; it is manufactured for immediate consumption.

Berlin White Beer (Weiss beer) is the Prussian national beverage, made from one part of barley malt and five parts of wheat malt.

Fancy names, such as "Oatmeal" stout, "Nourishing" stout, and others, are given to malt liquors brewed from oat malt, wheat malt, rice, etc. Some of these contain only a small proportion of alcohol, as shown in the analyses on pp. 824, 825.

The Manufacture of Ale and Beer.—It is not intended to describe fully the art of brewing ; the reader who desires a more complete knowledge of the subject is referred to the technical works named in the footnote on p. 820. The stages in the process are as follows :

(*a*) **Crushing.**—The malt about to be used is ground or crushed in such a way that every grain is broken and readily falls to a coarse powder. It is not ground into a fine powder, for the reason that this would interfere with the extraction of the malt and drainage of the wort.

(*b*) **Mashing.**—In England malt liquors are prepared by the *infusion* process. The malt is **mashed** or soaked in water ; by this means the saccharine matters are dissolved and diffuse out of the malt, the starch is gelatinized, and a sweet liquor, called the **wort,** is formed, and the diastatic, proteolytic, and other enzymes are thus enabled to perform their function. Water properly prepared to make the infusion is technically called " liquor." Each quarter of malt is mashed or infused for thirty minutes with one and three-quarters or two barrels of " liquor " at a temperature of 158° to 164° F. (called the " striking temperature "), by which an *initial* temperature of 145° to 147° F. is insured for the whole mash. It has been found by experience that water of this temperature will extract the largest amount of materials. But there are various systems of mashing, according to the object of the brewer ; the initial temperature of the mash, however, seldom ranges more than from 140° to 156° F. With the higher temperature, 153° to 156° F.,

TABLE I.—COMPOSITION OF MALT LIQUORS—PERCENTAGES.

	Water.	Alcohol by Volume.	Total Extract.	Protein	Sugar.	Dextrin.	Acidity as Lactic.	Ash.	Authority.
English beer, mild ..	84·71	8·45	6·74	·26	5·77		—	—	*Lancet*, Feb. 16, 1895.
,, ,, bitter ..	87·42	6·78	5·42	·16	4·22		—	—	
English ale and porter ..	89·10	4·89	6·93	·53	·84	—	·310	·31	Leyden.[1]
Burton pale ale	89·63	5·25	4·40	—	—	—	—	·35	Chittenden and Mendel.
Guinness's Dublin stout ..	—	5·50	5·42	—	—	—	—	·36	
Oatmeal stout	—	6·55	8·00	—	—	—	—	·33	
Nourishing stout	—	6·24	6·30	—	—	—	·900	·45	*Lancet*, 1902, ii. 1265.
Non-intoxicating malt beer	—	3·07	3·14	—	—	—	—	·10	
Pilsener lager beer ..	91·15	3·46	4·97	·37	—	—	·160	·20	
Bavarian winter beer ..	91·81	3·21	4·99	·81	·44	2·92	·116	·20	
,, summer be r ..	90·71	3·68	5·61	·49	·87	4·39	·128	·22	
Munich Bock beer ..	88·72	4·07	7·23	·71	·90	—	·170	·27	Leyden.[1]
,, Hofbräu	—	3·70	5·87	—	—	—	—	—	
,, Spatenbräu ..	—	3·23	6·61	—	—	—	—	—	
,, Löwenbräu ..	—	4·45	7·09	·57	6·15		—	·36	*Lancet*, Feb. 16, 1895.
Burton lager beer ..	89·49	4·34	6·42	·40	2·04	3·34	·120	·27	Cameron.
Danish beer	—	2·12	6·61	—	—	—	—	·20	*Lancet*, 1909, ii. 1265.

[1] "Handbuch der Ernahrungs Therapie," vol. i., 105.

TABLE II.—COMPOSITION OF MALT LIQUORS—PERCENTAGES.[1]

	Original Gravity.	Alcohol by Weight.	Total Solids.	Ash (Mineral Matter).	Maltose.	Dextrin.	Nitrogen.	Phosphoric Acid.	Total Acid.	Volatile Acid.	Fixed Acid.	Maltose : Dextrin Ratio.	Solids : Alcohols Ratio.	Attenuation.	Residue : Total Solids – (M+D).
Bass's ale (draught) ..	1060·8	5·02	5·80	·36	2·13	1·60	·076	·049	·098	·044	·054	1 : ·75	1 : ·86	63·1	2·07
Bass's pale ale (bottled)	1061·1	5·32	5·01	·35	1·43	1·57	·073	·054	·094	·060	·034	1 : 1·10	1 : 1·06	68·3	2·01
Guinness's extra stout (draught)	1074·7	5·70	7·89	·33	2·18	2·82	·141	·110	·157	·059	·098	1 : 1·30	1 : ·72	59·2	2·89
Guinness's extra stout (bottled)	1067·7	5·15	7·32	·44	2·84	2·13	·147	·116	·140	·065	·075	1 : ·75	1 : ·70	58·2	2·35
	1068·5	5·20	7·87											58·7	
Mild ale (draught) ..	1043·4	3·88	3·78	·30	1·44	·95	·044	·038	·090	·037	·053	1 : ·66	1 : 1·03	66·3	1·40
	1054·1	4·24	5·80	·49	2·83	·70	·067	·037	·104	·044	·060	1 : ·25	1 : ·73	58·6	2·27
	1040·9	3·60	3·76	·33	2·01	1·28	·068	·079	·118	·064	·054	1 : ·64	1 : ·96	64·5	·47
	1056·8	4·46	5·96	·30	3·33	·60	·077	·061	·088	·018	·070	1 : ·18	1 : ·74	59·4	2·03
Allsopp's draught ale ..	1055·1	4·55	5·27	·29	1·60	1·70	·078	·052	·112	·063	·049	1 : 1·06	1 : ·86	63·0	1·97
Light bitter (bottled) ..	1044·5	3·66	4·53	·22	1·78	1·33	·044	·040	·082	·035	·047	1 : ·75	1 : ·80	60·4	1·42
	1047·5	3·77	5·09	·20	2·47	1·44	·064	·047	·076	·022	·054	1 : ·58	1 : ·74	58·1	1·18
Stout (draught)	1091·4	6·23	11·20	·45	5·66	2·32	·074	·102	·162	·065	·097	1 : ·41	1 : ·56	52·7	3·22
,, (bottled)	1074·7	5·04	9·26	·36	5·66	·58	·130	·078	·119	·025	·094	1 : ·10	1 : ·54	52·0	3·02
Allsopp's lager (bottled)	1044·8	3·88	4·14	·33	1·02	1·56	·068	·021	·086	·059	·027	1 : 1·50	1 : ·93	64·3	1·56
,, ,, (draught)	1052·1	3·45	6·85	·23	2·03	3·27	·088	·045	·092	·048	·044	1 : 1·59	1 : ·50	47·3	1·59
,, ,, dark ..	1046·1	3·69	4·81												
,, ,, light ..	1046·9	4·01	4·38	·13	1·10	1·60	·077	·029	·082	·033	·049	1 : 1·45	1 : ·91	63·9	1·68

[1] Analyses from *The Hospital*, April 24, 1909.

a clean, dry, slow-conditioning beer is obtained, which is slow to ferment, on account of the high type of malto-dextrins produced; but with the lower initial temperature the wort contains a lower type of malto-dextrins which are highly fermentable. After the lapse of time while the mash is in process, an "underlet" of liquor (water) having a temperature of 185° to 190° F. is allowed to enter the mash-tub, with the object of raising the now falling temperature of the mash.

(*c*) **Sparging.**—After an interval of one and a half to two hours the infusion is run off, by means of taps, into the coppers. As the transference is going on, any additional water which is deemed necessary is "sparged" over the "goods"—*i.e.*, the malt in the mash-tub—until the required quantity is passed through. "Sparging" therefore is the technical term for sprinkling water over the malt during brewing, and it is performed by means of a special apparatus fixed inside the tun. If a *second* mash is required, the taps are stopped, the "goods" sparged with "liquor" (water), and the temperature maintained as before. Thus all the saccharine matter is extracted from the malt. During mashing and sparging a chemical reaction takes place, owing to the influence of the diastase, by means of which the starch is converted into dextrins, malto-dextrins, and maltose. At the same time the proteolytic enzyme converts proteins into proteoses and peptones, which are yeast foods. Of these substances, maltose is easily fermented with yeast, malto-dextrin (isomaltose) is less easily decomposed, while the dextrin is not fermented by yeast, but gives nourishing qualities and the property of palate-fulness, which is much appreciated.

(*d*) **Boiling.**—When the wort is transferred to the coppers, a due proportion of hops is added, and the entire substance boiled for one and a half to two hours; after which it is transferred to a receiver, called a "hop-pack." The wort is sterilized and enzyme action stopped by boiling, and the constituents of the hops extracted.

(*e*) **Fermentation.**—The material turned into the hop-pack is allowed to remain undisturbed for twenty to thirty minutes to precipitate the hops, albuminous, mucilaginous, and other matters. The hop-pack has a false bottom, which is perforated, whereon the solid materials collect, and through which the liquid percolates. The clear liquid is poured off into shallow vessels, or "coolers," or is pumped through refrigerators, in order to cool it prior to fermentation. It is absolutely essential that the liquid should not now become contaminated with dust and bacteria—a point which is sometimes neglected. Thatcher says: "Modern brewers consider careful boiling of the wort is an absolute necessity to effect sterilization, but they sometimes neglect to prevent contamination during cooling; yet this is equally necessary, for germs killed by heat and present as inert matter become food for other germs which may be introduced during cooling, and thus render the previous purification useless." Another object of cooling is the aeration of the wort; this is best obtained by passing the liquid

in a thin stream over a refrigerator, by which means also the oxidation and precipitation of albuminous and other putrescible matters are assisted. The presence of the latter substances during fermentation prevents vigorous "barm production," because micro-organisms develop in the liquid to such an extent as to destroy the vitality of the yeast.

The cooled and clarified wort is now run into the "gyle-tun," or fermenting vessel, and is "pitched" at a temperature of 60° F. By "pitching" is meant the addition of yeast; and the proportion added varies from 1 to 3 pounds per barrel, according to the known strength of the yeast and the desired quality of the beer. The fermentation is allowed to proceed for a certain length of time, during which various changes take place. There are two chief systems of treating the liquid at this stage, known as the "skimming" and the "cleansing" system.

In the **skimming system** the fermentation is begun and ended in the same vessel, and is allowed to proceed until a yeasty head is formed; this is then skimmed off, and the skimming is repeated in two to six hours again and again, the temperature of the liquid being controlled meanwhile by "attemperators." The scum which is removed consists of a dirty mass of hop-resin, albuminous materials, yeast, bacteria, etc. The beer is then allowed to stand until most of the remaining yeast is settled to the bottom of the tun. It is then run into casks, where it undergoes the secondary or complementary fermentation.

The **cleansing system** is the mode in common use in the Burton breweries. The fermentation is begun at about the same degree of heat, and is allowed to proceed until the temperature of the liquid rises to 67° or 70° F.; or about half the saccharine material is decomposed, or, as it is technically stated, *half the original gravity is attenuated*. It is then transferred to casks, and the casks placed on their side, with the bunghole at such an angle that the rising yeast flows out of the cask. The beer is thereby *cleansed* of mucilage, starch, and other unfermentable matters which rise to the surface and form part of the scum. This cleansing goes on until the fermentation is comlpete, which is known by the yeast ceasing to rise. What does not come out of the bunghole sinks to the bottom and forms the *lees*. When the fermentation is complete, the liquid is racked into barrels, stored, and matured. The scum and lees are retained as yeast for the next brewing. A comparison of the two systems, of the temperature attained, the amount of extract, and other particulars, is given in the following paragraphs and in the table on p. 828.

By **aeration** is meant *agitation* of the liquid after every skimming of the yeast; it is said to cause a separation of floating particles, and results in a clear and brilliant ale.

Attempering.—The rising temperature of the liquid is checked by placing in the fermenting substance a copper coil-pipe, through which cold water is run at intervals to reduce the temperature.

Skimming is generally begun when the density of the liquid has sunk to about one-half by fermentation of the carbohydrates. Thus, an 18-pound beer is first skimmed when the carbohydrate is decreased or "attenuated" to about 8 pounds, and the process is continued until it reaches a density of 4·5 pounds. Thatcher says it is never safe to leave a beer with a greater density than this, especially in the summer time, unless it is made from a large percentage of *raw* grain and fermented with very pure yeast. In the winter season, however, such beers may have a density of 6 or 8 pounds, because the cold weather causes an artificial thinness of the liquid.

CLEANSING SYSTEM.[1]

Period.		Temperature.	Extract (Brewers' Pounds).	Details.
Tuesday	5 p.m.	59·00° F.	18·0	Add the yeast.
Wednesday	7 a.m.	59·50° F.	17·3	Curly head appears.
	7 p.m.	61·00° F.	16·0	Rocky head appears.
Thursday	7 a.m.	65·00° F.	12·5	Frothy head appears.
	7 p.m.	69·50° F.	8·5	*Liquid is put into casks.*
Friday	7 a.m.	70·50° F.	7·0	Rapid expulsion of yeast occurs.
	7 p.m.	70·00° F.	6·0	
Saturday	7 a.m.	68·00° F.	4·8	Attemperation is done.
	7 p.m.	66·00° F.	4·5	Fermentation complete.
Sunday	7 a.m.	60·00° F.	4·5	Settling.
Monday	7 a.m.	58·00° F.	4·5	Racked or bottled.

SKIMMING SYSTEM.

Period.		Temperature.	Extract (Brewers' Pounds).	Details.
Tuesday	5 p.m.	58·50° F.	18·0	Add the yeast.
Wednesday	7 a.m.	60·00° F.	16·5	Rocky head appears.
	7 p.m.	63·00° F.	12·8	To be *aerated* every three hours.
Thursday	7 a.m.	65·00° F.	10·5	Begin *attempering.*
	7 p.m.	66·50° F.	8·0	Liquid is first *skimmed;* repeated every three or four hours.
Friday	7 a.m.	67·50° F.	6·0	
	7 p.m.	67·00° F.	4·5	*The last skimming is done;* add preservative and priming.
Saturday	7 a.m.	63·00° F.	6·0	
	7 p.m.	58·00° F.	6·0	Settling.
Sunday	7 a.m.	58·00° F.	6·0	
Monday	7 a.m.	57·75° F.	6·0	Racked or bottled.

Priming.—It is the custom of many brewers to *prime* their malt liquors by the addition of some saccharine material before it is put into casks, especially when the skimming system is adopted. The priming substance used is not always the same, but as a rule it

[1] Thatcher's "Brewing and Malting."

consists of *glucose* if it is desired to produce briskness rather than sweetness, or *invert sugar* when the property of palate-fulness and lusciousness are to be increased. The substances consist of the usual commercial materials, or they are prepared on the premises.

Finings.—When the beer is in cask, some material is usually added to clarify it. This material is called the "finings," and may be added before it leaves the brewery or after delivery. The substance used is generally *isinglass* dissolved in an acid solution—*e.g.*, acetic, sulphurous, or tartaric—or sour beer. Each solvent has its defects. Sour beer is the means of introducing lactic or butyric acid bacteria or other micro-organisms into the beer, and is therefore unsuitable. Taratric acid is an effective finings, but encourages the development of mildew. Sulphurous acid discourages mildew and other fungi, but does not make a very efficient finings. Acetic acid is used on the principle that it is this acid in sour beer which effects solution of the isinglass; but it is only used for mild ales, which are quickly sold and consumed. The best finings is said to be made by isinglass in a solution of tartaric acid, with just enough sulphurous acid to check the growth of mildew, etc. The isinglass acts mechanically by carrying down the suspended particles, including the remaining yeast cells and other impurities.

Lager Beer is prepared in the same way as ordinary beer. The ground or crushed malt is mashed with hot water, or "liquor," and the brown liquid resulting from it is the crude beer, or "sweet-wort." The wort is drawn off, the grains are sparged, and the wort boiled with hops and transformed to a hop-pack in the ordinary way. The liquid is then passed through a refrigerator to the fermenting vats, where the yeast is added. The yeast is of the "low-fermentation" type (*S. cerevisiæ II.*), and the fermentation is carried out at a low temperature. The fermentation is started at 40° F., and is done in cellars where the temperature ranges from 45° to 50° F. for three or four weeks. There is no formation of barm (frothy or rocky head) as in the case of top-fermentation, but the formation of a viscid sediment, or *Unterhefe*—that is, bottom yeast. Neither are cellars absolutely essential to the manufacture of lager beer; any chambers which can be kept cool by ice will answer the same purpose. Lager beer is made at Burton in chambers kept cool by refrigeration, the fermentation being completed in eight days, after which the beer is matured in a storage chamber, where the temperature is kept below freezing-point.

The Changes which occur in Brewing—Changes in the Malt.—During the mashing an enzyme (*peptase*) converts insoluble and indiffusible protein substances into diffusible and assimilable proteoses, peptones, and amino-acids, especially glutaminic acid and asparagin, which are of importance during fermentation as foods for the yeast. The peptase enzyme acts best in a distinctly acid medium, and the wort usually contains about 2 per cent. of lactic acid derived from the malt. The amylolytic enzyme (*diastase*), being set free, acts upon the starch of the cereal and converts it into

fermentable bodies. There are two chief theories respecting these :

(*a*) *The Theory of Free Maltose and Dextrin.*—According to the earlier theory, all the starch is converted by diastase into dextrins (amylo-, achroo-, and erythro-dextrin) and maltose. The proportion of these substances produced and the type of the dextrin varies with the heat or initial temperature of the mash. Under favourable conditions, such as an initial temperature not exceeding 140° F., the proportions are 80·8 per cent. of maltose and 19·2 per cent. of dextrin. The lower the heat the greater the proportion of maltose produced, and at the temperature stated the transformation occurs in this proportion in fifteen minutes. When a higher initial temperature, say 150° to 151° F., is used, only 75 per cent. of the maltose is produced in fifteen minutes, and the other 25 per cent. requires forty-five minutes for its production, owing to the fact that hydration of the higher dextrins into lower dextrins, and then into maltose, is performed more slowly

(*b*) *The Malto-Dextrin Theory* —According to this theory, promulgated by Brown and Morris,[1] a molecule of starch consists of five groups of $(C_{12}H_{20}O_{10})_3$, and hydration causes one of these ternary groups to become detached from the molecule and converted into malto-dextrin—thus :

$$\underset{\text{Dextrin.}}{(C_{12}H_{20}O_{10})_3} + H_2O = [\underset{\text{Malto-dextrin.}}{(C_{12}H_{22}O_{11}) + (C_{12}H_{20}O_{10})_2}].$$

This process continues until four out of five of the dextrin groups are reduced to malto-dextrin, only one remaining stable.

Malto-dextrin is regarded as a combination of one molecule of maltose and two molecules of dextrin, or maltose 34·6 and dextrin 65·4 per cent. As the action of the enzyme continues, most of the malto-dextrin is in turn converted into maltose :

$$[(C_{12}H_{22}O_{11}) + (C_{12}H_{20}O_{10})_2] + 2H_2O = 3C_{12}H_{22}O_{11}.$$

The wort contains more malto-dextrin in proportion to the initial heat of the mash. A high initial temperature determines an increase of malto-dextrin in the wort, but of a higher type, and this is considered the best for stock beers. This effect is brought about by raising the temperature of the mash by sparging, which also causes a solution of more starch in a medium possessing a weakened diastatic power. Weakened diastatic power (*e.g.*, by raising temperature) implies the production of dextrins of a higher type. Malto-dextrin is unfermentable by ordinary yeast or *S. cerevisiæ I.*, but it is slowly fermented by *S. ellipticus* and *S. pastorianus*, which commonly exist in yeast.

Changes during Boiling.—During boiling the hops are added, and the whole liquid is sterilized and concentrated. Hop-resins are extracted. Diastase is destroyed ; albuminoids are precipitated by tannic acid and heat. Lactic acid derived from the malt,

[1] *Chemical News*, 1885, ii. 308.

tannic and malic acids from the hops, assist the process of sterilization.

Changes during Fermentation.—The fermentation is begun at a temperature of 59° or 60° F., but the temperature rises owing to the activity of the yeast cells. During the first few hours the reproduction of yeast goes on very rapidly, and the temperature rises in accordance with it. The temperature rises 1° F. for every pound of density which is lost, or for every pound of *attenuation*. The degree of fermentation therefore depends on the regulation of the temperature. In England this is allowed to reach a moderate height; consequently most of the sugar is broken up and the beer is rich in alcohol. On the Continent the temperature is kept lower than in England; consequently less alcohol is produced, more sugar and dextrin are left in the beer. Moreover, when the beer is fermented at a low temperature it retains more CO_2, and it is better aerated than English-made beers.

Primary Fermentation.—In the English method, ten or twelve hours after "pitching"—*i.e.*, adding the yeast—a delicate white line appears around the sides of the tun, and a few hours later a brownish *head* breaks through the surface of the liquor, and is gradually covered with irregular white frothy bunches, or *rocks*, increasing in size as the temperature rises to 65° or 66°, when the froth begins to fall again. During this time maltose and cane-sugar are fermented. According to Pasteur, 100 parts of cane-sugar are first transformed into 105·25 parts of dextrose, and then into alcohol 51·11, CO_2 49·32, succinic acid 0·67, and glycerine 3·16, parts, less than 1 part of sugar going to make fresh enzyme. When cane-sugar occurs in beer, it must have been added either as a supplement or substitute for malt. It is converted by the *invertase* enzyme of yeast into dextrose. When the beer is made entirely from malt, the *free* maltose alone is fermented at this stage (*primary fermentation*), the malto-dextrin and dextrin being unaffected. According to Moritz, a 20-pound wort containing only *free* maltose and *free* dextrin would attenuate to 1·29 pounds; whereas a 20-pound wort containing 15 per cent. of malto-dextrin would only attenuate to 5·04 pounds, and the latter is considered to be a fair average beer.

The fermenting liquor requires *attempering* to keep the temperature of the mass within due bounds. As a rule it is first done when the temperature rises to 63° or 64° F. The temperature of pale ale and bitter beer is not allowed to rise above 68° F.; but "running" beer of 20-pound gravity is allowed to rise to 70° F., and that of 25-pounds gravity to 72° F. As the temperature attains a height of 65° or 66° F. the beer gives off an odour, which is due to the escape of carbonic acid gas, acetic ether, and ethereal oil of hops. The occurrence of a *high* temperature during fermentation favours the production of a *vinous* character. This is undesirable, because it is due to the formation of higher alcohols, a combination of which form **fusel-oil**, and stimulates other factors which make for un-

soundness in the finished product. The fusel-oil of beer consists chiefly of amylic alcohol, and according to Le Bel and Hamlet it is always present more or less. The largest quantity is produced when unmalted grain is used, and especially when the temperature is allowed to rise to a great height during fermentation or when the yeast is in a bad condition. According to these observers, the proportion of amylic alcohol in beer varies from 0·0245 to 0·89 grain, or an average of 0·05 grain per gallon.

Secondary or Complementary Fermentation.—When the beer is in the casks, a secondary fermentation occurs which is considered essential to its good quality. This fermentation is caused by various types of yeast, the presence of some of which is desirable or undesirable according to the results which they produce. During this complementary fermentation malto-dextrins are reduced to maltose, and the latter to alcohol and carbonic acid.

The malto-dextrins are unfermented by absolutely pure yeast—that is, *S. cerevisiæ I.*—but they are fermented by *S. pastorianus II.* and *S. ellipsoideus I.*, which degrade malto-dextrin to maltose, in which form only the *S. cerevisiæ I.* is able to deal with it. Yeast, however, is rarely pure, but usually contains some of the forms of secondary importance, especially those named. The action of these *Saccharomyces* is restrained to some extent by the constituents of the hops ; nevertheless it goes on slowly until all the dextrin is reduced to maltose, and the latter into alcohol. The process may occupy weeks or months. During this time the proportion of alcohol increases, volatile bodies develop and increase the flavour, and the production of CO_2 under pressure leads to a solution of that gas, which gives the liquor a sharp and pleasant taste. The total result of the secondary or complementary fermentation is summed up in the word " condition," which the foregoing properties indicate, together with the spontaneous occurrence of clarification or " star-brightness " on being poured into a glass. After bottling, the beer becomes even more brilliant and sparkling than it was in the cask, owing to the accumulation of CO_2. A good ale of moderate strength should keep for eighteen months in bottle.

Substances used in Brewing.—The fact that malt liquors form such a large proportion of the beverages consumed in some countries necessitates a constant watch being exercised over the purity and excellence of the materials used in their production. But this watchfulness is to the brewer's advantage, for unless the substances used are fresh and free from micro-organisms and other impurities the product will be of an inferior quality, its condition will not be good, it will be unstable and liable to various diseases and degenerations.

Water.—The importance of using a pure water impresses itself on the brewer for various reasons. Not only is the wort sterilized by boiling, but *boiled* water is preferred for *mashing* the malt. If an impure water is used, any micro-organisms which it contained, although killed by boiling, would subsequently undergo putrefac-

tion, and if such dead bacteria pass through the mash into the fermenting tun they would render the finished product unstable. The addition of unboiled water for the purpose of making up a definite quantity of wort, or even for " sparging " the malt, has the same effect, and is one of the factors which lead to the development of acidity, turbidity, and ropiness, in the beer.

Waters containing very much calcium carbonate are usually pure and have a proportionately high *temporary hardness ;* but waters containing an excess of calcium or magnesium sulphate are sometimes very impure, and have a proportionately high *permanent hardness.* The presence of nitrites indicates the worst form of impurities ; if they exceed 6 grains of nitric or nitrous acid per gallon, the use of such water would lead to a weakening of the yeast, a corresponding sluggishness of fermentation, and a " foxy " odour in the final product. The use of such a water would be too expensive to the brewer for him to continue it very long, and therefore the presence of nitrites in the water is a useful check against its continued use. It is considered that a good brewing water should contain not more than 0·05 part per million of albuminoid ammonia ; water of medium purity would have 0·08 part per million ; but one containing 0·10 part per million of albuminoid ammonia would be regarded as too impure to yield satisfactory beer. Indeed, the water used for brewing requires to be frequently analyzed in order to be sure that it retains the proper composition. Special ales probably owe their reputation quite as much to the quality of the water as to the quality of malt and hops, or the care exercised in brewing them. Besides freedom from micro-organisms and other impurities, the water must possess particular ingredients for particular liquors.

The water used for brewing *pale ale* must contain calcium and magnesium sulphates and sodium chloride, which are necessary to give the ale permanent condition, stability, and brilliancy. The calcium sulphate (gypsum), if in sufficient quantity, has the effect of checking the premature development of " condition," and at the same time gives " stability " to the mature beverage. Magnesium sulphate gives a certain amount of briskness, while the chlorides of calcium, magnesium and sodium contribute to " palate-fulness " and brilliancy. When the beer is about to be stored for several months, the presence of these salines in the water has the effect of retarding the development of " condition," which effect is desirable in malt liquors destined to be kept ; but such beverages would be considered flat and thin if consumed before they attained maturity.

Water used for making *draught* or *running ales* should contain less of the saline sulphates than the beverages which are made to be kept for weeks or months ; but the presence of the chlorides encourages the early development of condition, palate-fulness, and brilliancy. For *mild ales* the chlorides of calcium and magnesium appear to determine the development of a rich, full flavour,

for which reason chloride of sodium is often added to the mash in the proportion of 1 pound for each quarter of malt. When brewing *stout* and *porter*, **rain water** is used, but the alkaline chlorides are freely added to it.

When the available water does not correspond to the requirements of the brewer, it is treated, so as to bring its composition up to the required standard, by the addition of inorganic chlorides and sulphates. Thatcher[1] gives the following proportion of salines which is usually added for the beverages mentioned :

(*a*) **Stock Ales** are made from water containing calcium sulphate 40, magnesium sulphate 15, calcium chloride 5, sodium chloride 5 —total, 65 grains of salines per gallon.

(*b*) **Pale Running Ales** are made from water containing calcium sulphate 30, magnesium sulphate 10, calcium chloride 10, and sodium chloride 10—total, 60 grains of salines per gallon.

(*c*) **Mild Ales** are made with water containing calcium sulphate 20 and sodium chloride 30—total, 50 grains of salines per gallon.

(*d*) **Stout** and **Porter** are made with water containing sodium chloride 35 and sodium carbonate 10—total, 45 grains of salines per gallon.

The natural inorganic compound called **kainit**, found in the saline deposits of Stassfurt, is considered an admirable substance to give to water the desired properties. It is a combination of potassium and magnesium sulphates, magnesium chloride, and water ($K_2SO_4.MgSO_4.MgCl_2.6H_2O$). It is largely used for making mild ales. An excess gives a harsh flavour and briny taste to the beverage.

When water has been boiled and filtered, or treated with chemical reagents or salines to bring it to a standard composition, it is called the **liquor**. When the " liquor " is artificially prepared, the salines are added to the water prior to heating it for mashing and sparging—that is to say, all the water and all the salines to be used must be mixed at one time ; otherwise unequal results will be produced. The sulphates of calcium and magnesium precipitate nitrogenous matters from the wort in a flocculent form ; wort prepared with water containing them is clear and bright after filtration, whereas wort prepared with distilled water is cloudy. Calcium sulphate limits the extraction of the *bitter* principle from hops, and, therefore, by eliminating the harsh, bitter flavour permits considerably more hops to be used per barrel of beer than when the hardness of water depends chiefly on the carbonates. The Burton brewers use a considerable amount of calcium sulphate, on the ground that it permits the extraction of the hop flavour with less bitterness and colouring matter, and aids in the production of stability, creamy softness, and brilliancy.

The Malt.—A grain of barley or seed of any other grass consists chiefly of starch. Near one end of the grain is the **germ**, which consists of the plumula, or part which during normal growth

[1] " Brewing and Malting," p. 16.

ascends through the earth and becomes the stalk; and the radicle, or portion which descends into the earth and forms the root. The operation of malting consists in encouraging the development of the germ up to a certain stage, and the object of malting is to render soluble the starch and protein constituents of the grain, and to develop the enzyme *diastase*.

When the grain is exposed to moisture it absorbs water and swells; if the temperature of the surrounding air is suitable, the radicle thrusts itself out of the lower end of the grain, while the plumula forces itself along the grain under the husk before it thrusts itself out. As the plumula grows the starch of the seed is transformed into soluble and diffusible substances for the purpose of its growth. Thus, when the plumula, or **acrospire**, as it is now called, has passed along one-third of the grain, about a third of the constituents are converted into soluble materials, of which sugar is a prominent member; when the acrospire has attained two-thirds the length of the grain, two-thirds of its constituents are transformed; and when the acrospire is as long as the grain, practically all the starch of the grain is transformed, and the sugar produced from it is rapidly disappearing by absorption into the growing plant. The object of the maltster is to convert the maximum quantity of starch into saccharine materials, and then to stop the growth of the young plant.

The barley used for malting is the two-rowed variety (*H. distichon*). There are several named subvarieties and many strains, of which the following are important: Big Ben, Chevalier, Champion, Golden Drop, Golden Melon, Golden Thorpe, etc. It undergoes a preliminary preparation of *sweating* and *grading*. "Sweating" consists of drying the barley on a kiln at 105° F.; by this means excess of moisture is got rid of, and in the subsequent steeping a more even absorption of water is insured; it is also asserted that the barley is *mellowed* by the process. It is allowed to rest fourteen days after sweating; it is then graded into different sizes, which are malted separately, broken and half grains, which become the breeding-ground for mildew, being removed. The various stages in the process of malting are as follows:

1. *Steeping*.—The grains are soaked in water for forty-eight to sixty hours, small grain requiring a shorter time than larger ones. The water is used at a temperature of 50° to 55° F.; a lower temperature would be unfavourable to the growth of the acrospire, and a higher one (say 60° F.) would favour the development of lactic acid at the present stage, and of mouldiness at a later one. The latter trouble is checked by the addition of calcium bisulphite to the water before steeping. During this period there is an increase of weight to the extent of 20 per cent. or more by the absorption of water; the grains soften and the epidermis can easily be removed.

2. *Couching*.—The water is drained from the grains, and they are placed upon the floor in conical heaps about 5 feet high. The heaps are sprinkled with cold water every hour, and the grains

turned over so that the moisture is evenly distributed. It remains heaped for twenty-seven hours, during which time the temperature in the interior of each heap rises ; it should not rise to above 60° F.

3. *Flooring or Spreading.*—The grain is now spread upon the floor in a layer varying from 2 to 12 inches deep, where it remains for ten to thirteen days. It is turned over every three or five hours. The temperature in the interior of the mass should not rise to above 50° to 54° F. ; if it rises above 54° F. the grain is spread out thinner or turned over more frequently. If the temperature should rise to 58° or 60° F. moulds may develop, the growth of the grain is forced too much, and the crop of yeast grown in the wort from such malt will not always give good results, the beer undergoing a " fretty " fermentation.

The overgrowth of the acrospire results in a loss of malt extract. Grain usually lies on the floor from ten to thirteen days. If the growth of the acrospire flags between the fourth and seventh days, the grain is sprinkled with water ; otherwise the addition of water is unnecessary. Really sound malt is only produced by keeping the temperature low ; hence it is more usual to spread the grain in a thin layer than a thick one. Forced malt—*i.e.*, grain which has attained too high temperature—goes through its stages more quickly, but such malt is the cause of much unsound beer.

During this stage of malting the grain sprouts, or " chits." A small white point appears, which is soon replaced by five to seven rootlets ; at the same time the acrospire begins to travel up the grain, starting from near the rootlets. If crushed, the grain has the smell of freshly-cut cucumber.

4. *Withering.*—When the germination is complete, which is known by the length of the acrospire, the grains are " withered." This arrests the germination and causes an evaporation of moisture. After it is properly carried out, the crushed grain should be dry and floury. This part of the treatment is sometimes done in a kiln at a temperature of 100° F., but if the process is hurried the grain will not be tender. Before withering, the acrospire is allowed to grow to a length which differs with the kind of beer to be made or the source of the grain. Foreign grain is usually germinated until the acrospire reaches the end without piercing the cuticle. English barley is germinated until the acrospire reaches the end only when *a high temperature* is intended to be used in the kiln or in the mash-tun, or, again, if it is to be used along with unmalted grain ; but when it is desired that the beer shall possess much palate-fulness, it is unnecessary to allow the acrospire to grow to such a length—in other words, to permit such a complete transformation of the starch.

5. *Drying and Curing.*—It is necessary that the grain should now be dried in a kiln, the floor of which is heated by a furnace. The grain is spread on the floor to a thickness of 4 or 6 inches, and the temperature is gradually raised. On the first day the temperature is 95° to 100° F., on the second it is raised to 115° or 120° F.,

on the third to 140° or 145° F., and on the fourth day to 165° or 180° F., when pale malt is finished ; but the temperature is raised to 200° or even 230° F. for high-dried malt, which when finished is highly coloured. The latter part of the process is called *curing the malt*, the finished product being dry, crisp, and tender. The object of this process is to arrest fermentation, remove moisture, check the development of or destroy bacteria, and render the malt fit for storage. " Black malt " is sometimes roasted in a cylinder in the latter part of the process ; this has the effect of producing caramel and destroying the diastase ; consequently there is no further production of maltose or malto-dextrin during the brewing. In some districts the following classes of malt are recognized : *Pale malt*, dried at 100° F. ; *amber malt*, dried at 125° F. ; *brown malt*, dried at 165° F. ; and *black or patent malt*, dried at 370° F.

6. *Mellowing.*—Finally the malt is placed in a heap in the kiln to give it mellowness and flavour, after which it is stored in bins around the kiln walls for four to eight weeks. When freshly cured, good malt has only 2½ to 3½ per cent. of moisture, but during storage it rises to 5 or 6 per cent. If the moisture goes higher than the latter, the malt is said to be " slack," and the diastatic energy increases to such an extent that a low type of malto-dextrin is produced in considerable quantity in the wort. This type of malto-dextrin is easily reduced to maltose, and thence to alcohol. There is consequently a deficiency of malto-dextrin in the beer, and, instead of the secondary fermentation being beneficial, it frequently leads to what is known as a " fretty " fermentation. *Slack malt* is sometimes redried at a temperature of 120° to 132° F. until the moisture is driven off, and recured at a temperature of 160° to 170° F. ; but malt which has been treated in this way does not produce such good beer as first-class malt.

Chemical Changes in the Grain during Malting—(*a*) **Proteins.**—The insoluble albuminoids are in part converted into soluble proteins. The latter include asparagin, glutamin, and other amino-acids, which pass through the cellular tissues of the seed to supply the needs of the growing embryo. *Peptase* is developed, which converts albumin into peptone, also for the benefit of the growing plant. (In brewing the transformation of albumin to peptone continues during the *mash*.) *Diastase*, *maltase*, or amylohydrolyst is developed in the epithelium of the grain.

(*b*) **Carbohydrates.**—The proportion of starch is diminished and the sugars increased during malting. Barley loses 4 to 15 per cent. of starch, and gains a proportionate amount of sugar. The sugars in barley vary from 0·86 to 1·45 per cent. ; in green malt it varies from 4·6 to 5·1 per cent., and in finished malt from 11·5 to 15·5 per cent. This change is brought about by the amylolytic enzymes. The starch granules are enclosed in an envelope of *cellulose*, which renders the *granulose* of the interior inaccessible. This is only overcome by the effect of heat or enzymes. Great heat ruptures the cellulose envelopes, and thereby exposes the granulose to the

action of enzymes. But during germination (*e.g.*, in malting) there is developed in the absorptive epithelium of the seed a cellulose-dissolving enzyme, or *cytohydrolyst*, which erodes the amylocellulose, and enables the diastatic enzyme, or *amylohydrolyst*, to gain access to the granulose and convert it into soluble and diffusible substances—dextrose and lævulose—which are capable of passing through the membranes of living cells and serving to sustain them and provide material for the growth of the embryo. The sugars so formed revert to the insoluble and indiffusible carbohydrates of which the embryo tissues are made—that is, they form the starch and cellulose of the newly-formed cells.

The table on p. 839 will show the principal changes in composition, the analyses of the two samples of malt being by O'Sullivan.

Origin of the Enzymes.—It has been stated that a cellulose-dissolving enzyme is produced in the absorptive epithelium of the seed, but this enzyme is not necessarily developed by the cells of the epithelium. According to Wigand, of Marburg University, it is produced by bacteria. This theory receives support from the fact that, when flour is macerated in water, a similar pitting or erosion of the cellulose envelopes of the starch granules is observed, and during such maceration bacteria are copiously developed.

It has also been claimed that the absorptive epithelium of the grain produces the *diastase* of malt. According to Brown and Morris, this enzyme is secreted by the cellular membrane of the *scutellum*. The outer part of the scutellum lying on the farinaceous body of graminaceous seeds is enveloped in an epithelium of palisade-shaped cells, which on the one hand suck out from the farinaceous body stores of liquefied nutriment, and on the other hand carry them to the growing plant. These palisade-like cells are believed to be the source of the diastase. Professor Wigand, however, believes that it is produced by bacteria, and that these bacteria have their origin in a transformation of the cellular protoplasm. During maceration and germination the palisade-shaped cells of this epithelium undergo changes in character. The protoplasm becomes at first finely and irregularly granular, but afterwards it is transformed into large granules of equal size, which exhibit an active swarming movement of a vital character, between which, here and there, small rods are found. If a section of the scutellum be now made and placed on a microscope slide with a drop of water, and covered with a glass in such a way that the contents of the wounded cells find their way into the surrounding water, the little dancing bodies which have become free are transformed into rod-like bacilli. It is these bacilli, according to Wigand, Bertheim, etc., which secrete the diastase, and which have given rise to *the bacterial theory* of the origin of diastase.

During malting the diastase undergoes some modification; it develops the liquefying action, or power of converting insoluble into soluble starch. This effect of diastase reaches its *maximum*

COMPOSITION OF BARLEY AND MALT COMPARED.

	Barley per Cent.		Pale Malt per Cent.	
			Sample 1.	Sample 2.
Nitrogenous	11·25 to 11·75	Nitrogenous	13·09	13·80
		Including (*a*) Soluble in alcohol and cold water	·63	·46
		(*b*) Soluble in water at 68° C. ..	3·23	3·12
		(*c*) Insoluble in cold water, but soluble in water at 68° C. ..	2·37	1·36
		(*d*) Insoluble in water at 68° C., but soluble in cold water ..	·48	·37
		(*e*) Insoluble in cold water and at 70° C.	6·38	8·49
Fat	1·00 ,, 2·25	Fat	1·65	1·96
Carbohydrate: Starch	57·00 ,, 65·00	Carbohydrate: Starch	44·15	45·13
Sugar, dextrin, gum, pectin, inulin, and colouring matter	1·25 ,, 3·00	Sugar, dextrin, gum, inulin, pectin, colouring matter	21·23	19·39
Cellulose	7·25 ,, 10·50	Cellulose	11·57	13·80
Ash	2·25 ,, 2·75	Ash	2·60	1·92
Water	12·00 ,, 13·00	Water	5·83	7·47

at a temperature of 160° F., although the enzyme is still effective up to 200° F. The saccharifying action of diastase is most effective at about 130° F., and the enzyme is destroyed by a temperature of 176° F. The high temperature "curing" of the malt, therefore, limits the action of diastase; at this stage of malting the temperature is allowed to rise gradually from 120° to 180° or even 200° F., and the maximum heat is maintained for six hours. This of necessity destroys the diastase or checks its action. A high temperature employed in curing the malt determines the presence of a large percentage of malto-dextrins in the wort, but these are not of the highest type (which are required to give present palatefulness to the beer), and lead to a speedy development of "condition" in the cask. The malt used in brewing therefore varies in kind and quality according to the product which is desired. Thus *pale ale* is brewed from malt which has been cured at a *maximum* heat of 190° or 195° F. This contains more malto-dextrins than malt finished at a lower temperature; the wort therefore ferments with slowness even in the cask, which is essential in ales that are destined to be stored for several months. *Mild ale* is brewed with malt cured at a low temperature; such malt contains less malto-dextrin, but more maltose, and consequently the beer matures more rapidly. *Stout* and *porter* are brewed from malt cured at a high temperature, which gives more colour, in conjunction with some pale malt dried at a low temperature, or other adjunct. The proportion is usually 2 parts of roasted, 4 parts of brown, and 24 parts of pale malt. The following table shows the difference in composition of the extracts obtained from malt dried at different temperatures:

COMPOSITION OF MALT EXTRACT.

	Pale Malt.	Medium Brown.	Black Malt.
Temperature at which the malt was cured . .	170° F. (80° C.)	212° F. (100° C.)	248° F. (120° C.)
	Per Cent.	Per Cent.	Per Cent.
Solids : Maltose	57·01	52·44	51·32
Dextrin	14·92	18·49	19·35
Lactic acid	·56	·49	·31
Albuminoids (soluble)	2·09	1·60	1·50
Ash, colouring matter, etc. . . .	1·49	1·38	1·32
	76·07	74·40	73·80

Malt Substitutes.—Various substances besides malt are used by most brewers to supply sugar. Thatcher says these substances should be called *malt adjuncts* rather than malt substitutes. Beer can be produced from any substance which contains starch, if the

latter is converted by diastase into maltose and dextrin. The substances used are chiefly rice, wheat, maize, sugar, invert sugar, and commercial glucose.

Unmalted or *Raw Grain* is used to the extent of 25 per cent. of the total grain employed in the mash. It usually consists of maize flour and rice, which produce a brilliant wort, and finally a very bright beer. Raw grain, however, necessitates the use of a *converter*, whence prepared grain is more often used.

"*Flaked Malt*" consists of gelatinized rice. The grain is steamed so that the starch granules are ruptured ; it is afterwards rolled or pressed flat and dried. It is ground with the malt that is about to be mashed, and during mashing the diastase in the malt transforms the rice starch into maltose and dextrin.

"*Torrefied Grain*" consists of rice, barley, or maize, heated in a cylinder until the starch grains are burst. Thus, small foreign barley is put into the cylinder at one end, and it emerges from the other end increased to a size larger than that of the finest malt. It has a slightly empyreumatic odour, which, however, passes off when the mixture is brewed. Rice and wheat are torrefied in the same way. Maize is degermed before it is torrefied.

Malted Wheat is prepared and used in the same way as malted barley.

Brown or "*Blown*" *Malt* is made from barley by subjecting the well-germinated grains, after drying, to a sudden blast of intense heat, in consequence of which its bulk is increased 25 per cent. above that of ordinary malt.

Black or "*Roasted*" *Malt* is ordinary malt which is roasted over a coke fire in a perforated cylinder, until it develops a fine aroma and the proper colour. It is used for making porter, but is now very largely replaced by caramel (*burnt sugar*) in some breweries.

Sugar as an Adjunct to Malt.—The use of sugar is largely on the increase, but sugar-cane sugar is better for the purpose than beetroot sugar. Thatcher says for tinted ales and for stout or porter Penang and Egyptian sugars, and others of the same class, cannot be equalled ; but for stock ales commercial glucose or invert sugar can be used to advantage. Cane-sugar should be used for beers of low gravity, which are intended to have palate-fulness, because it is not fermented in the primary fermentation, but in the secondary fermentation, which occurs in the cask. The development of *condition* is due to the fermentation of various sugars in the cask, by special yeasts, and production of carbonic acid gas and alcohol. It is used in the proportion of 15 per cent. of the malt.

Either raw or refined sugar may be used in brewing, but it must be pure. Low-class raw sugar often contains impurities such as the spores of fungi, and especially *Leuconostoc mesenteroides*, besides the *Acarus sacchari* and a host of bacteria. The *Leuconostoc* is the cause of *ropiness* in beer. Dark or unrefined raw sugar is often used in making mild ales and porter, owing to the more pronounced flavour of the sugar ; and these are the kinds of beer in which the

viscous fermentation occurs or ropiness is developed. It is therefore impossible to use such sugar for first-class beer or ale, but only for "running" ales. Owing to this difficulty many porters are now made with black malt and burnt sugar instead of raw sugar. Beer could be made altogether of sugar—*that is, without malt*—but it would lack the flavour and other characteristics derived from grain, and it would not keep. The reasons why brewers employ sugar are—(*a*) It is said to improve the quality of the beer; (*b*) it replaces a portion of the malt, and with it much of the albuminous matter which renders beer unstable; (*c*) the beer comes into "condition" earlier, and enables the brewer to turn out rapidly a brilliant beer of good condition, and yet keep his stock low; (*d*) sugar is cheaper than malt.

Invert Sugar is very largely employed by brewers as a substitute for malt, as much as 50 per cent. of malt being replaced by it. It gives fulness, delicacy, and flavour, to the beer, and the liquor early becomes brilliant. The sugar is either inverted by mineral acids or the action of yeast, the latter being known as "Thomson's patent yeast process." Yeast-inverted sugar is free from colour, and is used for making pale ales. Invert sugar, however, is commonly made by boiling it for a couple of hours with sulphuric acid, the acid being afterwards neutralized by the addition of whiting, and the resulting sulphate allowed to settle before the nvert suga is drained off. This kind of invert sugar is coloured brown by the acid, a little sugar being carbonized; it is therefore not used for making pale ale, although it might be decolorized by passing it through charcoal. It is found that 19 parts of cane sugar become 20 parts of invert sugar, as water is taken up in the process; and it consists of equal parts of dextrose and lævulose.

Commercial Glucose is also largely used as a malt substitute, especially for beers or ales that are to be stocked. Invert sugar gives lusciousness; glucose tends to "dryness" of the beverage. Such glucose is usually manufactured in England from rice, sago, or maize starch, but on the Continent potato starch is used. The amylaceous substance is mashed in water containing 3 per cent. of sulphuric acid or an equivalent amount of acetic acid; it is then run into a receiver, where heat is applied by steam, or the starch and acid are boiled together in an open vessel, or in a copper vessel under high pressure, whereby the conversion is expedited. The action of the acid is stopped by neutralization with lime or whiting as soon as a little of the material (cooled down) ceases to give a blue colour with iodine. It is at this stage that the proportion of dextrin or malto-dextrin is the greatest, which is desired for most ales. If the inversion is pushed farther than this, there will be much less malto-dextrin, and the chief components of the glucose will be dextrose, dextrin, and a little maltose. As a general rule, commercial glucose consists of 60 per cent. of sugars (dextrose and maltose), 20 or 21 per cent. of dextrin, etc., 0·35 per cent. of ash, and 18 per cent. of water.

Priming for Beer.—Many brewers add some sugar to mild ales, stout, and porter, after they are finished, in order to impart " body " and briskness. If briskness is desired rather than sweetness, the sugar usually consists of glucose. If, on the other hand, lusciousness and body are desired, they usually " prime " the liquor with invert sugar, because the lævulose, which forms one-half of it, is less susceptible to fermentation than the malto-dextrins or dextrins of glucose.

Colouring Matters.—The natural colour of ale, beer, or stout, is that derived from malt and hops alone; and when nothing but malt and hops are used, no other colouring agent is necessary. But if raw grain, flaked malt, glucose, etc., are used in place of 25 to 50 per cent. of the malt, it is necessary to use some other colouring matter. The colouring agent may consist of black or roasted malt, but the use of too much of this substance may give rise to other difficulties, owing to the destruction of the diastase. Dark raw sugar might also be used for the same purpose, but difficulties again arise in the introduction of the spores of fungi, bacteria, etc. On the whole, it is found that **caramel** (burnt sugar) is the best colouring agent for ale, beer, or stout, when it is necessary to use any at all. Caramel gives flavour and a permanent high colour, and when of good quality is not detrimental to the liquor or the consumer. If, however, an inferior quality of caramel is used—*i.e.*, if it has been burnt too much—it throws down a deposit, and the liquor is more or less turbid.

Hops.—Hops consist of the strobiles, or greenish-yellow cones, of the female plant *Humulus lupulus*, N.O. Urticaceæ. It is largely cultivated for brewing. The male plant is not cultivated to any great extent—perhaps one plant is grown among 200 or 300 female plants to insure fecundation; but this is unnecessary for the brewer's purpose.

In England the most fruitful district for growing hops is Kent, but good hops are also grown in Sussex, Hereford, and Worcestershire. The varieties of English-grown hops are as follows—*Kent:* Goldings, equal to the best Bavarian. *Sussex:* Grapes, Colgates, Jones; they are coarser and have a ranker flavour than Kent hops. *Worcester and Hereford:* Goldings, White Mathou, Cooper's White, and Mayfield's Grape. *Surrey and Hants:* William's Whitebines, Greenbines, Bramblings, Golding Clusters, Early Goldings, and Prolifics.

On the Continent hops are grown in Bavaria (Spalt), Bohemia (Saaz), Würtemberg, Baden, Alsace-Lorraine, Belgium, and Burgundy. In America they are grown in California and other Pacific States. It is not the author's intention to discuss the quality of these various kinds of hops, but it appears to be a fact that few English brewers use foreign hops if those of their own country are available at a reasonable price. Foreign hops give a flavour to the beer which is decidedly harsh and bitter, and is not relished by English people. Brewers are able to use 50 per cent. of Continental hops with 50 per cent. of English hops, or 25 per cent. of American and 75 per cent. of English hops. Bavarian hops are useful for the production of black beer (stout or porter), and impart to it a rich nutty flavour. American hops have a black-

currant aroma. They are stronger and go farther than Kent hops, but they have not the delicate flavour which distinguishes English hops. But even English hops have distinguishing properties which it is unnecessary to go into here, beyond saying that East Kent hops (Goldings) are used for flavouring the choicest pale ales, Worcester and Hereford hops for mild and delicate-flavoured ales, other ales being made from any of the above-named hops, and stout and porter from the finest Bavarian hops.

The Constituents of Hops.—They contain 0·8 per cent. of an aromatic volatile oil, **valerol** ($C_6H_{10}O$), which is a clear yellow oil of agreeable odour and spicy taste. It is soluble in water (1 in 600), readily soluble in alcohol and ether, volatilizes on boiling, and is therefore dispersed during brewing. When exposed to the air at ordinary temperatures, it oxidizes into fugitive acids, one of which is valerianic acid ($C_5H_{10}O_2$). It also contains a resin or oleo-resin, which checks the volatilization of the oil from the hop ; possibly a liquid volatile alkaloid, called *lupuline ;* and 11 per cent of a crystalline bitter principle, *lupulinic acid* ($C_{32}H_{50}O_7$) ; with tannic acid 5 per cent. and ash 7 per cent. The bitter principle appears to be a compound consisting of *humulone* (α-lupamaric acid), lupulinic acid (β-lupamaric acid), and *hopeïn.* The latter substance has not been thoroughly investigated, but is credited with existing in hops in a small proportion, and with properties similar to those of morphia. According to Griess and Harrow,[1] hops also contain 0·05 per cent. of **cholin** in loose combination with the resin. They also found it in the beer. The glands from the strobiles are readily detached, and form a yellow or brownish-yellow granular powder called *lupulin.* It is composed of minute glands, each consisting of a hemispherical layer of cells, the cuticle of which has been raised by the secretion of the oil or oleo-resin contained in the gland. This powder has a strong hop-like odour, aromatic and bitter taste, which are due to the existence therein of 3 per cent. of the volatile oil of hops (valerol), with a proportion of the bitter principles, resin, wax, and cholin.

The Quality of Hops.—The hops are gathered when the flowers or strobiles are fully developed, being carefully picked, dried in kilns, and sometimes exposed to the fumes of burning sulphur. The quality depends upon their condition, freedom from rust, mildew (due to the fungus *Sphærotheca castagni*), aphides, fleas, and red spiders. They should have an elastic consistence, a bright greenish-yellow tint (more yellow than green), and when rubbed in the hand should yield plenty of the yellow resinous powder, or lupulin, an abundance of which indicates the fullest condition. Inferior hops are not elastic ; they may be greenish (unripe), reddish (overripe), or dark (overdried). Sometimes inferior hops are "sulphured" to improve their appearance. There should be an absence of broken strobiles, stalks, leaves, dust, etc.

The Use of Hops.—They impart aroma and flavour to the beer, they cause precipitation of albuminous matters, aid in sterilization

[1] *Chemical News*, 1885, ii. 149.

and clarification of the wort. The antiseptic properties are due to the presence of valerol; the precipitation of albumin is brought about by tannin and heat during boiling, and the precipitate is separated out by the liquor passing through the mass of hops (like a filter) in the hop-pack. The quantity of hops per quarter of malt used is stated by Thatcher to be as follows: London four ale (mild), 4 to 7 pounds per quarter of malt; London and county pale ale, 8 to 10 pounds; porter, 4 to 7 pounds; stout, 8 to 12 pounds; export stout, 12 to 16 pounds. Burton mild ales have 7 to 9 pounds per quarter of malt; strong ales, 10 to 14 pounds; best pale ale, 12 to 15 pounds; and the finest quality of export ale, 17 to 20 pounds. The hops are not usually added to the copper until the wort is boiling; and the custom varies as to whether the full quantity of hops is added at one time or in various stages, according to the kind of beer, the quality of the water, and the experience of the brewer. It should be observed that long boiling drives off the volatile oil upon which so much of the aroma and flavour depends.

Hop Substitutes.—All brewers admit that the best substance for bittering the beer is hops, and that nothing else will give exactly the same flavour and aroma, or replace the finest hops in the manufacture of beer. Nevertheless, for reasons best known to themselves, economy being one of them, various substitutes for hops have gradually grown into favour. Thatcher,[1] however, protests against the imputation that brewers constantly use such substitutes. He says: "There are no materials which can entirely take the place of hops in brewing; substitutes can only be used to replace 35 per cent. of the hops, unless the beer is to be deprived entirely of its original character." Nor is it to be understood that *any* bitter thing will do for the same purpose, although long lists of such articles are sometimes given in books, newspapers, etc. The chief substitutes are tannin, catechu, quassia, calysao, gentian, chamomile, and chiretta. Those which contain tannic acid—gentian, quassia, catechu, and tannin itself—have the same power of precipitating albuminoid substances as the hops; but they have a decidedly unpleasant bitterness, which prevents their being extensively employed. Southey says a pound of quassia equals 16 pounds of hops in bitterness, calysao equals 12 pounds, chiretta equals 10 pounds, gentian equals 7 pounds, and chamomile equals 5 pounds. When old hops are used in brewing, it is customary to add 12 to 16 ounces of tannin to every 50 barrels of wort, in order to precipitate the albuminous materials.

Chemicals used by Brewers.—Whether it is that the demand for full-flavoured and strong ales is passing away, or the exigencies of the trade demand a rapid turnover of the stock, it is a fact that an enormous quantity of the milder and weaker beverage is manufactured and speedily put on the market without waiting for that full development of flavour and condition which are the result of the

[1] "Brewing and Malting," p. 20.

complementary fermentation in cask or bottle. From the fact that these mild ales are put upon the market so soon after manufacture they are called "running ales." It is necessary that such ales should contain some antiseptic to insure their keeping, especially in hot weather, and they are frequently artificially aerated by carbonic acid gas. The antiseptics used as preservatives by brewers are salicylic acid and all reagents containing sulphurous acid—*e.g.*, bisulphites of lime, potash, magnesia, and soda. Formalin is also used, but to a much less extent. Many fancy preparations are sold to brewers, and guaranteed to be harmless to the beer or the consumer, while at the same time destroying or preventing the growth of micro-organisms. The basis of these is usually sulphite. It is argued by brewers that, while a moderate use of such antiseptics is advantageous, their excessive use would have the effect of spoiling first-class beers, ales, etc., and this acts as a check upon the use of anything more than the smallest possible quantity which will act as a preservative.

Calcium Bisulphite is very largely used as a preservative of pale ales. It has a great affinity for oxygen, and is therefore very soon partly transformed into *calcium sulphate*, which is precipitated. It is said to create brilliancy in the ale, and good "condition." An excess *flattens* the ale, and therefore checks its use. It cannot be used for all beers because of the development from it of "stench," or sulphuretted hydrogen, which is due to careless manipulation, dirty plant, or impurities in the yeast.

The action of bisulphite of lime or other bases as a preservative is said to be due to the fact that nitrogenous matters cannot take oxygen from the air while there is a bisulphite present which will do so; it is therefore owing to this fact that the ale is protected by the sulphite from the influence of putrefactive organisms. The antiseptic appropriates the oxygen, and the nitrogenous matters of the beer remain unchanged. Without a preservative such nitrogenous matters are very unstable; they decompose readily and become food for other bacteria, which give rise to "sick-frets," turbidity, ropiness, acidity, etc., in the beer. The proportion used at Burton is $\frac{1}{4}$ to $\frac{1}{2}$ pint of saturated solution of bisulphite per barrel for draught ales, and $\frac{1}{2}$ to 1 pint per barrel for export ales.

Potassium Bisulphite is preferred by many brewers on the ground that potash is a stimulant to the yeast during primary fermentation and the secondary fermentation in the cask. It is well known that yeast cells contain much potassium, and need more for their development; hence it is that barm is *strengthened* by the use of this antiseptic. It is used in the proportion of 3 to 6 ounces per quarter of malt sprinkled on the "goods" when the mash is made. It is also added to the cask in the proportion of $\frac{1}{2}$ ounce to a barrel of mild or draught ale, and 1 to $1\frac{1}{2}$ ounces per barrel of stock ale, stout, or porter.

Magnesium Bisulphite is sometimes used by the brewer in the proportion of 4 ounces per quarter of malt in the mash, and 1 ounce

added afterwards to each barrel during the "cleansing," or secondary fermentation. This is said to be the preservative preferred for stout, porter, or other beers, which usually have a soft taste.

Sodium Bisulphite is added when a natural or artificial *saline* water is used, the proportion being 3 or 4 ounces for each quarter of malt. Some calcium chloride is added to the "liquor" at the same time, so that the alkaline sulphite is transformed into sodium chloride, calcium and sodium sulphates. Sodium bisulphite is never added to the beer when in cask.

Sulphurous Acid is sometimes used by brewers. It indirectly hardens the water by converting carbonates into sulphates; it is also used for making "finings."

Salicylic Acid finds favour as a preservative with many brewers but it is not employed to the same extent as the sulphites, because it has a tendency to make the beer "flat," and stock ales, if preserved with this substance, sometimes develop an unpleasant flavour. It is therefore used only for light beers, which are intended for speedy consumption, in the proportion of ½ ounce to each barrel (36 gallons), added at the time of racking. It is sometimes used when the barm is known to be somewhat impure, which occasionally arises from the use of impure water, ½ to ⅓ ounce of salicylic acid being added to each barrel of wort.

Phosphate of Potash is used in a small proportion as a yeast stimulant, from 2 to 3 drachms being added to each barrel of wort at the time of yeasting it.

Tartaric and Acetic Acids are used for making "finings."

Tannic Acid is sometimes added to the wort before boiling it, especially when *old* hops are used, to assist in the precipitation of albuminoid bodies.

Changes in the Beer after it is finished arise from the presence of micro-organisms, but are favoured by temperature, etc.

(*a*) *Turbidity.*—Good beer has the property of clearness, which is best shown by holding a glassful in front of a lighted candle. It should also be bright. Turbidity in ale or beer arises from flatness, excess of saline matters in the water, impure yeast, bacteria, resinous or albuminoid matters. Flatness may arise from the beer being stored in a cellar where the temperature is too low; but a well-conditioned beer should never "chill," as such a change is termed, however low the temperature may be. The worst form of turbidity is that which arises from the presence of bacteria—*e.g.*, *B. termo, Saccharo-bacillus pastorianus;* these micro-organisms may be followed in time by *Bacterium aceti*, which will cause the beer to become clear and ultimately bright. Impurities in the yeast also give rise to turbidity; this is especially due to "wild yeasts"—*e.g.*, *Saccharomyces ellipsoideus, S. pastorianus*, and *S. exiguus*—which develop during storage. Resin may cause turbidity of the beer when it is brewed from unsatisfactory hops. Albuminoid matters and malto-dextrins in the finished article

may also cause turbidity, but they are by no means detrimental to the food value of the beer.

(*b*) *Acidity.*—Ale normally has a very slight acidity, owing to the presence of free organic acids from the malt, hops, and fermentation of the sugar; but this should be imperceptible. Ale and beer, however, become decidedly acid from the use of unsound materials, impure yeast, and the presence of acid-forming bacteria. *Acetic Acid* arises from the presence of *Bacterium aceti, Mycoderma aceti,* or *B. zylinum,* which act by conveying oxygen to the alcohol, dehydrogenizing it into aldehyde, whence it is oxidized into acetic acid:

1. $C_2H_6O + O = H_2O + C_2H_4O$ (acetic aldehyde).
2. $C_2H_4O + O = C_2H_4O_2$, or $C_2H_4O + 2OH = H_2O + C_2H_4O_2$ (acetic acid).

Lactic Acid arises from the presence of *Bacterium lactis, Pediococcus acidi lactici,* and *Bacillus subtilis.*

Butyric Acid arises from the presence of *Bacterium butyricum vel amylobacter, Clostridium butyricum,* and *B. subtilis.* These changes go on consecutively. If maltose or cane-sugar is the starting-point, the process is as follows:

1. $C_{12}H_{22}O_{11} + H_2O = 2C_6H_{12}O_6$.
2. $2C_6H_{12}O_6 = 4C_3H_6O_3$ (lactic acid).
3. $2C_3H_6O_3 = 2CO_2 + 4H + C_4H_8O_2$ (butyric acid).

Lactic acid is formed in the germinating grain by the transformation of sugar; it is therefore a normal constituent of malt. It is considered to be an essential ingredient of beer, activating the *peptase* or proteolytic enzyme to produce the peptones necessary as a food to the yeast growing during fermentation. Later on lactic acid is also of value by preventing the precipitation of these peptones from the wort either by tannin or the heat during boiling; and finally it assists in giving a piquancy to the finished product. But the acid is likely to be excessive if the malt is unsound, or if the lactic-acid-producing bacteria are present. In the latter case the acid is generated from cane-sugar, maltose, or dextrose, and later on may be transformed into butyric acid, which is objectionable to the consumer. When beer is known to have an undue acidity, the brewer or publican neutralizes the excess by the addition of potassium carbonate (*pearl ashes*) or sodium bicarbonate, and mixes the beer with new ale, or porter.

(*c*) *Ropiness in Ale or Beer.*—When beer is ropy it pours out like castor-oil, or it hangs in strings from a glass rod which has been stirred in it. This change is due to the presence of micro-organisms which transform the fermentable sugars into mannite and dextran, the latter being a carbohydrate isomeric with dextrin, and known as the "gum of fermentation." Its origin is due to various causes —*e.g.*, the use of inferior malt, too little hops, too much albuminous matter in the wort, contaminated yeast, exposure of the wort to the air before fermentation, or the use of doubtful sugar.

Beer in bottle is said to become ropy more readily than that in casks. The actual cause of the trouble is micro-organisms, several of which have been found associated with it and are actually capable of producing dextran. Van Laer of Ghent identified two bacteria, which he named *Bacillus viscosus I.* and *B. viscosus II.*, as the cause of ropiness in beer and other liquors. These bacilli consist of slender rods 1·6 to 2·4 μ long, and 0·8 μ wide. They caused sterilized beer to become ropy ; in forty-eight hours it was turbid and as viscid as the white of egg. But *B. viscosus* is not the only micro-organism which causes ropiness in beer ; sometimes the ropiness is due to *Leuconostoc mesenteroides*, the same coccus which causes ropiness in milk and bread, and also the *gomme de sucrerie* in sugar refineries. The sarcina, *Pediococcus cerevisiæ*, is also present in ropy beer, and is said to be a cause of viscosity ; finally, a mould, *Dematium pullulans*, is credited by Lintner as being a cause of ropiness.

Yeast-Bite.—Sometimes the ale or beer develops a disagreeable clinging bitter taste, which is called " yeast-bite," and the beer is said to be " barm-stricken." It is due to the presence of a wild yeast, *S. pastoridanus I.*, which is said to contain a substance dissolved by alcohol towards the end of primary fermentation. Yeast-bite only occurs when the temperature is allowed to rise too high, and therefore it can be checked by sufficient " attempering " during fermentation.

The fact that malt liquors are liable to the changes noted above, which effect the nutritive and commercial value of the beverage, is held by brewers to be a sufficent reason for the use of antiseptics for their prevention. It is asserted by brewers that the moderate use of such chemicals is innocuous, but is a weapon of considerable power in their hands against these deleterious changes. This argument is used by so many manufacturers of food that preservatives appear in an increasing number of both solids and liquids. The fact that malt liquors form such a large proportion of the beverages of the people of some countries necessitates constant vigilance to insure the purity and excellence of the materials used, as well as to reduce to a minimum the use of such chemicals.

Excise Charges.—Revenue is derived from malt liquors in proportion to the *specific gravity* of the wort before it is fermented. The amount levied is 6s. 3d. per barrel of wort having S.G. 1055, or 55° of gravity, as it is termed, with an allowance of 6 per cent. for loss and waste during fermentation. To render the charge an equitable one, the S.G. of all wort is taken, and the total number of gallons of various degrees of gravity is converted into gallons having the standard strength of 55°. Various saccharometers are used for this purpose. Baumé's hydrometer is also used, the degrees Baumé being afterwards converted to S.G.

Brewer's Pounds.—It is customary to speak of beer as being of the quality of 18, 20, 24, etc., pounds. What does this mean ? It means the excess of gravity over that of water. A gallon of water weighs 10 pounds, and a barrel of water 360 pounds ; but a barrel of beer wort may weigh 380 pounds or more, and the excess is called " a gravity of 20 pounds," and the beer is said to be a " 20-pound beer," etc., in spite of loss of weight due to fermentation.

It has, however, been found that the number of degrees of S.G. have a definite relation to the number of brewer's pounds :

Specific Gravity.		Brewer's Pounds.	Specific Gravity.		Brewer's Pounds.
1001	=	·36	1055	=	19·80
1010	=	3·60	1057	=	20·52
1020	=	7·20	1060	=	21·60
1030	=	10·80	1065	=	23·40
1035	=	12·60	1070	=	25·20
1040	=	14·40	1080	=	28·30
1045	=	16·20	1090	=	32·40
1050	=	18·00	1100	=	36·00

Thus, 84 pounds of malt or 64 pounds of invert sugar (or glucose) are expected to yield one barrel of wort having S.G. 1055, or 55° of original gravity.

The *solid extract* of beer is the actual weight of solid matter in solution or suspension, and is calculated as extract of malt per barrel (36 gallons) or extract per quarter of malt. The amount of extract can be ascertained either from the S.G. of the liquor or from the brewer's pounds per barrel by factors which have been long used. To find the amount of solid extract : (1) Multiply the degrees of gravity by the factor 0·936 The degrees of gravity are the last two figures of S.G. Example: If S.G. = 1050, the original gravity will be 50°, and

$$50 \times 0{\cdot}936 = 46{\cdot}8 \text{ pounds of solid extract per barrel.}$$

(2) Multiply the number of brewer's pounds by the factor 2·6 ; thus, if the beer is an 18-pound beer,

$$18 \times 2{\cdot}6 = 46{\cdot}8 \text{ pounds of solid extract per barrel.}$$

CHAPTER XXXII

SPIRITS

THE art of separating spirit from fermented saccharine liquids is of great antiquity. Practised by the Chinese in remote periods, the knowledge gradually spread westward, and, as the word "alcohol" implies, arrived in Europe through Arabia, which was the home of considerable chemical and physical knowledge. At the period of the invasion of Ireland by Henry III., the inhabitants of that country consumed "usequebagh," or whisky, which they made from ale or fermented barley wort. Its use became general in Scotland in the seventeenth century. In the middle of that century Dr. John French published in London a book on the "Art of Distillation." In it he gave directions for the distillation of *aqua vitæ* from beer. The apparatus then in use was the **pot-still**, an implement whose origin is lost in the mists of antiquity, and which has been used from time immemorial for the distillation of strong waters, spirits, and essences. Spirits are still produced by the same apparatus from many kinds of grain, as well as from beer, wine, molasses, potatoes, and other substances which yield a fermentable sugar. The first distillation yields a weak liquor called *low wine;* this being redistilled yields the spirit which was formerly called "aqua vitæ." Various by-products appear in the distillate, those of malted barley giving the characteristic flavour of whisky, those from molasses giving the flavour of rum, and those from wine giving the flavour of brandy. When the modern or patent still is used, the alcohol can be obtained almost entirely free from these by-products, and, no matter what is its origin, an almost pure spirit is obtained which is known as silent, neutral, plain, or grain spirit. This is usually about the strength of proof spirit, and after further distillation yields rectified spirits of wine. By blending and flavouring it with genuine spirits or ethers, this spirit can be made to resemble whisky, brandy, or rum, and it is used as the basis of a very large amount of the ordinary commercial spirits.

Absolute Alcohol.—Still further distillation of the spirit results in the production of absolute alcohol—pure dry alcohol, free from water. This, however, is somewhat difficult to procure, and it is so hygroscopic that it rapidly becomes diluted with water when exposed to a damp atmosphere. It is ethyl alcohol, C_2H_6O, or ethyl hydroxide, $C_2H_5 \cdot OH$, a transparent, colourless, mobile fluid, of pleasant ethereal odour, mixing with water in all proportions.

It boils at 78° C. (172·4° F.), and burns with *a white flame*. The specific gravity is 0·795. It is only used for technical purposes. What is known as *pure spirit of wine* consists of 93 to 95 per cent. of absolute alcohol and 5 to 7 per cent. of water. The small proportion of water causes it to burn with *a blue flame*.

Rectified Spirit of Wine of commerce contains 90 per cent. of alcohol, and has S.G. = 0·825. It is colourless, has a characteristic odour, neutral reaction, burns with a blue flame, evaporates without residue, presents no cloudy appearance when mixed with water, and should be free from other alcohols. Spirits of wine is sold at various strengths—*e.g.*, 75 per cent. of alcohol or S.G. 0·860, 70 per cent. of alcohol or S.G. 0·880, and as proof spirit.

Proof Spirit or neutral spirit consists of alcohol and water in about equal proportions. It contains 49·3 per cent. of alcohol by weight or 57·1 per cent. by volume, and its specific gravity is 0·92308. The strength of proof spirit was fixed by Act of Parliament (58 George III., c. 28) as a spirit "which at a temperature of 51° by Fahrenheit's thermometer weighs exactly twelve-thirteenths of an equal measure of distilled water at the same temperature." This is the Government standard for comparison of the strength of all spirits, and is used for ascertaining the amount of Excise duty which is payable. The term arose from a rough test which was formerly in use among Excise officers; the test was applied by moistening a little gunpowder with the spirit and setting it alight. If the spirit contained more than a certain amount of water, the gunpowder would not ignite on the application of a light to it, whence the spirit was said to be *below proof;* on the other hand, if the powder ignited the spirit was said to be "proof" or "over-proof." It was not, however, until a later day that the exact amount of water which would prevent the ignition was found. It is now known that more than 50·63 parts by weight of water will prevent the ignition.

Under-Proof and Over-Proof.—These terms have passed into use by virtue of the ancient test referred to, and their use is continued from custom. As proof spirit contains 49·3 parts of alcohol by weight, any spirit which contains more than that is over-proof, and less than that is under-proof. A spirit which is 25° over-proof (O.P.) would require the addition of 25 parts of water to 100 of spirit to reduce it to the strength of proof spirit; wherefore 100 gallons of such spirit would be charged the same duty as 125 gallons of proof spirit. A spirit which is 25° under-proof (U.P.) can only be reckoned as proof spirit *plus* 25 parts of water—that is to say, 100 gallons of this spirit would only be reckoned as 75 gallons of proof spirit for Excise duty:

Strength of Spirit.		Water.	Proof Spirit.
50 U.P.	=	50	50 per cent.
40 U.P.	=	40	60 ,,
30 U.P.	=	30	70 ,,
25 U.P.	=	25	75 ,,

Strength of Spirit.		Water.	Proof Spirit.
20 U.P.	=	20	80 per cent.
15 U.P.	=	15	85 ,,
10 U.P.	=	10	90 ,,
5 U.P.	=	5	95 ,,

Diluted Spirits.—The following table is useful for showing the amount of water which has been added to spirits which are sold below the legal strength :

Rum, Brandy, and Whisky (Legal Limit, 25° U.P.).		Gin (Legal Limit, 35° U.P.).	
Degrees U.P.	Added Water per Cent.	Degrees U.P.	Added Water per Cent.
26	1·4	36	1·6
27	2·7	37	3·1
28	4·0	38	4·6
29	5·4	39	6·2
30	6·7	40	7·7
33	10·7	43	12·3
36	14·7	46	16·9
40	20·0	50	23·1
43	24·0	53	27·7
47	29·4	57	33·8
50	33·4	60	38·5

There are various modes of ascertaining the strength of the spirit. But the instrument which is considered to be the most practical, and which also receives the sanction of the Excise Department, is Sykes's hydrometer. This instrument is not arranged to show the percentage of alcohol in the liquid, but the number of degrees over or under proof.

The proportion of alcohol can also be ascertained from the S.G. Alcohol is much lighter than water, and therefore the S.G. of an equal volume of alcohol has a lower S.G. *The specific gravity* is found by using a bottle which holds exactly 1,000 grains of water at 60° F. If this bottle be filled with absolute alcohol at the same temperature, it will be found that the alcohol weighs only 795 grains ; therefore

$$\text{The S.G.} = \frac{795}{1000} = 0{\cdot}795.$$

The S.G. of all alcoholic liquids can be obtained in the same way, and a reference to a table will show the proportion of alcohol per cent. which corresponds to the S.G.—thus :

S.G. ·795 = 100·0 per cent. of alcohol.
S.G. ·825 = 90·0 ,, ,,
S.G. ·860 = 75·0 ,, ,,
S.G. ·880 = 70·0 ,, ,,
S.G. ·923 = 49·3 ,, ,,

The S.G. of pure brandy, whisky, unsweetened gin, and some wines, corresponds fairly well with the amount of alcohol, and the percentage of alcohol may therefore be reckoned from that for these liquors. But, unfortunately, the S.G. does not correspond with the amount of alcohol in other wines and spirits, nor in liqueurs, sweetened gin, beer, cider, etc., because the liquid is made heavier by means of the sugar and other extractive matters which "obscure" the alcohol. In these cases the strength of the liquor is determined differently. The liquid is distilled until one-third has passed over. This part contains all the alcohol which was in the original fluid, and the distillate is made up with water to the original bulk ; the S.G. is then taken, and the proportion of alcohol is calculated from that as in the former cases. This method is frequently adopted for wines, beers, and sweetened spirits. Another mode is by determining the degree of *obscuration*. The S.G. of the

liquid is taken in the ordinary way, and we may suppose it is that of a spirit which is 25° over-proof; the liquid is then distilled until all the alcohol is driven off, the bulk made up to the original quantity, the S.G. taken again, and the proportion of alcohol represented by that S.G. is called the "obscuration." Suppose it represents 5° of alcohol over-proof; then

Apparent strength by S.G.	= 25°	over-proof.
Obscuration	= 5°	"
Real strength	= 30°	"

Alcohol by Weight and by Volume.—Although "proof" is the standard adopted by the British Government for purposes of revenue, it is more accurate to express the strength of alcohol by percentage. Supposing the spirit contains 35 per cent. of absolute alcohol *by weight*; that means 100 grammes of the spirit contain 35 grammes of absolute alcohol. If, however, we say 35 per cent. by volume, we mean that 100 c.c. of the spirit contain 35 c.c. of absolute alcohol. These quantities are not exactly the same, for, although 100 grammes of distilled water at 4° C. measure exactly 100 c.c., 100 grammes of proof spirit at 4° C. measure 110 c.c., and the volume of the spirit varies with the S.G. or alcoholic strength. Thus, a spirit having 35 per cent. of alcohol *by weight* will have 43·65 per cent. *by volume*. The terms are convertible:

The grammes of alcohol in 100 volumes × 1·12 = c.c. in 100 volumes, or percentage by volume.
The c.c. of alcohol in 100 volumes × 0·8 = grammes in 100 volumes, or percentage by weight.
And the grammes per litre × 7·0 = grains per gallon.

Whisky.

Whisky is a spirit obtained by the distillation of malted barley or a mixture of malted and unmalted barley. It should be made in a *pot-still*. It does not always correspond to the official description. But *Scotch whisky* of good quality is made from malted barley alone; *Irish whisky* from a combination of malted and unmalted barley. As certain districts of the earth appear to be more suitable for the production of good wine than others, so it would seem that certain regions produce a more celebrated whisky than others. The highlands of Scotland and Ireland are equally celebrated for its manufacture, the finest qualities being distilled from home-grown barley made into malt with water from heather-clad hills, and dried in kilns with fires made of peat obtained in the surrounding neighbourhood. *Grain whisky* is made from unmalted grain, such as barley, oats, wheat, and maize, which are dried and ground into meal. Various other substances also are used for its production, such as cane-sugar, glucose, molasses, potatoes, turnips, beetroot, mangolds, etc. This kind of whisky is stronger, but coarser, than malt whisky, and it is more cheaply made because the cost of malting is saved. Grain whisky is generally made in the *patent still*.

Whisky is generally "broken down"—that is, diluted—after it is taken out of bond, and is sold in strengths varying from 15 to 25 per cent. *under-proof*. As it is illegal to sell spirits of a lower strength than 25 per cent. under-proof without certifying the fact, we may assume that whisky has at least 34·1 per cent. of

absolute alcohol by weight and 42·7 per volume, and good Scotch whisky consists of 50 per cent. of alcohol by volume. Whisky is **blended,** the product of various distillations being combined. In this process a considerable amount of patent-still whisky (neutral, silent, or grain spirit) is used, because it is so much more cheaply produced. Many whiskies, indeed, consist of 80 or 90 per cent. of grain spirit, with only 10 or 20 per cent. of genuine Scotch or Irish whisky.

The **manufacture** of spirits consists of four processes : (1) *Mashing* the materials ; (2) *cooling* the wort ; (3) *fermentation* of the wort ; (4) *distillation* of the spirit. The materials used for making spirits are treated differently. The mode of extracting the saccharine substances or of converting starchy into saccharine materials also differs to some extent in different establishments. But when a saccharine solution is obtained, the mode of fermentation and distillation is the same for all substances. The process of forming the *wash,* or mashing the malt, is precisely the same as in brewing beer ; but no hops are used, and instead of being boiled the wort, or *wash,* is put into coolers, and afterwards into " backs," to be fermented with yeast. The proportions used in one Scotch distillery are 30 per cent. of malt, 30 of rye, and 40 of maize ; in another, 25 per cent. of malt, 72 of maize, and 3 of oats. In one Irish distillery the proportions adopted are 35 per cent. of malt, 30 of rye, and 35 of maize. But the proportions vary somewhat in nearly all manufactories. The following proportion of substances is used by a well-known firm for the manufacture of Irish whisky : 1,280 parts of pale barley malt and 3,840 parts of unmalted barley or rye are ground into a coarse powder and *mashed* by infusion with 8,500 parts of water at 170° F. After infusion for one hour, 1,020 parts of the liquid, or wort, is drawn off, cooled, and fermented with a large proportion of yeast. The remainder of the wort is drawn into separate vessels, and cooled down to 55° F. Another mash is meanwhile made of 80 parts of malt and 1,020 parts of hot water. The three liquids are mingled together, and the mixture should have S.G. 1084 to 1100. The fermentation, started by the addition of yeast to the first-made wort, is allowed to proceed for ten days, or until the S.G. falls to 1,002. In this time the yeast falls flat, and the liquid is fit for the still ; it is called the **wash.** A considerable amount of attention has to be given to the temperature of the liquid during fermentation. By " attempering," in the same way as in fermentation for the manufacture of beer, the temperature is kept down to 70° F. until the liquor grows fine and pungent to the taste and has a vinous odour, but not so long as to allow the acetous fermentation to begin. It is now ready to be distilled.

The Pot-Still.—The form of still used in many establishments is so ancient that the date and place of its origin is unknown. It is probable that the modern pot-still has been evolved from the primitive stills which are even now used by native races in Ceylon,

Indo-China, and the Malay Archipelago, where the art of distilling is believed to have originated. The pot-still is a very simple vessel, heated over a fire, and entirely closed in except for an outlet at the top, which communicates with a condenser. It is to all intents and purposes a retort, the neck of which ends in a condenser or worm. The retort consists of a *body*, in which is placed the liquid to be distilled; a *head*, which fits upon the body and ends in a pipe bent laterally, and which conveys the volatile vapour to the condenser. The latter consists of a *worm*, or metal tube, of considerable length, coiled upon itself, and so arranged that liquid put in at the top flows out at the bottom end uninterruptedly. The worm is fixed in a vessel and surrounded by cold water. It receives at its upper end the vapour from the still, which, passing through the coils of the pipe, becomes cooled and condensed into a liquid which passes out at the lower end of the worm into a receiver. The *wash*, or liquid to be distilled, having been put into the *body*, is heated by means of a gentle fire, which gradually expels the spirit from the fermented liquid. The principle of distillation depends upon the fact that alcohol boils at a much lower temperature than water—viz., at 173° F.; but the temperature of the water is raised sufficiently for some of it to be driven over in the form of vapour, and this evaporation is aided by the hygroscopic nature of the alcohol. The vapour of spirit and water carries with it the volatile flavouring matters of the materials used. The heat of the fire also renders some portion of the wash empyreumatic, and gives to the vaporized liquid a flavour which is characteristic and only obtained when the distillation is brought about by fire heat. A small portion of the sugar is caramelized and colours the liquid; and furfural, which is a constituent distinguishing pot-still from patent-still whisky, is produced by the transformation of pentose sugars—xylose, arabinose, etc.

During distillation about one-third or one-half of the *wash* is allowed to pass over; it contains all the alcohol, is a mixture of about 20 per cent. of alcohol in water, etc., has S.G. 0·975, and is called **low wine.** The "low wine" has to be redistilled to produce spirit of **proof** strength. The liquid which comes over first in redistillation is called "fore-shots," is of a milky appearance and fiery taste. As soon as a clear liquid begins to come over, the "fore-shots" is returned to the still. The clear liquid, "clean spirit" or whisky, is then collected until the specific gravity again alters, which shows that most of the spirit is volatilized. The vapour which comes over after this is much weaker, and is called "feints"; it is collected separately, and kept to be redistilled with the next parcel of low wines.

The Patent Still.—When the pot-still is used, at least two distillations are necessary to produce a spirit of proof strength, and repeated fractional distillation is required to separate the alcohol from the water and oils, as in the manufacture of spirits of wine. This entails much labour and is expensive. Various kinds of ap-

paratus have been made with the object of saving time, labour, and expense, in its manufacture. The most scientific, and that which is now employed in many distilleries, is the apparatus known as "Coffey's patent still." The use of this ingenious apparatus enables the entire process of distillation to be performed in a continuous operation, so that the fermented liquor, or *wash*, which enters the apparatus leaves it entirely deprived of alcohol. The spent wash leaves the apparatus by one exit, and a spirit of considerable strength, 65° to 67° over-proof—that is, of nearly uniform strength—leaves in a continuous stream by another exit.

"Coffey's patent still" consists of two columns or divisions, called the "analyzer" and the "rectifier," which are closely connected in their working. The **analyzer** is a wooden chamber, 20 to 30 feet high, divided into compartments by perforated copper plates. It is supplied by steam, which enters from an ordinary boiler at a pressure of 5 or 6 pounds to the square inch. The *wash*, or fermented liquor, already heated to about 200° F., passes in a continuous gentle current through the atmosphere of steam, and is thereby brought into a state of ebullition, when the spirit is volatilized together with the oils and watery vapour. This *low-wine vapour* passes out of the analyzer by a pipe which introduces it into the lowest compartment of the rectifier.

The **rectifier** is also a wooden structure divided into compartments by perforated plates, and is of the same height as the analyzer. It differs from the former by being devised to cool and condense the vapours, instead of volatilizing them; *but its action depends on the fact that alcohol remains a vapour at a considerably lower temperature than water does.* For this purpose a long pipe passes twice horizontally through each compartment, and is intended to conduct a current of cold liquid through the rectifier. The liquid used for this purpose is usually *wash*, or fermented wort, which gets heated as it passes through the rectifier on its way to the analyzer, a further economy being thereby practised. The *low-wine vapour*, arriving from the analyzer, enters at a high temperature the lowest compartment of the rectifier, and comes into contact with the pipes conveying through it a liquid at a much lower temperature. In the bottom compartment the temperature is below 200° F., and the vapour passes successively through the various compartments, each of which is cooler than the former. The vapour therefore soon reaches a point which is very little above the boiling-point of alcohol (173° F.), and consequently nearly all the water and the oils condense and resume the liquid form before the alcohol does—in fact, more water is abstracted from the vapour as it ascends through the successive divisions of the rectifier. Condensation of the water and purification of the vapour thus progress steadily, and when the vapour finally arrives at the spirit plate, near the upper part of the apparatus, it is **rectified**, or cleansed from all the impurities of the *wash*, excepting 5 per cent. of water, which were contained in the low-wine vapour. Thus, in the analyzer the heat communicated to the *wash* by steam vaporizes the spirit, with the oils and some watery vapour, which leaves the analyzer at a high temperature, and is known as the *low-wine vapour*. This vapour enters the rectifier at a temperature just below the boiling-point of water, and, passing through a succession of chambers, each cooler than the other, is rectified by the separation of oils and condensation of watery vapour. Finally, after leaving the rectifier, it passes through a refrigerator and is liquefied.

The product of the patent still is always uniform in character, no matter what is the source of the spirit. It is, as previously stated, called **grain spirit,** neutral or silent spirit, and is made from *raw* grain such as barley, oats, maize, or potatoes, mangolds, beet-root, molasses, glucose, and other saccharine substances. It

acquires colour by being stored in old sherry casks, and is usually reduced to 10° or 12° over-proof by the addition of water, and is blended with other spirits and substances which give it the appearance and flavour of true whisky.

Potato Spirit.—The process of manufacturing spirit from potatoes is as follows : The tubers are washed and ground to a pulp. This is mixed with water, which takes up any colouring matter, and it is run through a sieve to remove coarse particles. The starch is then collected by allowing it to deposit, or by straining the liquid through linen, when it becomes a solid and compact mass. The wet mass is treated by the addition of an acid in the proportion of 1 part of acid to 10 parts of pulp, whereby it is transformed into " glucose." The liquid is drawn off, transferred to the fermentation vats, and fermented by yeast. The period of fermentation lasts from fifteen to twenty days, during which the temperature rises to 80° or 85° F. When fermentation ceases, the liquid is transferred to the patent still, and distillation and purification occurs as in grain spirit. It may, however, be distilled in a pot-still, which produces *low wine* and requires redistillation, as in the case of malt.

Maturation.—When the spirit is newly distilled it is called **raw** spirit, and is considered unfit to drink. It is put into casks and stored away for a time, varying in duration, until it becomes mature. The process of maturation consists of certain changes in the spirit which are attended by a softening of the harshness which characterizes new spirit, the development of flavour and aroma, and deepening of colour, which characterize old spirits. The colour of whisky is partly due to the substance from which it originates—*e.g.*, malt—partly to empyreumatic changes which occur when the spirit is distilled by fire heat, and partly to the colour derived from the wood. The bouquet or flavour is also due, to a great extent, to the material from which it was obtained and the mode of preparation. Thus, whisky from all malt gets a flavour which is distinguishable from any other whisky ; spirit from potatoes alone has an odour of violets or raspberries. Whisky which is made in a pot-still develops a flavour which never arises in patent-still whisky, because the fire heat employed in pot-still distillation renders empyreumatic certain substances in the malt, and later in the wash, from which this flavour is derived. All new whisky is harsh and unpalatable, but during maturation the *higher* alcohols become converted into aldehydes and ethers, which give flavour and aroma and modify the harshness which is due to the presence of higher alcohols.

Age and Time of Maturation.—Some spirits mature earlier than others, but the *minimum* time allowed for maturation should be **five years,** and, as the spirit improves with age, it is better to avoid whisky which has been made less than eight or ten years. In this period the spirit should have attained excellent qualities, and the injurious properties of raw whisky should be reduced to a minimum. Many efforts have been made to hasten the process of maturation

or to produce the same effects by artificial means, but hitherto the natural changes have baffled all attempts at imitation.

Higher Alcohols or Fusel-Oil.—New whisky contains a varying proportion of the higher alcohols, which are commonly classed together as "fusel-oil." This term includes the following substances: Iso-amyl alcohol, which is derived from starch, and is always present in the greatest proportion when potatoes are used in the manufacture of whisky; propyl alcohol and normal butyl alcohol, which are almost constantly present, no matter what is the source of the whisky; isobutyl alcohol, which is most abundant when mangolds are used; hexyl and heptyl alcohols, almost always present in small amounts. According to Erhlich, some of the higher alcohols arise from the decomposition of amino-acids by the proteolytic enzyme of malt in the mashing process. The following analyses of fusel-oil were made by the authorities named:

	Whisky.		Potato Spirit: Rabuteau.[2]	Grain Spirit: Bell.[3]
	Clandin and Morin.[1]	Ordonneau.[1]		
Propyl alcohol	11·9	11·7	3·0	18·9
Isopropyl alcohol	—	—	15·0	—
Normal butyl alcohol	59·2	63·8	6·5	33·4
Isobutyl alcohol	4·5	—	5·0	—
Amyl alcohol	24·4	24·5	33·5	42·2
Products retaining amyl alcohol, boiling above 132° C.	—	—	17·0	—
Water	—	—	15·0	—
Undetermined	—	—	5·0	5·5
	100·0	100·0	100·0	100·0

Fusel-oil is injurious to living organisms, and speedily poisons small animals. In man it produces rapid intoxication, causes headache with depression and general nervous indisposition, and is followed by a further injurious action upon the tissues of the body.

In the process of maturation a considerable proportion of these higher alcohols becomes dehydrogenized or transformed into aldehydes, some of them in turn are oxidized into acids, and some of the acids by acting upon the corresponding alcohol may be transformed into ethers. For the sake of showing the relationship of the alcohols, aldehydes, acids, and ethers, a table is reproduced on p. 860.

Pot Still versus Patent Still.—A controversy has taken place as to the respective merits of pot-still and patent-still whisky. On the one hand, it is said that pot-still whisky alone retains the flavour which is derived from malt and the effects of heat. Just as wine

[1] *Compt. Rend.*, civ. 1187. [2] *Ibid.*, lxxxviii. 500.
[3] Report on Whisky, 1891.

ALCOHOLS, ALDEHYDES, ACIDS, AND ETHERS.

Hydrocarbons.	Alcohols derived from Hydrocarbons.	Aldehydes arising by Dehydrogenation of Alcohols.	Acids arising by Oxidation of Aldehydes.	Ethers arising by Action of Acids on Alcohols.
Methane—CH_4	Methyl—CH_4O	Formic—CH_2O	Formic—CH_2O_2	Methylic—$C_2H_4O_2$
Ethane—C_2H_6	Ethyl—C_2H_6O	Acetic—C_2H_4O	Acetic—$C_2H_4O_2$	Acetic—$C_4H_8O_2$
Propane—C_3H_8	Propyl—C_3H_8O	Propylic—C_3H_6O	Propionic—$C_3H_6O_2$	Propionic—$C_6H_{12}O_2$
Butane—C_4H_{10}	Butyl—$C_4H_{10}O$	Butylic—C_4H_8O	Butyric—$C_4H_8O_2$	Butyric—$C_8H_{16}O_2$
Pentane—C_5H_{12}	Amyl—$C_5H_{12}O$	Valeric—$C_5H_{10}O$	Valerianic—$C_5H_{10}O_2$	Valeric—$C_{10}H_{20}O_2$
Hexane—C_6H_{14}	Hexyl—$C_6H_{14}O$	Caproic—$C_6H_{12}O$	Caproic—$C_6H_{12}O_2$	Caproic—$C_{12}H_{24}O_2$
Heptane—C_7H_{16}	Heptyl—$C_7H_{16}O$	Œnanthylic—$C_7H_{14}O$	Œnanthic—$C_7H_{14}O_2$	Œnanthylic—$C_{14}H_{28}O_2$
Octane—C_8H_{18}	Octyl—$C_8H_{18}O$	Caprylic—$C_8H_{16}O$	Caprylic—$C_8H_{16}O_2$	Caprylylic—$C_{16}H_{32}O_2$
Nonane—C_9H_{20}	Nonyl—$C_9H_{20}O$	Nonylic—$C_9H_{18}O$	Pelargonic—$C_9H_{18}O_2$	Pelargonic—$C_{18}H_{36}O_2$
Decane—$C_{10}H_{22}$	Decyl—$C_{10}H_{22}O$	Capric—$C_{10}H_{20}O$	Capric—$C_{10}H_{20}O_2$	Capric—$C_{20}H_{40}O_2$
Dodecane—$C_{12}H_{26}$	Dodecyl—$C_{12}H_{26}O$	Lauric—$C_{12}H_{24}O$	Lauric—$C_{12}H_{24}O_2$	Lauric—$C_{24}H_{48}O_2$
Tetradecane—$C_{14}H_{30}$	Tetradecyl—$C_{14}H_{30}O$	Myristic—$C_{14}H_{28}O$	Myristic—$C_{14}H_{28}O_2$	Myristic—$C_{28}H_{56}O_2$
Hexadecane—$C_{16}H_{34}$	Cetyl—$C_{16}H_{34}O$	Cetylic—$C_{16}H_{34}O$	Palmitic—$C_{16}H_{32}O_2$	Cetylic—$C_{32}H_{64}O_2$
Octodecane—$C_{18}H_{38}$	Octodecyl—$C_{18}H_{38}O$	Octodecylic—$C_{18}H_{36}O$	Stearic—$C_{18}H_{36}O_2$	Octodecylic—$C_{36}H_{74}O_2$

COMPOSITION OF WHISKY AND OTHER SPIRITS.[1]

	Grain Spirit.	Beet Spirit.	Scotch Whisky.	Jamaica Rum.	Gin.	Three Star Brandy.	Scotch Whisky, "Big Ben."	Scotch Whisky, "Old Grans."	Irish Whisky.	Sloe Gin.
Alcohol per litre : By weight ..	932·60	912·90	436·20	619·00	401·50	410·50	408·30	393·00	408·00	—
By volume	956·00	942·00	512·00	695·00	475·00	485·00	476·70	465·90	484·90	270·04
Equal to proof spirit, per cent.	167·55	165·09	89·77	121·79	83·26	84·96	83·54	81·64	—	47·39
Extractives per litre ..	nil	nil	1·16	6·36	·52	6·70	—	—	—	18·13[2]
Secondary products :										
Acidity, as acetic acid ..	2·40	4·80	33·60	122·40	19·20	37·50	21·00	21·00	6·00	—
Aldehydes, as ethyl aldehyde	·15	10·92	14·38	15·41	4·72	6·10	—	—	—	—
Furfural	nil	nil	1·94	2·08	·13	·82	—	—	—	—
Alcohols in ethers (not reckoned in total)	1·84	9·20	20·24	161·00	4·60	28·88	—	—	—	—
Ethers, as ethyl acetate ..	3·52	17·60	38·72	308·00	8·80	53·35	—	—	—	—
Higher alcohols	2·80	6·96	122·76	62·58	13·26	58·48	—	—	—	—
Grammes in 100 litres of liquor	8·87	40·27	211·40	510·47	46·10	156·25	—	—	—	—
Grammes per 100 litres of absolute alcohol	9·10	42·40	412·60	738·00	97·00	322·20	—	—	—	—

[1] *The Lancet*, 1902, ii. 1515, and 1896, i., June 20.

[2] Including sugar.

depends for its flavour upon the substance used, so does whisky. Malt whisky obtained by means of the pot-still has a flavour of malt, and the heat imparts a characteristic flavour by rendering empyreumatic some portion of the wash, which is increased by pyro and creosotic bodies derived from the smoke of peat, coke, or anthracite. This flavour is distinctly recognized in pot-still whisky, but is absent from the patent-still product. The product of the patent still is of such a character, no matter what is the origin of the wort or saccharine solution, that the resulting spirits are practically indistinguishable from one another. That is to say, the spirit is practically the same whether it is derived from malt, barley, oats, wheat, rye, maize, potatoes, mangolds, beetroot, or whatever it may be. Such spirits are nearly tasteless, and an expert blender would be scarcely able to state their origin with certainty. They constitute plain, silent, or neutral spirit, although commonly called "grain spirit." The analyses of spirits given on p. 861 show that there is a considerable difference in the amount of secondary products contained in the spirits from pot-still and the patent still.

The analyses show that grain spirit and beet spirit contain a very small amount of secondary products, especially the higher alcohols, which by dehydrogenation and oxidation form the aldehydes and ethers which ultimately produce the bouquet, the flavour, and aroma, of the spirit. It follows that the results of the *maturation* of grain spirit are comparatively insignificant. Good malt whisky, produced in a pot-still, never contains less than 380 parts of secondary products per 100,000 parts of absolute alcohol, and may contain much more. Patent-still whisky (silent, neutral, or grain spirit) only contains from 89 to 204 parts of secondary products, with an average of 140 parts per 100,000 of absolute alcohol, and may be much less. Furfural arises from the fermentation of pentoses and pentosans; arabinose yields 43 and xylose 52 per cent. Genuine malt whisky contains an appreciable quantity of this alcohol; but grain or beet spirit contains no furfural, nor any appreciable proportion of higher alcohols or ethers. The higher alcohols are more abundant in beet spirit than in grain spirit, because of the sugar; but the amount is insignificant compared with that in malt whisky, brandy, or rum. The aldehydes and acids are also absent from grain spirit, but form an important item in the others. Indeed, the differences between pot-still and patent-still spirits are so great as to be recognizable readily. The patent spirit, however, is very largely used by the blender to combine with the *crude* productions or immature whiskies of the pot-still, by which combination the harshness and unpalatability of the latter is softened, and it attains one of the characteristics due to maturity.

Malt Spirit versus Grain Spirit.—The process of malting sets up changes in the grain which are unobtainable by other means. These changes are undoubtedly the source of the differences between mature pot-still whisky made from malt and mature pot-

still whisky made from unmalted grain, or from potatoes, beet, or other substances combined with malted grain. *Potheen* whisky, the produce of the illicit stills of Ireland, was made from malt alone, because it was the readiest method ; this liquor possessed a flavour so agreeable that the demand for it constantly increased, until its production was checked by the revenue officers aided by the military. Grain spirit, the produce of raw grain, and other substances converted into fermentable sugars, lacks the flavour of all-malt whisky, and possesses so little of the higher alcohols that it never develops (during maturation) the abundance of ethers and aldehydes which occur in well-matured malt whisky. On the other hand, it retains the properties and flavour of neutral spirit or alcohol. Being almost chemically pure, such spirit remains, like rectified spirits of wine, practically unchangeable. Whisky is not a mere mixture of alcohol and water ; there are fundamental differences between the two, which, however, are more or less subtle and not easily estimated. The effect of grain spirit, or neutral spirit and water, upon the organism is different from that of whisky. Diluted alcohol stimulates the heart ; whisky (in addition) invigorates the nerves, enlivens the mind, and produces other effects which are due to the matured secondary products. The changes due to maturation of malt whisky are changes in these secondary products ; it follows therefore, from the absence of the higher alcohols and other secondary products, that grain spirit never has its qualities ameliorated by time, however long it may be stored. Further, the blending of grain or neutral spirit with all-malt whisky is not to be desired, for such a combination results in a dilution of the secondary products of malt whisky, and probably does not produce such a perfect commingling of the alcohols, ethers, and aldehydes, as when the whole is the result of the same fermentation. It is true that the addition of grain spirit, which is neutral and practically tasteless, to new or crude whisky diminishes the coarseness of the latter and gives a false impression of age. Further, the dilution of crude whisky by plain or neutral grain spirit tends to the greater consumption of the liquor, owing to the absence of flavour, which causes it to be consumed in greater quantity or with a smaller addition of water or other diluent than the full-flavoured and matured malt whisky. The latter, even when well diluted, retains the flavour of malt and peat smoke, but is still mild and smooth to the taste, and has not the insipidity of blended spirit and water. The absence of flavour is never a proof of the age of whisky, for want of taste can be produced in the *crude* production of the pot-still by the addition of neutral or grain spirit, until the harshness and coarseness are ameliorated and a soft, smooth-drinking liquor is produced.

Observations of the effects resulting from the consumption of new or crude whisky have suggested that the deleterious effects arising therefrom are due to the *immature* flavourings or secondary products ; but when spirits of wine was taken by the same individuals, in

quantities equivalent to a moderate amount of the raw or new whisky, the results were quite as or even more disagreeable than when the new whisky was taken. It was argued from this that the substances which produce the flavours in mature whisky are not very active, and play no part in making the new spirit disagreeable. On the other hand, it is also argued by other authorities that the ethers and aldehydes, which are produced during the maturation of malt whisky, act as *correctives to the action of alcohol*, just as atropine acts as a corrective of morphia. That these flavouring agents have some effect is shown by the experience of persons who conscientiously affirm that whisky or brandy never disagrees with them, but that spirits of wine, grain spirit, or raw *crude* whisky, does disagree. It is probable, therefore, that in genuine mature pot-still malt whisky we have a spirit of a complex character, wherein the action of one substance is modified by that of others. On the other hand, the dire effects of "fusel-oil" or the higher alcohols of raw or crude whisky cannot be denied, and have already been commented on. The presence of **furfural** ($C_5H_4O_2$) in such spirits is also deleterious. Furfural is a volatile oil, soluble in water, alcohol, and ether; it has a pungent odour resembling bitter almonds; it is colourless, but turns yellow or brown on exposure to light. It is very poisonous; when administered to animals it causes tetanic and epileptic convulsions, the respiratory movements becoming impeded and very soon completely arrested. It is considered that this substance is very probably the cause of alcoholic epilepsy in certain subjects, and is certainly the cause of other injurious effects upon the human organism.

Brandy.

Brandy is the spirit distilled from the fermented juice of grapes. It is manufactured in almost all districts where wine is made from grapes, as in France, Spain, Portugal, and California; but the finest brandies are those of Cognac and Armagnac in France, and are the produce of vineyards in the Département de la Charente. These alone possess the fine bouquet and other qualities which characterise true cognac. The finest or liqueur brandy is that known as Grande Champagne; Petite Champagne and Première Bois, when sold pure, constitute *real* cognac, but they are frequently blended with the produce of inferior vineyards and sold as cognac. The brandy produced in other districts in France never attains the delicacy and other agreeable qualities of cognac. Inferior French brandy, *eau de vie*, is frequently the produce of dark red wines, or is obtained by distilling the marc, lees, and other refuse of the wine-vats. The brandy of Spain and Portugal is sometimes distinguished by a fiery taste, and may be disagreeable, or even acrid; but that produced by the distillation of wines of the Jerez district has been found equal to French brandy in respect to flavour and bouquet, and has about the same amount of ether as genuine cognac. In the United States brandy is made from the fermented

juice of other fruit besides grapes, such as peaches, cherries, and apples. In Great Britain a liquor sold under the name of brandy is manufactured by the maceration of bruised prunes and argol in grain spirit, rice spirit, beet spirit, or potato spirit, the product being mingled with a little French wine vinegar or genuine cognac, or *cognac essence*, to give flavour. Cheap brandy is never made from grapes.

Long experience has shown that certain areas of the earth, by reason of subtle characteristics of the soil and climate, yield material for the production of brandy which cannot be *equalled* elsewhere either by art or the cultivation of the vines. It has long been claimed that the Department of Charente produces the fruit most suitable for the distillation of brandy. Unfortunately, the vines in both Superior and Inferior Charente were attacked by phylloxera in 1872, and for many years afterwards. Owing to this, the production of genuine cognac was diminished to such an extent that it appeared probable that cognac would soon be a thing of the past, in spite of the enormous stores of the liquor in the cellars along the banks of the Charente. It was then that the nefarious practice of selling inferior brandy as true cognac began, and was as injurious to the trade as it was unnecessary, for the stores could not be exhausted in a few years. However, the restocking of the vineyards of both Charentes has since been steadily progressing, and is now (1912) about complete, so that the production of the genuine article is again increasing. Very little wine is distilled in Cognac itself, which is a town situate in the heart of the Charente Department, and is the chief centre of the trade. The distillation is either performed at the vineyards or the grape farmer brings his wine to the distillers, who pay for it according to its quality.

The Distillation of Brandy.—Enough has been said in the section on whisky about the art of distillation. All spirits are distilled in the same way ; but in the manufacture of brandy fermented grape-juice is put into the still instead of fermented malt or grain wort. The form of apparatus used in most brandy distilleries is the old-fashioned **pot-still.** The best brandy is always distilled in this apparatus. At the present day, however, various modifications are made in the apparatus. In some establishments the hot spirituous vapour which comes off is made to pass through a chamber containing wine before it passes to the refrigerator. This is an economical arrangement similar to that of the patent still ; the spirit is cooled by passing through the wine ; the wine, which is on its way to the still, is warmed by contact with the hot vapour. Instead of the brandy being robbed of essential secondary products by this manœuvre, it is asserted by some authorities that it actually gains an improved flavour by contact with the wine. A typical modern still holds 300 gallons of wine ; it consists of the boiler, which is the body of the still, fixed into a furnace like a domestic copper. The boiler is closed by a top or head, which is bulbous-shaped and terminates in a lateral bent pipe which conveys the vapour to the worm in a condenser. The bulbous head retains any gross particles or scum thrown up during ebullition, and collects a certain amount of watery vapour. The wine about to be distilled is new, contains the lees, and is therefore in a muddy

condition. It is generally *white*, being derived from small white grapes, and harsh or sour, unfit to drink. It is said that the harshest wine produces the finest brandy, and a wine which is soft and palatable yields an oily spirit, having no delicacy or "finesse." The grapes of the Grande Champagne are credited with yielding the finest brandy; those of the Petite Champagne also yield a fine quality, but not such a perfect spirit. Many good spirits, however, are often the "blended" product of several vineyards. All the wines used for the distillation of brandy contain only 6 or 8 per cent. of alcohol, but there is also a proportion of higher alcohols, acids, ethers, and extractives. The two following analyses[1] show the composition of wines about to be used for distillation:

WINES USED FOR DISTILLATION—PERCENTAGES.

	Grande Champagne (Juillac de Coq).	Petite Champagne (Archiac).
Absolute alcohol: By weight	5·870	6·430
By volume	7·320	8·010
Equal to proof spirit	12·840	14·040
Extractives	1·590	1·500
Sugar	·160	·140
Volatile acids	·180	·160
Fixed acids	·510	·540
Aldehydes	trace	trace
Volatile ethers	·035	·022
Higher alcohols	·003	·003

The process employed in the manufacture is that of fractional distillation, and consists, like that of whisky, of two separate distillations.

In the *first distillation* the first fraction of spirit which comes off, called "tête de brouillis," has a very disagreeable odour. It contains the *crudities* of the wine with about 43 to 45 per cent. of alcohol, with a large proportion of ethers, aldehydes, acids, and aromatic bodies. It is a highly stimulating liquor, but it has bad physiological effects, and is therefore returned to the still. The middle running of this distillation is called "cœur de brouillis," and corresponds to the *low wine* of whisky distillation. It is retained for the second distillation, and goes to make the finest brandy. In its present state it contains about 36 to 40 per cent. of alcohol, with considerably less secondary products than the first fraction; it is also smoother to the palate and less toxic in its effects. The "tailings," or "queue de brouillis," corresponds to the *feints* in whisky manufacture. It contains only 5 to 8 per cent. of alcohol, but a larger proportion of acids than "cœur de brouillis," and is sent back to be mingled with fresh wine in the next distillation.

In the *second distillation* the apparatus is charged with "cœur

[1] *The Lancet*, 1902, ii. 1509.

de brouillis," corresponding to low wine. The product of this distillation is likewise collected in three parts. The first fraction, called " tête d'eau de vie," contains a high proportion of ethers, acids, aldehydes, and furfural, and is returned to the still or mingled with fresh wine about to be distilled. The second fraction, called " cœur de distillation," **constitutes brandy ;** it contains 65 to 70 per cent. of alcohol, and is reserved for the finest production of the distillery. The third fraction, or " tailings," called " queue de distillation," contains only 27 to 40 per cent. of alcohol, with considerably less secondary products ; it is reserved for the production of second quality of brandy, or " seconds." The composition of these is given in the table on p. 868.

Maturation of Brandy.—The formation of the alcohol is due to the transformation of the sugar in grape-juice ; during this transformation other bodies or flavouring agents are developed in connection with the alcohol. If the fermented grape-juice is now stored away, the fragrant odour of wine soon becomes perceptible ; but if the fermented grape-juice is distilled at once, it yields the flavoured spirit called " brandy " or " grape spirit." This consists of the " cœur de distillation " collected in the second distillation of the spirit. It is a colourless spirit, and retains some of the characters of the fermented juice. An analysis shows that it contains about 75 per cent. of alcohol by volume, but a smaller proportion of acids, ethers, aldehydes, and higher alcohols, than is contained in the second fraction, " cœur de brouillis," of the first distillation. The amyl and butyl alcohols are mostly driven off in the first distillation ; during the second distillation fresh ethers are developed, and the existing ones are modified. The young or raw brandy is now stored away in casks for years to undergo the process of *maturation*. During this period it gains colour, the colouring matter being deprived mostly from the wood. Increasing age results in the production of changes similar to those of whisky—viz., it develops the taste and flavour of brandy, which are chiefly due to the conversion of the higher alcohols into a group of ethereal bodies, aldehydes, and other aromatic substances. Time produces these changes by the gradual oxidation of some elements, dehydrogenation and possibly the evaporation of others. The amount of furfural—probably the most objectionable constituent of brandy —decreases year by year ; it appears to be transformed into other and less harmful substances by oxidation. The aldehydes and acids increase in proportion to age, being direct products of oxidation. The proportion of alcohol diminishes by evaporation, oxidation to acetic acid, and transformation to acetates, acetic aldehydes, and ether. The development of ethers in old brandy is due to the reaction of alcohols upon oxidation products—acids and aldehydes (see Ethers) ; but the increase of higher alcohols and ethers does not progress at quite the same rate as the production of acids and aldehydes. It is to these transformations that the flavour and aroma of brandy is due.

COMPOSITION OF THE DISTILLATE AT VARIOUS STAGES.[1]

	First Distillation.			Second Distillation.	
	Tête de Brouillis.	Cœur de Brouillis.	Queue de Brouillis.	Tête l'Eau de Vie.	Cœur de Distillation.
Alcohol: By weight, per litre	382·20	298·70	40·00	696·30	679·60
By volume, ,,	454·10	360·40	50·00	765·70	750·80
Equal to proof spirit, per cent.	79·57	63·17	8·77	126·85	131·58
Extract per litre	nil	nil	·20	nil	·10
Secondary products:					
Acidity, calculated as acetic acid	79·80	36·00	60·00	42·00	18·00
Aldehydes, as ethylic aldehyde	20·00	1·87	trace	33·32	·52
Furfural	·60	·37	nil	·25	·66
Ethers, as ethyl acetate	625·68	44·77	41·36	601·20	40·48
Higher alcohols	152·00	50·00	31·20	50·00	30·00
Total secondary products: grammes per 100 litres	878·08	133·01	132·56	726·77	89·64

[1] *The Lancet*, 1902, ii. 1510.

A cognac expert says the bouquet of brandy reminds one of a vineyard in springtime, and the flavour should suggest the freshness of the fruit, just as the bouquet reveals the fragrance of flowers; a brandy which lacks this bouquet and flavour is inferior. In common brandy the flavour is dead, the fragrance is stale.

The Composition of Brandy.—The table on p. 870 is of great value by showing the variation in brandy of different ages and qualities. The analysis of a genuine cognac of mature age affords us a good standard. The proportion of alcohol in genuine unadulterated brandy varies from 50 to 70 per cent. by volume and 35 to 60 per cent. by weight. Vintage brandies usually contain 60 per cent. or more by volume, but these are usually diluted before being sold. Brandy bought in the open market averages about 50 per cent. of alcohol by volume. Genuine brandy is known by the proportion of secondary products, which vary from 250 to 380 grammes per 100 litres of absolute alcohol, in brandy bought in the open market. Examples are given in the foregoing table. Ordonneau obtained from 100 litres of cognac the following secondary products—*Higher Alcohols:* Propyl alcohol, 40 grammes; butyl alcohol, 218 grammes; amyl alcohol, 83·8 grammes; hexyl alcohol, 0·6 gramme; heptyl alcohol, 1·5 grammes. *Ethers:* Ethyl acetate, 35 grammes; œnanthic ether, 4 grammes; ethyl propionate, butyrate, and caproate, 3 grammes; aldehydes, 3 grammes; and traces of acetyl and amines. Furfural is constantly present in genuine brandy, and varies from 1·60 to 2·62 grammes per 100 litres of absolute alcohol; it decreases with age. The acidity, reckoned as acetic acid, varies from 64 to 86 grammes per 100 litres of alcohol, and increases with age. The extract varies considerably; there is very little in vintage brandies, but more in "Star" brandies, which are frequently artificially coloured, burnt sugar and distilled water being added just before bottling.

Other Brandies.—Algerian brandy, distilled from the wine of Algeria, is said to be of good quality. A considerable amount is sent to France, and reshipped as French brandy. Spanish brandy is made from the fully fermented juice of fresh grapes, has a flavour similar to that of French brandy, and commands a high price. Egyptian brandy is made from grapes grown in Roumelia, Cyprus, Greece, and Asia Minor. The fruit is brought fresh to Alexandria, where it is converted into wine and the brandy distilled therefrom. There are other brandies, so-called "Egyptian," which are probably made from currants grown in Greece. Most wine-growing countries produce some genuine brandy, but these are comparatively small in amount, and inferior to cognac.

Fictitious Brandy is sold in very large quantities. Such is Hamburg brandy, made in Germany, Holland, and Normandy. It is not grape spirit, the produce of fermented grape-juice, but is a mixture consisting of neutral, silent, or grain spirit (produced by the distillation of rice, rye, maize, mangolds, beetroot, potatoes,

COMPOSITION, SOURCE, AND AGE, OF BRANDY.[1]

	Age Unknown.					Grande Champagne, 1901.	Petite Champagne, 1895.	Bois, 1888.	Petite Champagne, 1870.	Bois, 1858.	Grande Champagne, 1811.
	Public-house.	Railway Restaurant.	Purchased in Open Market.								
			One Star.	Two Star.	Three Star.						
Alcohol per litre:											
By weight	340·50	432·40	427·60	418·00	410·50	606·70	563·20	540·00	376·70	450·90	450·90
By volume ..	407·90	508·20	503·10	492·90	485·00	683·30	641·40	618·40	447·90	527·70	527·70
Equal to proof spirit, per cent.	71·48	89·06	88·18	86·37	84·96	119·74	112·41	108·36	78·50	92·48	92·48
Extract per litre ..	7·10	7·10	6·40	6·70	·10	·90	1·50	3·60	3·20	3·20	5·30
Secondary products:											
Acidity, as acetic acid	32·40	36·00	28·80	32·40	37·50	41·76	46·80	68·40	118·80	115·20	158·40
Aldehydes, as ethylic aldehyde ..	3·00	6·00	6·00	6·00	6·10	7·11	6·25	11·10	16·66	12·50	25·00
Furfural	·25	·20	1·20	1·30	·82	3·03	1·50	1·50	·80	·50	·41
Alcohol in ethers (not in total)	6·90	24·30	23·00	26·60	27·88	77·70	41·80	38·70	32·20	49·20	58·80
Ethers, as ethyl acetate	13·20	46·60	44·00	51·00	53·35	148·00	80·00	77·40	61·60	94·10	102·00
Higher alcohols ..	20·00	49·99	46·66	53·33	58·48	113·32	104·00	91·00	153·30	144·00	196·00
Total grammes per 100 litres of brandy	68·85	139·09	126·66	144·03	156·25	313·22	238·55	249·40	351·16	366·30	481·80
Total grammes per 100 litres of alcohol	168·74	273·58	251·15	292·37	322·20	461·99	371·88	403·25	783·79	694·11	913·14

[1] Report of *Lancet* Commission on Brandy: *The Lancet*, 1902, ii. 1513-1516.

glucose, etc.), coloured with prune-juice, caramel, or other colouring agent, and flavoured with cognac essence. The latter is composed of ethyl acetate and ethyl nitrite and other essences. It is a clever imitation; but in such "brandies" the flavour vanishes immediately it is tasted, and leaves a dryness on the tongue. The flavour is therefore dull and lifeless, and the aroma or bouquet is evanescent; in fact, it has been "grafted" upon the spirit instead of springing naturally from it, as it does in genuine brandy. There are other differences between fictitious and genuine brandy: that made from grain spirit contains no furfural, and no appreciable quantity of higher alcohols or ethers, excepting what are added to it. According to Ordonneau,[1] "genuine wine brandy contains normal butylic acid, that made from grain spirit, potato spirit, or beet spirit, contains isobutylic acid,[2] but not a trace of normal butylic acid." Isobutylic acid is the cause of the disagreeable odour and taste of these alcohols, and, according to Ordonneau, it is not produced when the fermentation of the saccharine material of grain, beetroot, or potatoes, is effected by the proper ferment of wine (*Saccharomyces ellipsoideus*) instead of that of beer. About one-third of the secondary products in potato spirit consist of amyl alcohol. The colour of fictitious brandy is usually deeper than that of genuine spirit, and is due to the addition of prune-juice or burnt sugar. It is sometimes sweetened by the addition of sugar, flavoured as already indicated, and often "fortified" by adding tincture of capsicum or some other heating substance. So long, however, as the alcoholic strength of the liquid does not fall below 25° under-proof, and corresponds to the strength stated on the label, the law affords no protection to the public against these artificial substitutes. On the other hand, it should be pointed out that *cheap* brandy must necessarily be inferior in quality, and most probably is a blend of fictitious brandy with a little genuine brandy put in for flavour. The age of brandy is somewhat important also; immature brandy is quite as unsuitable for consumption as immature whisky, and, as in that spirit, time alone can produce those changes in the higher alcohols which will reduce them from injurious alcohols to stimulating and vivifying ethers and aldehydes. Propyl, butyl, and amyl alcohol are in excess in new or unmatured brandy, and they are very injurious. Time, oxidation, and dehydrogenation, reduce them to a less deleterious form. Genuine brandy has valuable medicinal properties. Spurious brandy usually contains an excess of acids and ethers over the higher alcohols, the proportion of total secondary products is low, and the effect, like that of spurious whisky, is simply that of diluted spirits of wine. Genuine brandy is not usually adulterated except by the addition of water to "extend" it, and caramel to restore the colour of the diluted article.

[1] *Compt. Rend.*, 1886, cii., January.
[2] Butyric and isobutyric acids are meant.

Rum.

Rum is a spirit distilled direct from sugar-cane products in sugar-cane-growing countries. There are two distinct types of genuine rum : (1) *Jamaica rum*, distilled from liquor of high original gravity slowly fermented for a period of ten or twelve days ; and (2) *Demerara rum*, which is distilled from " wash " of a low original gravity, but rapidly fermented for a period of only thirty-six to forty-eight hours. In addition to these there are (3) *Imitation rum*, imported from countries where the sugar-cane is not grown, and usually made from beetroot molasses or the scum taken from the pans during the manufacture of beet or other sugars (not sugar-cane sugar) ; and (4) *Mixed rum*, which may consist of imitation rum and genuine spirits combined, or it may be an entirely fictitious article consisting of grain or silent spirit flavoured with ethyl butyrate and coloured with burnt sugar.

The best rum is that produced from fermented sugar-cane juice, and the finest quality is that manufactured in Jamaica. Just as the flavour of genuine brandy can be produced only from fermented grape-juice, and the fruit of the Charente is unequalled for producing it, so the sugar-cane of the West Indies cannot be equalled by anything else for the production of rum. The mode of distillation and maturation is the same as in other spirits, and the changes during maturation also are the same.

Composition.—Rum contains, when properly made, from 50 to 90 per cent. of alcohol by volume ; but it is not sold containing more than 70 per cent. by volume. On the other hand, it is more usually sold at *proof* strength or at 10, 20, or even 30 or more degrees under-proof. Exceptionally good *old* Jamaica rum may be obtained containing about 43 or 45 per cent. of alcohol. Many cheap spirits are sold which may be stronger than this, but they are frequently fortified by the addition of grain or beet spirit ; indeed, fictitious rum consists of grain spirit flavoured and coloured.

Genuine rum contains a very high proportion of ethers, the chief of which is ethyl butyrate, formed during maturation by the interaction of sugar, acids, and alcohols ; the ethers exceed the higher alcohols in the proportion of 5 : 1, whereas in brandy they are about equal in amount. Rum also contains a notable amount of furfural, and the acidity is high. The extractive matter is also high ; it consists mostly of colouring matter, and is more or less burnt sugar. Fine old Jamaica rum, well matured, is soft to the palate, and has a mellow flavour and aroma due to the natural combination of ethers and aldehydes. The following represents the composition of a good quality of rum containing 69·5 per cent. of alcohol by volume :

Composition of Rum.

Absolute alcohol :	By weight	619·20 grammes per litre.
	By volume	695·00 c.c. per litre.
	Equal to proof spirit	121·59 per cent.
	Extractives	6·36 grammes per litre.

Secondary products :			
Acids, calculated as acetic acid ..	122·40	grammes per	100 litres.
Aldehydes, as ethylic aldehyde ..	15·41	,,	,,
Furfural	2·08	,,	,,
Ethers, calculated as ethyl acetate ..	308·00	,,	,,
Higher alcohols	62·58	,,	,,
Total secondary products	510·47	,,	,,

Equivalent to 738 grammes for every 100 litres of absolute alcohol.

Rum is sometimes faulty ; it becomes turbid and fluorescent on dilution. This defect was formerly believed to arise from the presence of resinous or other matters from the cask ; but, according to Veley,[1] it is due more usually to a micro-organism called *Coleothrix methystes*, which belongs to the group of Chlamydobacteriseæ, and it retains its vitality in rum containing as much as 70 per cent. of alcohol.

Gin.

Gin is a spirit distilled from a mixture of malt, rye or rye malt, maize, and various substances which give to the liquor special properties. The varieties are—

1. Hollands gin, or schnapps, a variety manufactured in Schiedam, Holland, from a mash of the cereals mentioned, and distilled three times in a pot-still, juniper berries being added before the last distillation. Aalborg schnapps is a subvariety made in Denmark.

2. Irish gin is made from the same cereals, with a combination of aromatic, carminative, and diuretic substances, derived from angelica root, almond cake (the marc from nuts out of which the oil has been expressed), calamus, cardamoms, cassia, cinnamon, coriander, juniper, fennel, grains of paradise, liquorice, orris root, and other substances.

3. "Old Tom," or sweetened gin, is a London beverage made by the addition of cane-sugar syrup to gin made in the Irish way.

Hollands Gin is made in the following way : Two parts of rye and one part of barley malt are mixed together ; a hundredweight of the mixed grain is mashed in 24 gallons of water at 170° F. ; the *wort* is standardized to a specific gravity of 1033 or 1036. It is then fermented and distilled. The first distillate is called *low wine*, as in whisky manufacture. This is redistilled along with some juniper berries, a little salt, and any other essential oils or substances which characterize the makers' special brand. The name **gin** is a corruption of the French word *genièvre* (juniper).

London Gin.—The following recipe is from the book of a distiller : Take 700 gallons of spirit of the second rectification ; macerate in it 70 pounds of German juniper berries, 70 pounds of coriander seeds, 3½ pounds of almond cake, 1½ pounds of angelica root, and 6 pounds of liquorice-powder. The spirit is then redistilled. It is sold "dry"—that is, unsweetened—or sweetened.

[1] *British Medical Journal*, 1899, i. 416.

The substances used for making gin all contain essential oils and active principles, which contribute to the carminative, aromatic, and intoxicating properties of the spirit. In particular, the juniper berries contain from 0·5 to 0·7 per cent. of an oil having a characteristic taste and aromatic odour, and add diuretic properties to the carminative effects derived from other essential oils. Cardamoms and coriander seeds contain a pale yellow oil having antispasmodic and carminative properties. Grains of paradise also contain an oil which causes excitement followed by intoxication.

Maturation.—New or raw gin is as injurious as new whisky or brandy, and undergoes changes similar to those which have been described in connection with other spirits. It is usually stored in tanks lined by white tiles, in order to prevent it becoming coloured. But the changes due to age are not so great as in other spirits, probably because so little is stored.

Composition.—Gin resembles beet spirit more than any other; the ethers and higher alcohols are comparatively insignificant, the secondary products are therefore small in amount, and the extractive matter is only about 0·5 gramme per litre.

Composition of Gin.[1]

Absolute alcohol:	By weight	401·50 grammes per litre.
	By volume	475·00 ,, ,,
	Equal to proof spirit	83·26 per cent
Extractives		·52 grammes per litre.
Secondary products:		
Acids, calculated as acetic acid ..		19·20 grammes per 100 litres.
Aldehydes, as ethylic aldehyde ..		4·72 ,, ,,
Furfural		·13 ,, ,,
Alcohols in ethers (not reckoned in total)		4·60 ,, ,,
Ethers, calculated as ethyl acetate ..		8·80 ,, ,,
Higher alcohols		13·26 ,, ,,
Total secondary products of gin ..		46·10 ,, ,,

Equivalent to 97 grammes per 100 litres of absolute alcohol.

The colouring matter is usually small, as the liquor is in most cases as colourless as water or spirits of wine. Unsweetened or "dry" gin is sold usually at about 15° under-proof—*i.e.*, with 45 per cent. of alcohol; but it may vary from the strength of proof spirit down to 40 or 50° under-proof—that is, containing from 25 to 30 per cent. of alcohol. Sweetened gin, or "Old Tom," varies from 40° under-proof up to proof strength—that containing from 30 to 50 per cent. of alcohol. Hollands gin varies from 36 to 18° under-proof—that is, from 35 to 43 per cent. of alcohol.

As gin presents characters more or less resembling beet or grain spirit saturated with aromatic oils and ethers, it is exceedingly easy to make imitations of the genuine article. It is, indeed, a well-known fact that an enormous proportion of the unguaranteed gin,

[1] *The Lancet*, 1902, ii. 1515.

sold in drinking saloons and restaurants, is spurious, and is merely neutral, silent, grain, or beet spirit, combined with oil of juniper, turpentine, and other flavouring oils and essences.

Good gin is a valuable stimulant in certain pathological conditions where the diuretic properties of this spirit are of advantage. In such cases an absolutely "dry gin"—that is, without sugar—is the best; it should be guaranteed as genuine. Unsweetened gin has a "sweetness" of its own, due to the substances from which it is made. As a carminative, aromatic stimulant, and stomachic, genuine gin might have a wide range of application if abuse of it could be provided against.

Liqueurs.

Liqueurs are spirituous liquids of high alcoholic strength, sweetened with sugar and flavoured with essences, ethers, and sometimes bitter principles. These spirits were originally distilled from a fermented liquor made from herbs, roots, barks, and seeds. The majority of them are now sold in the form of a tincture of these substances, made with spirits of wine, silent, grain, or beet spirit. In some cases they consist merely of a solution of the oils derived from these vegetables, and in others of a solution of artificial essences, and their colour is due to cochineal, turmeric, chlorophyll, picric acid, or aniline dyes. In a communication to the French Academy of Medicine,[1] Laborde reported as follows: Liqueurs are now largely made of artificial essences which are very poisonous. Genuine vegetable essences are bad enough, but these are not now used. The essences are made of synthetic flavourings, which are more poisonous than the vegetable essences. Synthetic essence of anisette contains a quantity of hydrocyanic acid, and the inhalation of the vapour from this essence was sufficient to cause grave syncope followed by illness lasting several days. Chartreuse essence contains thirteen poisonous substances which bring about serious effects. Vulnerary contains fifteen poisonous substances. Brouardel,[2] another authority, says liqueurs were formerly distilled from wine holding aromatic substances in solution; they are now simply solutions of essences in rectified alcohol. Like absinthe, they cause drunkenness, loss of sensation and motion, and veritable attacks of epilepsy. Laborde considers that absinthe and its compounds, chartreuse, gin, noyau, vermouth, vulnerary, and Angostura bitters, should be absolutely forbidden to be sold, except for medicinal purposes, and that public authorities ought to forbid the manufacture or sale of these drinks, as containing substances harmful to the public health. The table on p. 876 shows the composition of some of those most commonly used.

Absinthe is a spirituous liquor of a greenish-yellow or opalescent colour, containing the essential oils of various herbs having aromatic and antispasmodic properties, such as wormwood (*Artemisia absinthium*), angelica, cinnamon, cloves, and parsley. The colour of the liquor, when properly made, is entirely due to *chlorophyll* derived

[1] *The Lancet*, 1902, ii. 49.

[2] *Ibid.*, 1877, ii. 739.

from the green leaves of wormwood, hyssop, spinach, parsley, nettles, and veronica ; but in recent years the liqueur has been most frequently coloured by artificial agents. Absinthe derives its name from wormwood, which contains from 0·5 to 1·0 per cent. of volatile oil consisting of **absinthol**, $C_{10}H_{16}O$ (also called "tanacetone" and "thujone"), thujyl aclohol, $C_{10}H_{18}O$, acetic and other organic acids in the free or combined condition, pinene, phellandrene, cadinene, etc. The herb also contains absinthic acid and absinthin, $C_{15}H_{20}O$, a bitter glucoside. The essential oils, however, are now frequently used, instead of the green herbs, in the manufacture of absinthe. Its composition, according to Hubert,[1] is as follows :

Composition of Absinthe.

Alcohol	50 to 70 per cent.
Acidity	·0900 ,, ·280 per cent.
Aldehydes	·0250 ,, ·150 ,,
Furfural	·0002 ,, ·004 ,,
Essential oils	2·6140 ,, 4·250 ,,

Absinthe was first introduced as a febrifuge for the French army (1844), but its use for the French service is now prohibited. It produces the customary effects of alcohol with the added physiological effects of the essential oils. The primary effect of the beverage is that of exaltation of the nervous system, quickening of the circulation, and an increase of appetite due to the bitter principles ; but this is followed by a depression, which may be profound. When it is taken habitually or to excess, the essential oils, especially the absinthol, have a very deleterious effect on the nervous system. Headache, giddiness, hallucinations, loss of memory, with the subsequent degeneration of the mental and moral faculties, ultimately render the absinthe-drinker a very depraved creature. Magnan[2] says : Absinthe poisoning or drunkenness is attended by a sudden and severe headache, giddiness, and delirium in which hallucinations affecting all the special senses occur, epileptiform seizures, loss of consciousness, and, on recovery, loss of memory and a tendency to hysterical manifestations.

Composition of Liqueurs (König)—Percentages.

	Alcohol.		Extract.	Cane-Sugar.	Secondary Products, Oils, etc.	Ash.
	Weight.	Volume.				
Absinthe	—	58·93	·18	—	·32	—
Angostura bitters ..	—	49·70	5·85	4·16	1·69	·068
Anisette	30·7	42·00	34·82	34·44	·38	·068
Benedictine	38·5	52·00	36·00	32·57	3·43	·406
Chartreuse	—	43·18	36·11	34·37	1·76	—
Crème de menthe ..	36·5	48·00	28·28	27·63	·65	·043
Curaçoa	42·5	55·00	28·60	28·50	·10	·040
Kümmell	24·8	33·00	32·02	31·18	·84	·058

[1] *Ann. de Chim. Anal.*, 1901, vi. 409. [2] *Revue de Hygiène*, 1890, 1909.

Angostura Bitters is really a tincture of Angostura bark and various spices, slightly sweetened with sugar. It is made in Trinidad.

Benedictine, made at the Abbey of Fécamp, and **Chartreuse**, made at the Carthusian monastery near Grenoble, and also in Florence, are properly made from angelica, hyssop, nutmeg, and peppermint, distilled and sweetened. Like other liqueurs, they are now made very largely from volatile oils and essences.

Crème de Menthe should consist of the distillate obtained from a fermented decoction or infusion of mint, sage, balm, cinnamon, orris and ginger roots, sweetened with sugar. The colour should be derived from the chlorophyll of the plants. De Bravans gives the following recipe for it: Mint 600, balm 40, sage 10, cinnamon 20, orris root 10, ginger 15, alcohol (85 per cent.) 5,030, sugar 3,750, parts; macerate the herbs, roots, and bark, in the alcohol for fourteen days, filter, add the sugar, and colour it. According to this recipe, the liqueur is clearly a tincture, sweetened, and artificially coloured with aniline or other colouring matters.

Curaçoa is a liqueur made in Amsterdam from the peel of bitter oranges imported from the island of Curaçoa. It was formerly the distillate obtained from a fermented liquor obtained by infusion or decoction. De Bravans says it is now made in the following manner: Take the peel rasped from eighteen oranges, 4 grammes of cinnamon, 2 grammes of mace; macerate in 5 litres of alcohol (85 per cent.) for fourteen days, filter; add 1,750 grammes of sugar, and a little caramel to give colour. "Dry"—that is, unsweetened—curaçoa may also be had.

Kümmell was formerly the distillate obtained from a fermented infusion of cumin and coriander seeds, sweetened with sugar. It is now a tincture of cumin and coriander, *made with brandy*, and sweetened with sugar.

Maraschino was originally made from the small sour cherries (*marasca*) of Italy, which, including the stones, were crushed, mingled with honey and water, fermented, distilled, and matured. It is now made from crushed wild-cherries, peach nuts, raspberries, cherry leaves, and orris root, which are macerated for fourteen days in alcohol of 85 per cent. strength, filtered, and sweetened with sugar, in the same way as crème de menthe.

Noyau was originally made from the stones of cherries, and **Kirschwasser** from crushed cherries grown in the Black Forest. Noyau, much used by confectioners as a flavouring agent, is now usually made from almonds. The following is a recipe for it: Bitter almonds, 50 grammes; sweet almonds, 25 grammes; white sugar, 500 grammes; honey, 25 grammes; the rind of three fresh lemons; milk, 280 c.c.; alcohol, 1 litre. The almonds are blanched, pounded, and mixed with the sugar; the milk is boiled and allowed to get cold; the zest only of the lemons is used; the spirit consists of brandy, but sometimes gin or whisky is used. The ingredients are mixed together, macerated and agitated for ten days, and filtered.

Ratafia.—Various liqueurs and cordials made in France from aromatic herbs and alcohol, subsequently sweetened with sugar, pass under this name. Some are prepared by crushing the stones of apricots, peaches, plums, or cherries, mingling with spices, making a fermented liquor and distilling it. In other cases the crushed kernels and spices are macerated in cheap brandy, subsequently sweetened and filtered. It usually contains about 25 per cent. of alcohol.

Vermouth, made in Turin, consists of orange wine and white wine, made bitter with wormwood, distilled, and sweetened with 20 per cent. of white sugar.

Arrach and Other Spirits.—**Arrach** is a spirit obtained by the distillation of fermented rice liquor; but rice is not the only substance used. It is made from the juice or sap of cocoanut and other palm trees, and the flowers of the mnowha-tree are also used in India. Rice spirit is not everywhere called "arrach." In Calcutta it is called **Doasta**; in Eastern India, **Samsu**; in China, **Sautchu**; in Japan, **Sochu**; in Thibet, **Arra.** Rice spirit is made in Eastern Asia by boiling the rice in water, cooling it and fermenting it. At the end of fermentation it is distilled three times in an old-fashioned still. The third distillate is the true **Samsu,** and it contains a high proportion of alcohol. It undergoes maturation by keeping it. It contains 50 per cent. or more of absolute alcohol, but, according to Mann,[1] it is usually sold at about 20° under-proof, and he found it contained higher alcohols amounting to 0·561 per cent., or 491 grains per gallon. It is sometimes drugged with Indian hemp or other narcotics.[2] The substance used to produce fermentation is a secret preparation, sold either as a powder or cake. On adding a small portion of this powder or cake to sterilized rice, a fungoid growth of a red or purple colour soon made its appearance.[3] This is a species of *Monascus*, one of the simplest Ascomycetes. The biological process on which the manufacture of rice spirit depends is the conversion of the starch into fermentable sugar by fungi, especially the *Monascus*, and the alcoholic fermentation of these sugars by yeasts or bacteria, which are present in the ferment.[4]

Mahua Spirit is made from the flowers of *Bassia latifolia* in Bengal and Assam. These flowers contain 53 per cent. of fermentable sugar. The spirit is sold in strengths varying from 20° to 60° under-proof, but it contains 0·04 to 0·33 per cent. of fusel-oil or higher alcohols,[5] which must be very prejudicial to the health of the consumer.

Arika is a spirit made in Tartary by the distillation of koumiss.

Skhou is a similar spirit made in the Caucasus from kephir.

Puichui is a spirit obtained in Peru from a fermented liquor made from manioc or maize.

Octli is a spirit made in Mexico from the fermented juice of the American agave. According to Bausingault,[6] this juice contains saccharose 61·71, lævulose 26·45, dextrin 5·4, albumin 10·13, malic acid 3·53, and salts, 6·2, parts per 1,000.

Methylated Spirit.

A large amount of methylated spirit is consumed by various people. This liquid is a mixture of 19 parts of alcohol of a strength not less than 50 over-proof (about 86 per cent. of alcohol) and 1 part of commercial wood naphtha. As sold at retail shops, it

[1] *The Analyst*, 1904, xxix. 149.
[2] Blyth's "Foods."
[3] *The Lancet*, 1902, ii. 882.
[4] *Ibid.*
[5] Mann, *The Analyst*, 1904, xxix. 149.
[6] *Ibid.*, February, 1905.

consists of the above mixture with the addition of not less than ⅜ per cent. of petroleum oil or mineral napthha. It would be imagined that the latter addition would be a sufficient protection against its consumption ; but it is not. There are many persons who drink 1 to 2 pints in a week. In acute intoxication by it the symptoms are similar to those arising from other spirits ; but while the coma from ethyl alcohol rarely lasts more than six hours, and never more than twenty-four hours, that from methyl alcohol may last two to four days. This is not due to impurities, for Hunt[1] found that pure methyl alcohol will produce the same effect. Lethal doses of methyl alcohol do not produce the death of animals so quickly as lethal doses of ethyl alcohol. But in chronic intoxication methyl alcohol is retained longer in the nerve tissues than ethyl alcohol ; hence small doses of methylated spirit taken frequently act very deleteriously by their cumulative effect. Dogs treated with methylated spirits died from a single dose, whereas the same amount of ethyl alcohol did not prove fatal.

[1] Johns Hopkins Hospital Bulletin, 1902.

CHAPTER XXXIII

WINE

WINE is the fermented juice of sound ripe grapes, matured in cellars. When grape-juice is kept for a few days at ordinary temperatures it changes into wine, the dextrose and lævulose which the juice contains being transformed into alcohol and carbonic acid gas. The ferment which produces these changes is present on the grapes or their stalks and in the atmosphere of the manufactories.

Wine has been celebrated from time immemorial, as indicated in the writings of ancient peoples, such as the Hebrews, Chaldeans, Greeks, and Romans. "Noah planted a vineyard and drank the wine thereof" about 2347 B.C.[1] Special wines have attained a high celebrity at various periods. The Lesbian and Chian wines were highly esteemed by the ancient Greeks; the Falernian and Cecuban were as highly prized by the Romans; certain classes of sherry and claret by the Spaniards and French in more recent times. The commencement of wine manufacture in France is very vague, being almost lost in the mists of antiquity. A colony of vine-dressers from Phocea in Iona settled at Marseilles about 600 B.C., and instructed the Gauls in the cultivation of the grape, as well as the manufacture and commerce of wine. It has usually been considered that the vine is a native of Southern France, and grew there spontaneously; but it is known that it was carried into Champagne and part of Germnay by the Emperor Probus about A.D. 279.

Modern wines are very numerous, and are distinguished from each other by differences in the fruit arising from variations in the vine, the soil, climate, and the mode of treatment. Equally important are the differences in the mode of manufacture. The most perfect wine is produced from grapes which are fully ripe and have been grown in a moderately dry and warm climate; but the grapes of each district give a wine which is characteristic of that region, and distinguishable by its own qualities. Equally important for the manufacture of good wine is a good season, and freedom from the various fungi which at times devastate the vineyards.

The vine disease is due to a fungus, *Oidium tuckeri*, belonging to the mildews, or Erysiphæ, of the group *Ascomycetes*, which appear on the leaves in yellowish patches, and cause them to become pale and anæmic, so that the plant languishes. Another mildew, *Peronospora viticola*, belonging to the *Oomycetes*, appears on the young shoots or leaves, and exhausts them so that they wither and fall. These fungi hinder nutrition, and the fruit dries up before it is ripe. Another fungus gives rise to the black rot (*Sphaceloma ampelium*, N.O. Ascomycetes), and devastates some vineyards. Another

[1] Gen. ix. 20.

disease is called "aubernage," or the "black disease," and is due to a bacillus. The *Phylloxera vastatrix* is an insect which formerly committed great ravages amongst the vines, but is now thought to be exterminated.

Wine-Making.—The wine season is when the fruit is ripe—viz., from the middle of August to the end of September. The juice of the grapes is expressed in a winepress, the unripe, decayed, or withered fruit being carefully excluded. The greatest care is taken, for the majority of wines, to avoid crushing the grape-seeds and stalks; hence the method of pressing out the juice by treading is considered preferable. The **must**, as the liquor is now called, consists of water 70 to 85 per cent., dextrose and lævulose 10 to 30 per cent., tartaric, racemic, malic, and tannic acids, albuminous, fatty, and mucoid substances, essential oils, extractives, mineral and colouring matters. The ratio of dextrose and lævulose is about 3 : 1. The character of the future wine, however, does not depend on the sugars alone, but on other things—for instance, the albuminoid matters. The nitrogenous substances of the juice are necessary for the yeast. When the must contains these in abundance the yeast is most vigorous, and does not cease its activity until all the sugar is used up; hence such a wine is "dry," and probably acid, like hock. Should the albuminoid matters be scanty, the fermentation will cease before all the sugar is hydrolyzed, and the resulting wine will be sweet like marsala or madeira. When both the sugars and albuminoid matters are in good proportion, the result of the fermentation will be a wine of sub-acid flavour and good "body" like Burgundy. Now, 100 parts of sugar yield 51 parts of alcohol, and, as the amount of sugar in the must varies from 10 to 30 per cent., the proportion of alcohol produced in the wine varies from 6 to 16 per cent.

In the manufacture of a few wines the must is concentrated—*e.g.*, for some of the most celebrated dessert wines of Spain; for other wines the grapes are only gathered when they are perfectly ripe, so that a portion of the water is lost by evaporation; for other wines, again, the grapes are allowed to become nearly dry, almost like muscatel raisins, before they are gathered and pressed—consequently the wine is both sweeter and more alcoholic. The celebrated "straw wines" are made from grapes which have lost some of their water by evaporation in a similar manner; the changes in the fruit are also attended by some form of fermentation in the uncrushed cluster, in consequence of which more of the colouring and astringent matters are dissolved. These wines, however, are not numerous or abundant, and it may be stated as a rule that wine produced from unsophisticated must does not contain more than 16 per cent. of alcohol.

Fermentation of Must.—When the grape-juice is kept for a few days at ordinary temperatures it changes into wine, the dextrose and lævulose becoming transformed into alcohol and carbonic anhydride. The fermentation is produced by the yeast, **Saccharomyces ellipsoideus**, which exists upon the grapes, the stalks, and in

the air of the manufactory. This is the usual ferment of wine, but in modern wine-making other yeasts also are used[1]; *e.g.*, in the manufacture of hock another species of Saccharomyces is used than that named above. The yeast reproduces itself in the must more or less rapidly, according to the temperature of the mass and the surrounding air, as in malt liquors. After a few hours—a day or two at most—according to the rapidity with which the fermentation begins, the temperature of the liquid rises, and a scum forms upon the surface, consisting of yeast and the gross matters of the must, such as grape skins, stones, mucus, and other débris, which are buoyed up by the evolution of carbonic acid gas. The mass in the vats therefore appears to increase in bulk owing to this buoyancy; but the scum is frequently broken up, and owing to the escape of CO_2 the débris sinks back into the liquor, to rise again and again so long as the fermentation continues to be brisk. The fermentation continues from twenty-one to forty-two days, the duration being in inverse ratio to the capacity of the vats, and direct ratio to the maturity of the grapes. When the fermentation is nearly completed, the coarse matters are no longer buoyed up by the evolution of gas, and sink to the bottom. It is then left on the **lees** until the spring, when the liquid is decanted, filtered, clarified by finings, put into barrels or other closed vessels, and transferred to cool cellars.

During this second stage in the process, there is first of all a period of repose, after which the fermentation is completed, or, rather, a secondary or complementary fermentation occurs, as in the maturation of malt liquors. During this period there is a gradual increase in the proportion of alcohol, a partial oxidation of tannic acid, and a deposition of potassium bitartrate and organic substances from the wine, which adhere to the sides of the vessel as *argol*, or impure cream of tartar. The wine is greatly improved by this insensible fermentation, *if the primary fermentation has been stopped at the proper time*, which is known by the "attentuation"; it is matured or ripened: whence old wine is better than new. If the primary fermentation is allowed to continue too long—that is, until nearly the *natural* termination or exhaustion of the sugars—the complementary fermentation does not occur. On the other hand, if the primary fermentation is not allowed to go on very long, a considerable proportion of unfermented glucose remains in the wine, which ferments and gives rise to an evolution of carbonic acid gas after it is bottled, and thereby produces a sparkling wine. In ordinary or **still wines**

[1] Hansen found in the lees of wine no fewer than fifteen ferments (*Moniteur Scientifique*, November, 1888). *Saccharomyces apiculatus* is even more plentiful on the skins and stalks of grapes than *S. ellipsoideus*. Martinand and Reitsch (*Compt. Rend.*, 1891, cxii. 14) state that during the first twenty-four hours the spontaneous fermentation is carried on by *S. apiculatus*, which afterwards gives place to *S. ellipsoideus*, but does not entirely disappear. Various acid-producing bacteria and others also occur on the grapes, and appear at the outset of fermentation or in the lees. The latter are probably the cause of diseases affecting the wine after its fermentation.

the primary fermentation must be completed, or checked by the addition of alcohol or preservatives, in order to prevent the formation of carbonic acid gas in the bottle, and to insure that the succeeding changes shall be imperceptible. But care is usually taken that the primary fermentation is not carried too far; otherwise it will be succeeded by acid fermentations, which are undesirable. In **sparkling wines**—*e.g.*, champagne—the primary fermentation is checked at an early stage, so that a secondary or complementary fermentation may occur in the bottle, and cause the sparkle and froth which are characteristic of this class of wine. Rheims is the champagne centre of France. The juice of *black grapes* only is used for some kinds, the skins being rejected to avoid the extraction of the colouring matter and tannin. The must is stored in rock cellars, where it ferments and deposits lees, and is transferred from one cask to another until the fermentation has reached a proper stage, the liquid being clear and bright. The proportion of unfermented sugar is then ascertained, and any deficiency made up by the addition of cane-sugar or sugar-candy; a definite quantity of sugar, at the time of bottling, being necessary to produce the future sparkle. It is now bottled, and racked in a warmer atmosphere until the effervescing character begins to appear, after which it is transferred to cellars *for three or four years* to mature. During maturation the secondary fermentation occurs, a deposit being formed, and the bottles are racked at such an angle that the deposit falls upon the cork. When the wine is mature, the cork is removed and a fresh one put in; at the same time some brandy or liqueur is sometimes added. The proportion of liqueur varies according to the market it is destined for (see Champagne). **Vin brut** is the natural wine without any added liqueur. The wine also varies as to the amount of sugar it contains when marketed; some have a considerable amount of sugar, or are sweet wines, and are said to be *rich* or *full;* others contain very little sugar, and are *sec*, or "dry," and those from which sugar is practically absent are *très sec*, or "very dry."

Wines classified according to Character and Composition.

1. **Natural Wine** is that produced from fresh grapes only, without added spirit. It should contain not less than 7 per cent. or more than 16 per cent. of alcohol by volume. The existence of any proportion of alcohol above 16 per cent. would lead to the presumption that such wine was fortified by the addition of alcohol. 100 c.c. of natural wine at 20° C. should not contain more than

0·10 gramme of sodium chloride.
0·20 ,, of potassium sulphate.
0·14 ,, of volatile acids in red wine
0·12 ,, of volatile acids in white wine } reckoned as acetic acid.

Red Wine contains the natural colouring matter from the skin of the grapes, but artificial colouring matters are frequently added.

The dry **extract** in *natural red wine* should not be more than 3·5 or less than 2·4 per cent., when the reducing-sugar is deducted. *White Wine* is the product of the juice of fresh white grapes or the expressed juice of other grapes. It contains not more than 1·7 per cent. of dry **extract**, when the reducing-sugar has been extracted.

2. **Dry Wines** are those in which the destruction of sugar by fermentation is complete ; they are often fortified by the addition of brandy or grain spirit. *Dry Red Wine* should contain less than 1 gramme of sugar and less than 0·16 gramme of grape ash, but not less than 1·6 grammes of grape solids, in 100 c.c. at 20° C. *Dry White Wine* should also contain less than 1 gramme of sugar, but not less than 0·13 gramme of grape ash or 1·4 grammes of grape solids, in 100 c.c at 20° C.

3. **Sweet Wines** are those in which the fermentation has been arrested. They contain more than 1 gramme of sugar, and not less than 0·16 gramme of grape ash, in 100 c.c. of red wine, or 0·13 gramme of grape ash in 100 c.c. of white wine. They often have the natural percentage of alcohol raised by the addition of brandy.

4. **Sparkling Wines** are those in which the fermentation is partly completed in bottle ; a sediment is formed and removed ; sugar or syrup is added. It should contain not less than 0·12 gramme of grape ash in 100 c.c. at 20° C.

5. **Sophisticated Wines.**—A very large proportion of wines on the market belong to this class—that is to say, some substance is added either to the must before fermentation or to the wine after fermentation. It is not considered injurious or illegal to add the following :

(*a*) *To the Must :* Cane-sugar, concentrated must, citric, malic, tartaric, and sulphurous acids, the acids being subsequently neutralized by pure carbonate of potassium or calcium.

(*b*) *To the Wine :* Citric, malic, tartaric, tannic, and carbonic acids, potassium and calcium carbonates, neutral potassium tartrate, sulphites of sodium and calcium, or pure sulphurous ahydride.

(*c*) *To assist Clarification :* Isinglass, gelatin, albumin, pure kaolin, gypsum, or sulphate of lime.

The addition of most of these things has a legitimate object.

Plastering the wine by sprinkling calcium sulphate over grapes before they are crushed, or to the must, is done with the object of precipitating potassium tartrate in an insoluble form ; this matter will be referred to again. The resulting wine should not contain more than 2 grammes of sulphate of potassium per litre. The sugar is added to the must in order to increase the production of alcohol. Sulphurous acid or sulphites of sodium and calcium are used as preservatives ; they are added in the cellar treatment of the wine ; the proportion which is considered allowable varies. In France the *maximum* limit is 400 milligrammes of sulphurous acid per litre. In the United States the following legal standard is fixed :

1. *Dry wine* should contain not more than 200 milligrammes of

sulphurous acid per litre, of which 20 milligrammes may be free or pure anhydrous acid.

2. *Wines nearly dry* or containing 2 per cent. of sugar may have 250 milligrammes of sulphurous acid per litre.

3. *Sweet wines* or those containing 3 per cent. of sugar and over may have 350 milligrammes of sulphurous acid per litre.

Other Substances.—Starch and glucose are sometimes added to the must, and saccharin or other artificial sweetening agents to the wine. Foreign colouring matters, salicylic acid, *abrastol*, and other preservatives, are sometimes used. The wine may also contain salts of lead, barium, or alumina, which are not normal constituents of fruit-juice, and may be very injurious to the consumer.

The Composition of Wine.—The chief constituent of all wines is alcohol ; but this is not the only substance by far. Wine contains a great number of other bodies in a proportion which is small, exceedingly small in some cases, but whose existence is of great importance in the formation of the character of wine. There is, moreover, something about the wine which is inimitable. It is impossible to *make* wine by a combination of water, alcohol, ethers, cream of tartar, and other salts. There is something about natural wine which baffles the imitator, which is probably due, not only to the presence of an exceedingly small proportion of a number of substances, but to their existence in the wine in the forms of ions or dissociated particles which are constantly acting and reacting upon each other. The following was given by Bouchardat[1] as the composition of ordinary red wine :

Composition of Red Wine—Average of Parts per One Thousand.

Water	878
Ethylic alcohol	100
Higher alcohols : Amylic, butylic, propylic	traces
Aldehydes : Acetic, ethylic, etc.	,,
Ethers : Acetic, butyric, capric, caprylic, malic, pelargonic, etc.	,,
Essential oils	,,
Sugars : Grape-sugar, mannite, etc.	4
Albuminoid matters and gum ; succinic acid, glycerine ; fatty bodies, ferments ; colouring matters ; tannin ; mineral matters ; free or volatile acids, as acetic ; fixed acids, as tartaric acid ; tartrates, racemates, acetates, malates, citrates, lactates, butyrates, propionates, succinates, sulphates, phosphates, nitrates ; chlorides, iodides, bromides, fluorides ; silicates of potassium, sodium, magnesium, calcium, and ammonium ; oxide of iron	18

The *Alcohol* in natural wines never exceeds 16 per cent. of absolute alcohol ; it varies from 6 to 16 per cent. by volume. If it contains any more than the maximum, it is added to it. The action of yeast is stopped when the alcohol reaches 16 per cent. The pro-

[1] "The Use of Alcoholic Liquors."

THE COMPOSITION OF WINES—PERCENTAGES.

	Alcohol.			Extractives.	Mineral Matters.	Sugars.	Tannin.	Volatile Acids, as Acetic.	Fixed Acids, as Tartaric.
	Weight.	Volume.	Equal to Proof Spirit.						
Burgundy and Bordeaux: Minimum ..	10·85	13·43	23·54	2·28	·24	·140	·11	·096	·220
Maximum	12·38	15·30	26·83	2·71	·27	·210	·30	·108	·307
Burgundy (*red wines*): Romanée ..	11·00	13·62	—	1·49	—	·010	·12	·200	·330
Chambertin	11·15	13·81	—	1·86	—	·010	·11	·300	·370
Margeaux	10·85	13·43	23·54	2·67	·27	·210	—	·078	·307
Macon, 1875	9·00	11·17	—	2·02	—	·080	·12	·220	·380
Beaujolais, 1875	9·57	11·87	—	2·09	—	·070	·20	·220	·380
Beaune	9·57	11·87	—	1·78	—	·070	·19	·220	·330
	11·62	14·37	25·18	2·90	·25	·300	—	·102	·307
Pommard	12·38	15·30	26·82	2·74	·20	·230	—	·103	·262
Volnay	13·15	16·42	28·46	2·69	·24	·210	—	·030	·200
Burgundy (*white wines*): Chablis ..	10·85	13·43	23·54	2·62	·26	1·200	—	·084	·420
	8·86	11·00	—	1·89	—	·050	—	·130	·610
Montrachet	12·08	14·93	—	1·99	—	·310	—	·120	·460
Mersault	10·77	13·34	—	1·98	—	·080	—	·130	·480
Bordeaux (*clarets*): 1875	8·71	10·82	—	2·01	—	·120	·19	·230	·420
Clos d'Estournel	9·29	11·52	—	1·93	—	·090	·24	·220	·350
Chateau Duhart Milon	8·21	10·21	—	2·06	—	·090	·14	·220	·350
St. Julien (*adet*)	12·38	15·30	26·83	2·71	·27	·170	—	·072	·285
Dinner Claret	9·07	11·26	—	2·14	—	·100	·14	·240	·410

Vin Ordinaire	7·00	—	—	5·00	—	·100	—	·110	·610
Castle A	9·14	11·35	—	1·95	—	·070	·22	·260	·400
Château Loudenne	9·07	11·26	—	1·83	—	·090	·19	·190	·350
,, Quinsac	8·21	10·21	—	1·64	—	·080	—	·210	·340
,, Larose	10·85	13·43	23·54	2·47	·24	·160	—	·096	·225
,, Montrose	10·85	13·43	23·54	2·28	·24	·140	—	·120	·220
,, Rothschild	10·85	13·43	23·54	2·44	·26	·160	—	·108	·262
White Bordeaux : Graves	9·57	11·87	—	2·03	—	·220	—	·120	·520
	10·31	12·77	—	4·95	—	·400	—	·290	·310
Sauterne (Yquem)	11·62	14·37	25·18	4·68	·20	2·900	—	·048	·510
Haut Sauterne	13·15	16·24	28·46	3·59	·28	1·660	—	·337	·180
Champagne	12·38	15·30	26·82	3·67	·11	1·920	—	·090	·600
Moselle	8·64	10·73	18·81	2·14	·18	·250	—	·070	·670
Hock	8·80	—	—	2·30	·20	—	—	·110	·020
Port	17·05	21·19	37·13	9·20	·22	7·560	—	·071	·340
Sherry : Minimum	15·00	—	—	2·20	—	·500	—	·120	·340
Maximum	22·00	—	—	5·45	—	4·000	—	·200	·520
Italian wine : Chianti	9·36	11·61	—	—	—	·170	—	·180	·600
Capri	11·62	14·37	—	—	—	·760	—	·310	·520
Falerno	8·64	10·73	—	—	—	·760	—	·130	·660
Greek wine	12·35	—	—	2·50	·30	·225	—	·215	·342
Madeira	17·82	—	—	4·44	·37	1·850	—	·247	·373
Marsala	16·81	—	—	5·36	·26	3·500	—	·120	·206
Hungarian	10·16	—	—	1·90	·18	·077	—	·192	·454
Californian : Red	10·35	13·00	—	2·37	·18	—	—	·185	·505
Sauterne	10·31	12·77	—	2·31	·16	—	—	·194	·496
Hock	10·00	12·40	—	1·90	·20	—	—	·335	·345
Australian	11·62	14·37	25·18	2·85	·23	·300	—	·115	·262

portion of alcohol in the wine may increase *after it is bottled*, if the maximum is not previously reached, owing to the complementary fermentation. But this gradual increase cannot go on indefinitely, but only until the sugar is used up or the alcohol reaches the maximum. Old wine is not stronger than that of moderate age ; indeed, as age increases there is a slight diminution in the amount of alcohol, owing to its transformation into acetic acid, aldehyde, and ether. The wine therefore may be *assumed to be fortified* when the proportion of alcohol is above 16 per cent. by volume. It is claimed by manufacturers that fortification is necessary to preserve wines intended for consumption in hot countries, because the proportion existing in natural wines is not always sufficient to check fermentation either by ordinary or wild yeasts. Ordinary yeast is inactive in solutions of sugar containing more than 16 per cent. of alcohol, and any proportion of alcohol below that amount will not prevent wild-yeasts (which often contaminate the wine) from producing acidity and other degenerations. Fortified wines do not mature so rapidly as natural wines—that is to say, they are longer before they acquire a genuine vinous flavour and aroma.

The question of the propriety of fortifying wine is a matter of public health. Fortification is dangerous to the public health, not only from the quantity, but from the *quality*, of the spirit added to the wine, and because it opens the way to subsequent dilution by water. Again, the higher alcohols considerably increase the dangers arising from the addition of brandy and liqueurs. There is therefore good reason for demanding that the alcohol used in fortifying wines shall be absolutely pure. The Academy of Medicine of Paris resolved that the fortification of wines by means of *pure* alcohol, and not beyond 2 per cent., may be tolerated, but excepting under these conditions it should be entirely prohibited.[1] The following table is from Mulhall and other sources :

AVERAGE PERCENTAGE OF ALCOHOL IN WINES, BY VOLUME.

SHERRY	19·17	Rioja (Spanish Burgundy)	16·35
Madeira	22·27	Californian Burgundy	12·17
Marsala	25·90	Australian Burgundy	13·24
Malmsey	16·40	Cape Burgundy	23·50
Malaga	18·94	Sauterne	14·22
Muscatel	18·25	Hermitage, red	12·32
Teneriffe (sack)	19·79	,, white	17·45
PORT	23·50	Hungarian, red	10·50
Lisbon	22·00	TOKAY	9·88
Tent	13·30	Rhine wine	12·50
Tarragona	18·00	Hock	12·08
Rousillon	18·13	MOSELLE	10·73
Canary	21·36	CHAMPAGNE	12·61
CLARET	13·10	Sillery	11·00
Bordeaux	11·50	Saumur	11·85
Burgundy	14·57	ITALIAN : Chianti	11·60
Chablis	12·54	,, Falerno	10·73
Cahors	12·33	GREEK WINES	15·30

[1] *Moniteur Scientifique*, January, 1887.

Secondary Products.—Wine contains, besides ethyl alcohol, various ethers and several higher alcohols amounting to 110 per 100,000 of absolute alcohol — *e.g.*, amyl, butyl, and propyl alcohols, which are derived from amino-acids and from the fatty bodies in the skins, stones, etc. *The proportion of higher alcohols is very small;* normal butylic alcohol and butryic acid are absent. The following table is instructive. Clandon and Morin submitted 100 kilos of sugar to the action of elliptical yeast, obtained from the lees of a white wine of Rouillac (*Charente*) ; the product had a vinous odour, very distinct from that presented by the production of fermentation by beer yeast.

THE PRODUCTS OF FERMENTATION BY WINE YEAST.

One hundred thousand parts of sugar yielded :

Ethylic alcohol	50,615·0 parts.
Aldehyde	traces.
Normal propyl alcohol	2·0 ,,
Isobutylic alcohol	1·5 ,,
Amylic alcohol	51·0 ,,
Œnanthic ether	2·0 ,,
Isobutylene glycol	158·0 ,,
Glycerine	2,120·0 ,,
Acetic acid	205·3 ,,
Succinic acid	452·0 ,,

The proportion of ethers is about 1 in 300 of wine. Their formation increases during maturation, and appears to reach a maximum about five years after bottling. They arise by the interaction of alcohols and acids, and are both volatile and fixed ; the former are produced by volatile acids such as acetic, the latter by fixed acids such as capric. Thus are formed acetic ether (the most abundant), aceto-amylic, aceto-propylic, aceto-caproic, aceto-caprylic, and others, including œnanthic ether, which exists in the proportion of 1 in 40,000, and is one of the chief substances in forming the bouquet.

The Aroma and Bouquet of Wine.—All natural wines have a more or less agreeable aroma, due to the combination of higher alcohols, aldehydes, and ethers, such as caproic, caprylic, acetic, malic, butyric, œnanthic, and pelargonic. Grape-juice contains no aldehydes, but they are always formed in wine, and constitute a normal product of alcoholic fermentation of fruit-juices. They arise by the oxidation of alcohol or by the action of ferments. According to Passerini,[1] the aerobic ferments *Mycoderma vini and Bacterium aceti* produce considerable quantities of aldehydes, but the anaerobic ferments do not. He found that Tuscan wines contain from 1 to 6 milligrammes of aldehydes per litre, and that the larger amounts were in those wines which contained most alcohol, and, generally speaking, that they increase with the age of the wine. It has been found that a too violent primary fermentation interferes with the ultimate production of bouquet. In comparatively new wine

[1] *Staz. Sperim. Agrar. Ital.*, xxxix. 221-240.

of great alcoholic strength the aroma is not perceptible, either because it is hidden by the greater proportion of alcohol, or because the aldehydes and ethers have not yet been developed.

The *Extractives or Solid Matters* in wine consist of colouring matters, sugar, gum, pectin, glycerine, tannin, etc.; they give "body" to the beverage. The *Colour of Wine* is derived from the skin of the grapes. It does not begin to appear until alcohol is produced in the fermenting must; it is the spirit which effects the solution of the colouring matter, and it is therefore only after a proportion of alcohol has been formed that the liquid acquires a colour. White wines are produced from juice fermented without the skins. In order to obtain the fullest *natural colour*, Nessler[1] found that the fermentation of the juice must be begun between 14° and 20° C., and that the skins should not be excessively comminuted; nor should the wine be allowed to remain in contact with skins when the primary fermentation is complete, or there will be a loss of colour. If a deep-coloured wine be exposed to the sun for a few days, practically all the colouring matter may be deposited, without any loss of the perfume or strength of the wine. The chief colouring matter is *ænocyanine*, but more than one pigment has been separated.

The *Sugar* in natural wines varies from 0·15 to 3·0 per cent., but sweetened wines, such as port, sherry, marsala, etc., may have 5 per cent. or more. The amount of sugar in wine varies to some extent in proportion to the temperature at which the must is kept during fermentation. A full-bodied wine is produced from grapes rich in sugar by reducing the temperature of the must, immediately after the grapes are pressed, in proportion to the amount of sugar it contains. The regulation of the temperature by "attempering" the must is as important to produce good wine as it is to produce good beer. When all the sugar is decomposed the wine is "dry"; but this is undesirable in most of the wines used as a daily beverage. The fermentation is therefore checked at the proper time before the wine is racked and bottled. Dupré found the following wines contained the amount of sugar stated:

SUGAR IN WINE.

Hock	.. .. ..	1·4 to 8·6	grains per bottle.
Claret	.. .. ..	11·0 ,, 18·0	,, ,,
Sherry	.. .. ..	217 ,, 421	,, ,,
Port	.. .. ..	121 ,, 519	,, ,,
Marsala	.. .. ..	388 ,, 451	,, ,,
Sauterne	.. .. ..	125	,, ,,
Champagne	.. ..	nil to 500	,, ,,

Glycerine and *Succinic Acid* are among the normal products of the alcoholic fermentation of sugar, about 2 parts of glycerine and 0·5 part of succinic acid being produced by the fermentation of 100 parts of sugar.

Tannin exists in red wine in the proportion of 1 in 400 or 500; it

[1] Biedermann's *Centralb. f. Agric. Chem.*, vol. xv., par. viii.

is derived from the seeds and skins of the grapes. It is considered to have a modifying influence on the action of the wine in the stomach.

The *Mineral Substances* are the salts of the fruit ; the bases are numerous, but the acids are more numerous (see Composition of Red Wine, p. 885). The salts of sodium and potassium predominate. Oxide of iron is present to a variable degree in some red wines, and has a special value from a therapeutic point of view.

Acidity of Wines.—Acids exist in all wines in the form of *free* acids or acid salts ; but all wines are not acid to the same degree. The *total acidity* varies from 0·25 to 1·0 per cent., and arises from the presence of acid salts or *fixed acids*, such as tartrates, citrates, acetates, malates, racemates, etc., and *free acids*, such as tartaric, citric, acetic, malic, butyric, succinic, lactic, tannic, etc. The *volatile acids*, reckoned as acetic, vary from 0·075 to 0·25 per cent., and the *fixed acids*, reckoned as tartaric, vary from 0·25 to 0·75 per cent. in good wines. There is, however, a limit to the production of free or volatile acids in good natural wine, and it has been found that an unsophisticated natural red wine should not contain more than 0·14, and white wine not more than 0·12, gramme of volatile acids calculated as acetic in 100 c.c. ; if the amount of volatile acid exceeds 0·25 per cent., the wine is decidedly " vinegary." The natural acidity of some wines is characteristic. Those produced from grapes not fully ripe or from certain districts or in certain seasons have this property. But wine produced from grapes which are mature and contain the fullest proportion of saccharine constituents have a minimum of acidity.

The natural acidity of wine arises to a great extent from **tartaric acid**, which is present in the proportion of 0·2 to 0·6 per cent. " Tartar " exists in the fruit, and also in the must, and consists of crude cream of tartar, or hydrogen-potassium tartrate, $KHC_4H_4O_6$. Its existence has a value which is appreciated by the vintner ; it gives to the must a slight acid reaction, which facilitates fermentation, and therefore the production of alcohol. It is deposited from the new wine during maturation in the cask, and is then called **argol,** and is red or white according to the colour of the wine. This is impure cream of tartar, containing 40 to 70 per cent. of tartaric acid ; it is mingled more or less with *lees*, which consists of yeast, albuminous and other organic matters, precipitated from the wine. The deposit is more abundant in proportion as the complementary fermentation is slower ; it is plentiful in new wines, but mature and old wines are more or less free from it. There is, however, a proportion of *free* tartaric acid in wine as well as cream of tartar. According to German regulations, the amount of *free tartaric acid* in wines containing not more than 0·8 gramme of total acids per 100 c.c. should not exceed $\frac{1}{5}$ or $\frac{1}{6}$ of the total non-volatile acids (that is, 0·5 to 1·5 grammes per litre); in wine containing more than 0·8 gramme of total acids per 100 c.c. the free tartaric acid may be more. French chemists, on the other hand, assert that certain genuine wines of the South of France frequently contains 2·0 grammes

of free tartaric acid per litre. This point (the quantity of *free* tartaric acid in natural wines) has been much disputed. Wines made from grapes grown near Narbonne were analyzed by J. Fiehe,[1] and he found those of Aranian contained 2·18 and 2·63 grammes of free tartaric per litre. The analyses are as follows :

WINE FROM GRAPES GROWN IN 1907—PERCENTAGES.

	Aranian.		Carignan.		Bouvret : White.
	White.	Red.	White.	Red.	
Alcohol by volume ..	7·700	5·200	9·500	9·600	11·000
Extract	1·370	1·900	1·900	2·340	1·550
Sugar	·100	·120	·130	·110	·100
Ash	·196	·330	·214	·330	·354
Total acids	·675	·937	·675	·825	·487
Non-volatile acids ..	·570	·825	·584	·700	·427
Total tartaric acid ..	·450	·670	·270	·375	·150
Free tartaric acid ..	·218	·263	·084	·037	·023
Specific gravity	·9954	1·0014	·9952	·9973	·9928

The genuineness of such wines had been questioned because of the disproportion between the amount of *extractive* matters and the free tartaric acid ; but the foregoing analyses show that a wine may have an abnormally low percentage of extract (lower than that which is considered evidence of a genuine wine), and at the same time a high percentage of free tartaric acid (above that which is normally present in genuine wines). This frequently high proportion of acid in wines from the district in question must be attributed to the soil and climate, and not to the addition of acid to the wine. Another acid which frequently gives rise to doubt as to the genuineness of a particular wine is *malic acid*. Unripe grapes and grapes from certain districts—*e.g.*, Vendée—contain malic acid, either free or combined. Thus, Ordonneau[2] found that 1890 wine from the Vendée yielded 15 grammes of tartro-malate per litre, and that certain white wines contain more malic than tartaric acid.

The volatile acids increase somewhat according to age. During maturation some alcohol becomes transformed to acetic acid by oxidation, and a little is produced in the must by *Mycoderma aceti*. This micro-organism may at any time get into the wine if air gains access to it, and would, if unchecked, transform the wine into vinegar. As a rule, however, good wine becomes less acid by maturation, which is due to the fact that the " tartar " becomes less soluble as the alcohol increases, and is precipitated, more or less. But the *taste* of wine is no guide to its acidity, because the actual acidity

[1] *Chem. Zeit.*, 1908, 1105-1116.
[2] *Bull. de le Soc. Chim.*, September 5, 1891.

may be disguised by the presence of sugar ; in consequence of being thus covered, many sweet wines have an acidity equal to that of sour wines. Dupré[1] found the acidity, reckoned as tartaric, in various wines to be as follows ; the minimum and maximum acidity of wines is added by the author :

Acids in One Bottle of Wine, reckoned as Tartaric.

Claret	65 to 75 grains.
Hock	57 ,, 70 ,,
Sherry	54 ,, 61 ,,
Port	49 ,, 62 ,,
Marsala	39 ,, 46 ,,
All wines : variation	44 ,, 130 ,,

The Quality of Wines.—As a general rule it may be assumed that wines bought at a fair price of a respectable dealer, and on his recommendation, are genuine. But various wines placed upon the market are alcoholic and fiery. They frequently consist of an inferior wine, fortified with equally inferior brandy, sweetened with sugar, acidified by the addition of *argol* or cream of tartar, and flavoured with ethers to give the characteristics of age. They are *plastered* with gypsum ; their brilliance increased by alum, and their colour improved by vegetable or artificial colouring matters. Cheap wines are usually the product of years when the season is bad for the fruit or for other reasons. Thus, the burgundies of 1897 were recorded as a complete failure ; in 1901 thin poor wines only were produced ; the harvests of Bordeaux in 1901-2-3 were failures as regards superior wines, but light beverage wines were produced. In other years or other districts the wines have been " indifferent," " inferior," " coarse and rough," and so on, throughout the records of most wine-producing countries. A market is, however, found for these wines in some part of the world ; but they are usually " faked " to improve them in the manner indicated. According to Bouchardat and Gautier,[2] **wines are coloured** in France with elderberries (*Sambucus niger*), sometimes with cochineal, rarely with poke-berries (*Phytolacca decandra*), but never with fuchsine. Fuchsined wines come chiefly from Italy, Spain, Belgium, and Switzerland. Wines containing elderberries and poke-berries also come from Spain and Portugal. Elderberry colouring is made by digesting elderberries and pressing out the juice. The following proportions are used :

Elderberries	250 to 500 grammes.
Alum or tartaric acid	30 ,, 60 ,,
Water	500 ,, 800 ,,

Phytolacca decandra, whose berries give a violet-red colouring matter, is cultivated in America, France, Germany, Spain, and Portugal. *Altheæ roseæ*, var. *nigra*, yields a deep violet wine

[1] " What is Wine ?" *Popular Science Review*, vol. vii.
[2] *Prov. Med. Jour.*, 1884, 105-141.

colour called *mauve-noir ;* the flowers are used to colour wine in Germany. Other substances which have been used for the same purpose are logwood, brazil-wood, cochineal, fresh beetroot, the fruit of whortleberry-tree, privet, mulberry, hollyhock, and portugal-berry. The juice of mulberries, elderberries, and whortleberries, is not injurious, but the same cannot be said of some of the other vegetable colouring matters, nor of fuchsin or *rosaniline.*

The Detection of Artificial Colouring Matters in Wine.[1]—Let a piece of caustic potash be dissolved in the liquid. If it is a natural wine, it assumes a greenish shade of colour, and is without deposit ; the formation of a deposit indicates the presence of artificial colouring. If the deposit is violet, the colour is due to elderberries or mulberries. A red deposit indicates the presence of brazil-wood or beetroot ; a red-violet deposit indicates log-wood ; blue-violet indicates privet-berries ; and a pale violet indicates litmus. Fuchsin may be detected thus :[2] " Add a little acetate of lead and amylic alcohol to the wine ; shake it briskly, and allow it to stand. The amylic alcohol will soon separate, and be coloured red if fuchsin is present ; if it is not so coloured, fuchsin is absent."

Plastering of Wines.—Many wines are " plastered " with gypsum, or " plaster of Paris " (*calcium sulphate*), by sprinkling the fruit with about 2½ pounds of this substance per ton at the time it is " trodden," pressed, or put into the vat. The wines most frequently plastered are those of Spain, Italy, and the South of France. There is a natural prejudice against the practice, but there is very little trustworthy evidence of baneful effects. The practice is of great antiquity, having prevailed from time immemorial, and is mentioned by Pliny. The advantages claimed for it are—It facilitates vinification by causing a more rapid and complete fermentation ; it hastens clarification by causing a deposition of albuminous and gummy matters ; produces a deeper colour (fiery red) ; the wine is more stable and durable. It is also claimed that it is a preservative against the *Bacillus viscosus,* which causes ropy degeneration and affects the wines of southern climates more than those of northern regions ; indeed, it is the general opinion that sherry could not be produced without it. The calcium sulphate decomposes the potassium bitartrate of the grape-juice, and produces insoluble calcium bitartrate, potassium sulphate, and tartaric acid—thus :

$$2KHC_4H_4O_6 + CaSO_4 = K_2SO_4 + CaC_4H_4O_6 + H_2C_4H_4O_6$$

Potassium bitartrate.	Calcium sulphate.	Potassium sulphate.	Calcium bitartrate.	Tartaric acid.

The tartrate of lime is thrown out of solution, and carries down with it the albuminous, gummy, and other suspended organic matters. Phosphates are included in the precipitate. The *free* tartaric acid deepens the red colour of the wine, increases the organic acidity, and aids in the production of ethers during maturation. The chemists, however, are not all agreed as to the reaction which takes place between the potassium bitartrate and calcium sulphate ; some hold that *acid* potassium sulphate, others that only *neutral*

[1] *Year-Book of Pharmacy,* 1878, 378. [2] *Ibid.,* 140.

potassium sulphate, is produced in wines of normal maturity.[1] L. Magnier de la Source[2] fermented two exactly equal and homologous portions of the juice of the same kind of grape. One was fermented without, and the other with, the addition of 100 grammes of calcium sulphate. The results showed that the alcohol and glucose in the two wines was approximately identical; the *total solids* were increased by plastering, but the cream of tartar was entirely removed; the *total acidity* was also increased, especially the sulphuric acid; the total solids were increased from 23·3 to 27·3 grammes per 1,000. Not only was the potassium bitartrate decomposed, but the neutral organic compounds of potash, which exist in ripe grapes in a very notable proportion, were also decomposed by plastering.

In consequence of "plastering" there is introduced into the wine 0·3 gramme of calcium sulphate and 1·2 grammes of potassium sulphate. The potassium salts, particularly acid potassium sulphate, have been credited with causing distinctly injurious effects in the human organism, not the least important of which is cirrhosis of the liver. This opinion received the support of Lancereaux, who many years ago published an account of experiments which he considered proved it. But his opinion was not generally accepted. The subject was reconsidered by Roos and Vires,[3] who state that the facts will not bear the interpretation put on them by Lanceraux—viz., that cirrhosis of the liver is caused by potassium salts, particularly acid potassium sulphate, in the wine. On the other hand, they affirm that it is not the *acid* sulphate, but *normal* sulphate of potassium, which is produced by plastering, and that atrophic cirrhosis of the liver is due to alcohol. It is true that the potassium sulphate will have a laxative effect upon those who drink plastered wines freely, but no serious injury can be attributed to that. It has, in fact, been asserted that Spanish workmen employed in the wine-cellars consume as much as 6 litres (10½ pints) of sherry per diem without its producing any effects which could be attributed to these salts.

Deplastering of Wines.—It is possible to deplaster the wines by using salts of strontium, but it is very questionable if such wines are salutary. A commission was named by the Academy of Sciences of Paris to inquire into the matter. The conclusion arrived at[4] was that they could not approve of the deplastering of wines by strontium, but, on the other hand, they condemned the practice.

The Place of Wine in the Diet.—Wine is drunk by many people to satisfy the natural demands of the organism for water. In France, for instance, where wine is obtainable at a cheap rate, it is to the peasant what beer is to the English labourer. But the property of satisfying thirst, whether regarded as an essential

[1] Roos and Vires, *Revue d'Hygiène*, 1907, 662.
[2] *Compt. Rend.*, 1884, xcviii., January 14.
[3] *Revue d'Hygiène*, 1907, 662.
[4] *Compt. Rend.*, January 5, 1892.

property of wine or not, could as easily be replaced by water or any other simple beverage. As a source of nutriment wine is far inferior to milk, being dependent upon the content of alcohol and sugar. Reckoning the alcohol as yielding 7 calories per gramme and the sugar 4 calories per gramme, wine will yield from 15 to 45 calories per ounce, according to the proportion of alcohol and sugar ; an average good quality of natural wine will not yield more than 20 calories per ounce ; but an ounce of *dry* sherry, containing about 21 per cent. of alcohol, will yield 40 calories, and an ounce of port, containing 25 per cent. of alcohol, will yield 48 calories. Milk yields 20 to 25 calories per ounce, but the essential food constituents—protein, fat, and carbohydrate—are there, whereas in most wines they are conspicuous by their absence. Good natural wines, sound and unsophisticated, are, however, among the best stimulants to mental activity ; at the same time they form a combination of various principles which invigorate the body and arouse the nutritive and blood-making functions. They are classed with what Sir W. Roberts termed " brain foods," including tea, coffee, tobacco to some extent, and spirits, which Roberts considered " must be regarded as an important part of the equipment in the struggle for that higher and better existence among civilized men, which is almost exclusively a brain struggle." Wine has a specific gravity approximating to that of water, a favourable circumstance, in consequence of which it is very slowly absorbed, and is thereby rendered less dangerous as a beverage than diluted spirits. Wine undergoes no change in the stomach other than dilution with gastric juice, no digestive effort is required, and it is absorbed by osmosis. The aroma and bouquet stimulate taste and appetite, and, after ingestion, the aromatic substances favourably influence nutrition by stimulating the glands of the abdomen and the manufacture of blood cells. The tannin and colouring matters have an action upon the gastric functions which is regarded as *stomachic,* and are believed to give tone to the stomach and muscular system in general. Those wines which contain more tannin are of greater value therapeutically as tonic and restorative wines than others in which this substance is deficient. The recognition of this fact has led to the introduction of medicinal wines containing the astringent principles of calisaya and cinchona barks ; but natural wines, which are pleasanter, are probably of equal value, in proportion to the tannin they contain, to restore the strength of patients weakened by age or disease, and to revive the energy of the digestive apparatus. The small proportion of iron in some wines renders them a valuable adjunct to the diet of those who are unable to digest green vegetables or other iron-bearing foods. It also renders this kind of wine of restorative effect in anæmia, chlorosis, general debility, and other diseases in which iron is of therapeutic value.

A generous wine, therefore, is well adapted to the digestive apparatus, and is of value in convalescence from acute illness, in general debility, atony of the digestive organs, and especially for

the inhabitants of cold, damp regions of the earth, and other parts in bad seasons. These effects are not to be attributed to the alcohol alone. Undoubtedly the alcohol contributes very largely to the effects of the wine, but the special combination of ethers, alcohol, aldehydes, acids, tannin, etc., is believed to give to wine as a daily beverage a superiority over spirits such as whisky, brandy, or rum. "Daily observation shows," says Bouchardat, "that, with the same proportion of alcohol, wine rich in tannin and astringent principles excites the brain less than alcoholic wines or spirits." Again, "Not only do the two flavours, acid and alcoholic, combine agreeably in the wine, but taken together the acid moderates the destructive energy of alcohol in the economy, and thereby diminishes its excessive action on the nervous system." Therefore, wine invigorates and enlivens to a degree which is proportionate to the alcohol and ethers; it invigorates by these principles and other aromatic bodies, and it is stomachic by reason of its astringent properties.

This is not the place to discuss the propriety of a regular daily use of wine, or whether work is better done with or without it. To open the question would lead to a discussion which could not be terminated in a few lines or paragraphs; the pros and cons are numerous. Suffice it to say that there is a large class of men, leaders of science, who agree that work of all kinds is much better done without any alcohol; others, equally well able to lead us in their special departments, agree that the daily consumption of a small amount of alcohol in the form of wine, beer, or spirits, is far from injurious, that it stimulates mental and bodily activity, and therefore encourages and improves the working capacity. But regarding the *abuse* of alcohol there is no difference of opinion. The abuse of wine leads to the same evils as the abuse of other forms of alcohol. Some wines, especially port, and sometimes claret, provoke an attack of gout, and, like all other forms of alcohol, may be the means of causing gastric, hepatic, renal, vascular, and nervous diseases.

There is a *fashion in wine*, as in other things. In England from the twelfth to the seventeenth century the wines of France were in the ascendant; after that period port wine asserted itself, and for a long time held sway, whilst the French wines became of only secondary importance. Later on French wines recovered their ascendancy, in turn giving way to Spanish wines, especially sherry, which again has sunk into comparative insignificance; while the lighter French wines—for example, champagne—have recovered their former position. These fluctuations have probably been influenced by political tendencies as much as by variations in the tastes of connoisseurs. The following wines were those recommended by a celebrated chef as being the most suitable to accompany the various courses of a dinner:

1. *Oysters before Dinner:* Chablis or Sauterne.
2. *Soup:* Old Madeira or Sherry (*Amontillado*).
3. *Fish:* Hock, Sauterne, Château Grillé, Barsac, Amontillado, Montrachet, Mersault.
4. *Entrées and Joints:* Sherry, Haut Brion, Lafite, Latour, Médoc, Margaux, Maçon, St. Julien, Bucellas, Champagne.
5. *Dessert:* Port, Madeira, Malaga, Muscat, Tokay, Vin de Paille, Contance, etc.; Liqueurs.

Classification and Characters of Wine.

Class A.—These consist of wine made from must which has been concentrated to such a degree that a complete decomposition of the sugar into alcohol and CO_2 cannot take place by means of yeast. Such wines contain very little acid, but a high proportion of extract, including sugar ; usually 14 or 15 per cent., and not more than 16 per cent., of alcohol. They are called "Ausbruch" wines in Germany ; there is no English equivalent for the name.

Class B : Liqueur Wines.—In this class the complete decomposition of sugar in the must is *prevented* by the addition of alcohol. They usually contain brandy, and the alcohol amounts to 18 or 25 per cent., but there is less extractive matter than in Class A. They include port, sherry, malaga, madeira, marsala, Hermitage, Arbois, etc.

Class C : Bouquet Wines.—The normal fermentation is allowed to go on unchecked ; they are therefore deficient in sugar, but have an acidulous flavour. They contain from 10 to 15 per cent. of alcohol ; their chief value depends upon the development of ethers and aldehydes, which give flavour and aroma. The class includes the finest Burgundy, Bordeaux, and Rhine wines — *e.g.*, Clos Vougeot, Montrachet, Lafite, Latour, Léoville, Château Margaux, Haut Brion, Larose, Volnay, Richebourg, Sauterne, Hermitage, Côtes du Rhône, Langlade, etc.

Class D : Heavy Table Wines.—Wines which are more or less dry—that is, without sweetness—but having little acidity, a full flavour, and 10 to 20 per cent. of alcohol. They are wines of Burgundy, Bordeaux, Austria and Hungary—*e.g.*, Beaune, Pommard, Volnay, Chablis, Montrachet, St. Julien, Sauterne, also red and white Hungarian, Californian, Australian wines, and some champagnes.

Class E : Light Table Wines.—Wines which have little acidity and are not very alcoholic ; they contain from 7 to 15 per cent. of alcohol—*e.g.*, Romanée, Chambertin, Maçon, Mersault ; Clos d'Estournel—Duhat Milon—Châteaux Loudenne, Quinsac, and Barsac ; Hock, Moselle, and some champagnes ; Chianti, Falerno, etc.

Class F : Labourers' Wines.—These contain little alcohol and extractives, but often much acid. Common Burgundy and Bordeaux wines may be included in the class.

Class G : Sparkling Wines form a special class merely by reason of their containing carbonic acid gas in solution, which produces a sparkle and effervescence when poured into a glass. It includes champagne, saumur, sparkling sillery, moselle, and hock. Some are bouquet wines ; others are light or heavy table wines.

Claret.

Most of the claret consumed in England and America consists of Bordelais wines—*i.e.*, wines from the Bordeaux district. The finest examples of Bordeaux wine are equal to anything France

can produce. The grapes chiefly cultivated for this wine are Franc Carbenet, Malbec, Merlot, and Carbenet Sauvignon. The original or primary fermentation is carried to completion ; the wine contains little alcohol, but keeps well, is not liable to degenerate, does not become very acid, and, instead of being damaged by transportation, appears to be improved by it. Bordeaux wines are among the most perfect, and are the very safest which can be recommended for daily use. They contain somewhat less alcohol than Burgundy wines and do not easily induce intoxication. Being astringent, they are also stomachic, and are especially suitable for the inhabitants of northern climates, by stimulating the digestive functions and producing harmony in the organs of nutrition. They have been accused of producing gout, but this appears to be without actual foundation. It is, however, a fact that people who drink largely of port, sherry, madeira, and other fiery wines, may be afflicted by an attack of gout after an occasional debauch with claret, because a transition from one to the other may be followed by derangement of the digestive organs.

Bordeaux wines are divided into four large groups—viz., Fine growths, Bourgeois, Artisan, and Paysan wines. The *first group* only forms the " Classed wines " and " Château wines," and it is subdivided into five qualities or growths of wine, which, according to " The Practical Grocer," are as follows, the name of the commune being bracketed with them :

CLASSIFIED WINES OF THE BORDEAUX DISTRICT.

First Growth or Quality.

Châteaux : Lafite (Pauillac).
Latour (Pauillac).

Châteaux: Margaux (Margaux).
Haut Brion (Pessac).

Second Growth or Quality.

Châteaux : Mouton Rothschild (Pauillac).
Pichon-Langueville-Lalande (Pauillac).
Rauzan-Segla (Margaux).
Rauzan-Glassies (Margaux).
Dufort-Vivens (Margaux).
Lascombes (Margaux)
Brane-Cantenac (Cantenac).
Léoville-Lacassus (St. Julien).

Châteaux: Léoville-Barton (St. Julien).
Grand-Larose-Bethmann (St. Julien).
Grand-Larose-Sarget (St. Julien).
Ducru-Beau Caillon (St. Julien).
Clos d'Estournel (St. Estèphe).
Montrose (St. Estèphe).

Third Growth or Quality.

Châteaux : Malescot (Margaux).
Becker (Margaux).
Ferrière (Margaux).
Desmirail (Margaux).
Kirwan (Cantenac).
D'Issan (Cantenac).
Palmer (Cantenac).

Châteaux: Brown Cantenac (Cantenac).
Giscours (Labarde).
Lagrange (St. Julien).
Langoa (St. Julien).
La Lagune (Ludon).
Calon-Ségur (St. Estèphe).

Fourth Growth or Quality.

Châteaux : St. Pierre (St. Julien).
Talbot (St. Julien).
Beycheville (St. Julien).
Branaire-Duluc (St. Julien).
Duhart-Milon (Pauillac).

Châteaux : Poujet (Cantenac).
La Tour Carnet (St. Laurent).
Rochet (St. Estèphe).
Le Prieuré (Cantenac).
Marquis de Therme (Margaux).

Fifth Growth or Quality.

Châteaux : Batailley.
Clerc-Millon.
Croizet-Bages.
Ducasse-Grand-Puy.
Grande-Puy-Lacoste.
Haut-Bages.
Lynch-Bages.
Lynch-Moussas.

Châteaux : Mouton-d'Armailhaq.
Pedeoclaux.
Pontet-Cantet (Pauillac).
Belgrave Camensac (St. Laurent).
Dauzac (Labarde).
Cos Labory (St. Estèphe).
Le Tertre (Arsac).
Cantemerle (Macau).

The principal vineyards of Bordeaux are in the Médoc, Graves Pallus, and Vignes Blanches ; those of St. Émilion, Entre Deux Mers, and the Bourgeois, are the next in importance. The famous Lafite, Latour, and Château Margaux wines are the produce of the first growth of the Médoc. Lafite is characterized by a silky softness on the palate, and a bouquet of violets and raspberries. Latour is fuller, has more aroma, but less softness. Château Margeaux is lighter than Latour, delicate like Lafite, but has not such a fine aroma. Léoville and Rauzan are very good wines produced from the second growth of the Médoc ; Léoville has palate-fulness, softness, and an excellent bouquet. The " first growth " of Graves produces very excellent wines, of which Haut Brion rivals the finest wines of the first growth of the Médoc.

The wines of the Pallus district are stronger than those of the Médoc ; they are hard and rough to the taste, but they are improved by transportation and storage, by which means they become light and delicate and develop an aroma resembling that of the raspberry.

It is a fact that the finest wines are never exported ; they are far too valuable to be disposed of. They are only produced in a small quantity, and cannot always be procured in the district where they are grown. These wines, however, have a commercial value which is of importance to the vintner. They are used—or such proportion as the makers are disposed to sell—to mingle with the more abundant wines of the second growth, to which they communicate the much-desired flavour and aroma. Therefore the wines usually exported as of " the highest quality " consist of the product of the second growth of the Médoc combined with more or less of the rougher and more astringent Pauillac. Some very good wines of a lower class are produced in the St. Julien, St. Estèphe, Cadaujac, Cantenac, and other districts.

The **white wines** of Bordeaux are some of them very fine flavoured, especially the St. Bris, the Carbonnieux of Graves, and the Sauternes —Barsac and Yquem. These wines are made from grapes which

are allowed to remain on the vine until they are almost dry, like raisins, in order to produce the greatest amount of saccharine material. They are therefore very sweet wines as a rule. The finest of all white wines is Yquem.

Burgundy.

Burgundy wines are produced in Upper and Lower Burgundy, where great skill is applied to the cultivation of the vine and fermentation of its juice. They are red and white wines, and are classified as follows :

I. Red Wines.

Class I.

Romanée-Conti.	Clos de Vougeot.
Chambertin.	Richbourg la Tache.

Class II.

Musigny.	Le Corton.
Romanée-St. Vincent.	Les Bonnes Mares.
Le Clos St. Georges (*Nuits*).	Le Clos du Tart.

Class III.

Arvelets.	Perrets.
Rugiens.	Pruliers.
Beaumont.	Thaurey.
Cailles.	Vaucrains.
Oras-Murge.	Clos Margeot.
Boudots.	Etc.

Unclassified.

Macon.	Volnay.
Beaujolais.	Beaune.
Pommard.	

II. White Wines.

Class I.

Montrachet.	Mersault.

Class II.

Chevalier Montrachet.	Genevrières.
Batard Montrachet.	Goutte d'Or.
Combettes.	Charlemagne.

Unclassified.

Chablis (still wine).	Sparkling Médoc.
Château Poncié (sparkling).	

The red wines are the most numerous and abundant. Continuous sunshine is required for the flowering of the vine and to produce good burgundy. As a class they are rich in flavour and aroma, and possess the delicate properties of the fruit. They are spirituous, aromatic, and more heating than some wines which contain more alcohol. Nevertheless, they produce an exhilaration and liveliness which is said to be more innocent than that resulting from the consumption of many other wines and alcoholic beverages. Authorities assert that the finest Burgundy wines are inferior to

none in the world ; *but they do not bear transportation except in bottle*, and, being produced in small quantity only, are rarely seen in foreign countries—at any rate, in a pure condition. The best wines are those of the first and second class, which are distinguished for their beautiful colour, exquisite flavour and aroma ; they combine lightness and delicacy with richness and fulness of body. The wines which are unclassified do not agree in *character* with those of either the first or second class—that is to say, they are deficient in bouquet and aroma. In other respects they rank as second-class wines, and are distinguished by purity of flavour, lightness, and delicacy. Good Beaune is soft and mature ; Volnay is also soft and well flavoured ; Pommard is light, but has rather more body ; good Maçon is a sound light wine. The wines of the third class are more or less inferior, and are exported in casks from January to May. Many of these are full-flavoured and admirable beverages, but they will only keep a few years, and may acquire a bitter taste. On the other hand, some of the finest wines are above twenty years old, and have developed a fine bouquet and aroma by maturation.

White burgundy is less abundant than red, but is not inferior in aroma and flavour. Montrachet is equal to the best red wines, and is distinguished by an agreeable nutty flavour ; Mersault is also fine and rich, soft, but of good body. Chablis is an excellent second-class wine, soft, light, and of nice bouquet, and there are others equally good in quality.

Sauterne.

Sauterne is the principal white wine of France, and is chiefly produced in South Bordeaux, in the communes of Sauternes, Barsac, Graves, Bommes, Fargues, and Preignac. The wine is made in October from grapes which are fully ripe and almost dry like raisins Three qualities of must are recognized : *tête, milieu*, and *queue*. The first produces a *sweet*, luscious wine, " vin de tête," chiefly exported to Russia ; the second produces " vin de milieu," or wines of the sauterne quality ; the third produces " vin de queue," a *dry* white wine. They are classified as follows, the communal name being in brackets :

CLASS A.—Chateau Yquem (Sauternes).

CLASS B.—*First Growth.*

Châteaux : Latour Blanche (Bommes).
Peyraquey (Bommes).
Robint (Bommes).
Vigneau (Bommes).

Châteaux : Bayle (Sauternes).
Climens (Barsac).
Coutet (Barsac).
Suduirant (Preignac).

Second Growth.

Châteaux : Myrat (Barsac).
Doisy (Barsac).
D'Arche (Sauternes).
Filhot (Sauternes).
Lamothe (Sauternes).

Châteaux : Malle (Preignac).
Romer (Preignac).
Bronstat-Nersac (Barsac).
Caillon and Suan.
Peyxotto (Bommes).

Chablis.

Chablis is the white wine of the Burgundy district, prepared in the ordinary way. It is an excellent second-class wine, having a nice flavour and aroma. The varieties are full-bodied (sweet), medium dry, and dry.

Hermitage Wines.

These are red and white wines produced along the Lower Rhone, and are named after a small hill near Tain, in the department of Drôme. They belong to the kind known as "straw wines," being of moderately full flavour, excellent aroma, delicate character, and light—*i.e.*, not very alcoholic. The group includes Hermitage, Macon, and Beaujolais.

Sherry Wines.

Sherry is so called from Xeres, or Jeres, the chief centre for the production and commerce of sherry in Spain. Both red and white grapes are used, and they are carefully ripened and sorted before making the must, some partially sun-dried grapes being added to them. The primary fermentation is allowed to continue until the end of the year in which the wine is made, when the new wine is drawn off from the deposit or lees, and is racked or bottled. It is customary to *plaster* the grapes with about 2½ pounds of gypsum to each ton before they are trodden ; the reasons for this custom are explained elsewhere. The light sherry consumed in the country of its origin is not very alcoholic, and is drunk as freely as beer by the employés in the wine-cellars. When first made the wine is raw and harsh, but is toned down and mellowed by storing it in cellars for a few years, during which time a complementary fermentation and maturation occur. The *natural* wine, however, is deficient in keeping properties, so that it is customary to add Spanish brandy or grain spirit, when the fermentation is complete, to fortify and preserve it. The wine is *dry*, *medium dry*, or *sweet*, according to the amount of sugar it contains ; this varies from 0·5 to 4·0 per cent., being more abundant in wines made from grapes which have been partly dried on the vines, or when made of must which has been concentrated by heat. In the latter case a little sugar is transformed to caramel and deepens the colour. With medium dry wines a small quantity of sugar is frequently added, at the same time as the brandy or liqueur, and to some other wines crushed bitter almonds are added to give flavour. All sherries consumed in England are fortified, so that they contain from 18 to 22 per cent. of alcohol. The acidity of sherry is lower than that of hock or claret. The proportion of volatile ethers increases during maturation, and *old* sherry probably contains more ethers than any other alcoholic beverage, except the finest brandy. The existence of these ethers enhances the therapeutic value of sherry, for which reason the older the wine the more stimulating and restoring will be the effects.

COMPOSITION OF SHERRY—PERCENTAGES.[1]

	Amontillado.	Medium.	Oleroso.
Solids, total	2·200	2·870	5·45
Sugar	·215	·650	1·03
Potassium bitartrate ..	·080	·130	·25
Tartaric acid	·340	·410	·52
Acetic acid	·120	·100	·20
Ash	·550	·700	·86
Sulphate of potash ..	·520	·650	·76
Alcohol by weight ..	14·820	15·670	18·85
,, by volume ..	18·250	19·280	23·10
Total ethers	·060	·075	·21

There are three grades of sherry: (*a*) "Fino," including the light pale-coloured wines of Amontillado, Manzanilla, and Montilla. They have a fine, delicate bouquet and contain *little sugar*, and are usually called *dry* wines. Amontillado is of a deeper colour and stronger in alcohol; Manzanilla is a lighter and dryer wine, and is not usually fortified before exportation; Montilla is also a light wine, of pale colour and little fortified. (*b*) "Oleroso" is darker than the former, has more body, and contains more sugar and alcohol. The Solera wines of Andalusia have a high value among the stronger wines. (*c*) "Palo Cortado" is a medium type of wine, intermediate between the two former.

Port Wine.

Port wine is the produce of fruit grown chiefly in the valley of the Douro, Portugal, and North-East Spain, and shipped from Oporto, whence its name. The grapes are gathered in September, removed from the stalks, and pressed by treading them for two or three days in a stone tank, the final pressure being made by a screw press. The must is then run into vats and left to ferment. Enough alcohol, distilled from a previous fermentation, is added to check alcoholic and prevent acetous fermentation. When the lees have settled the wine is drawn off, more alcohol is added, and it is then allowed to remain undisturbed until the following spring, when it is sent to Oporto to be stored in cellars for three years in a temperature of 58° F., free from chills and draughts.

Port wines vary in colour from pale red or tawny to dark purple. They are "fruity and full-bodied" or "dry" in character, the former containing more sugar and extract than the latter. They are "fortified" with alcohol to prevent the complete fermentation of sugar. The full-coloured vintage ports have in recent years given place to light, tawny-coloured wines matured in casks. During the process of maturation they lose colour, extract, and a certain amount of alcohol; they become light, agreeably aromatic,

[1] Report of Commission on Sherry, *The Lancet*, October 29, 1898.

and develop bouquet by the production of ethers, acids, and aldehydes. Wines matured in casks have a delicacy of tone and flavour ; but the development of bouquet is believed to take place more rapidly in bottle than in wood, hence the best port is usually that which has been long in bottle and thrown down a crust. Within reasonable limits, the longer the wine has been in bottle, the more it is improved in flavour and delicacy. The crust, or " beeswing," which deposits in bottle on long keeping, consists of the colouring matter and the last remains of cream of tartar.

It is considered that very little pure and unsophisticated port comes to the British Islands. The grape-juice or must, even for good qualities of wine, is mixed with juice of elderberries, molasses, silent spirit, and other ingredients, to give aroma and flavour and increase the tawny colour. After fermentation the wines are " blended " and fortified to increase the alcohol and throw the tartar out of solution, so that a deposit is formed, and " crusted port " is sooner produced. Blended wines mature much earlier than unblended wines. *Young* port is very astringent, rough, and " heavy," owing to its containing a large amount of tannin ; a considerable proportion of the latter is oxidized during maturation, and deposited with the " tartar " and extractives. Mature wine has a rich delicate flavour, and possesses characters and properties due to the climate and soil. It contains from 16 to 25 per cent. of alcohol, and a large proportion of extract, which gives fulness of " body." Average port is sweeter than average sherry, the fermentation being checked before it is complete by the addition of alcohol. The acidity of port is not so great as that of claret or hock, because the greater proportion of " tartar " is thrown out of solution by the addition of alcohol, and the acidity due to volatile acids, reckoned as " acetic," is relatively greater than that due to fixed acids or tartaric acid. The older the wine, as a rule, the less " gouty " it is. Increasing age produces a lightness due to the transformation of alcohol into acids and ethers ; the ethers give flavour and aroma, and the *fixed* predominate over the *volatile* ethers.

Tarragona Port Wine is from the district of that name in Spain. When genuine it is a good wine, full-bodied, of moderate strength and value.

Roussillon Port is produced in France, and possesses some of the characteristics of claret. **Cape Port** is a wine from the Cape of Good Hope. **Canary Port**, or Teneriffe wine, is the product of the Canary Islands.

Rhine Wines : Hock, Moselle.

Hock is a light wine chiefly produced about Maine in the Rhine Valley, although Niersteiner and Liebfraumilch are made in Hesse, and Bucellas hock in Portugal. In all cases the wine is made from the juice of the Riesling grape, is usually of fine quality, has an excellent flavour and good bouquet. It is classed among light wines, the proportion of alcohol being 8 to 10 per cent. It is a *dry* wine, contains hardly any sugar, and has an acid taste, although

the total acidity is only about 0·5 per cent. and it contains no acetic acid. The varieties are as follows :

A.—Still Hock.

Hattenheimer.	Niersteiner.
Hochheimer.	Rauenthaler.
Laubenheimer.	Rüdesheimer.
Liebfraumilch.	Steinwein.
Marcobrunner.	Steinberger.

B.—Sparkling Hock.

Johannisberger.	Liebfraumilch.
Kaiser Blume.	Müllers.

Hockheimer, Steinberger, and Johannisberger, are excellent wines.

Moselle wines are produced in the Moselle district of Germany. They are usually good light wines, natural, and unfortified, of somewhat acid taste, but delicate and agreeable in flavour. They are favourites with a large number of people, and are much used as a table wine in Germany. Some of the chief varieties are as follows :

Brauneberger.	Schwarzberger.
Berncastler.	Stephansberger.
Berncastler Doctor.	Zettinger.
Casel.	

There are "still" and "sparkling" varieties. When dry and well matured they are excellent, and equal to some of the finest wines of France. The sparkling moselle of Koblenz is famed for its peculiar bouquet and muscatel flavour ; this flavour, however, is sometimes derived from an alcoholic extract of elder-flowers, instead of the muscatel grape. Some of the Californian wines are of the moselle type. Moselle wine has from 7 to 10 per cent. of alcohol, average 9·5 ; 2 per cent. of extractives ; 0·25 per cent. of sugar ; total acidity, 0·740, due to volatile acids 0·070, to fixed or tartaric acid 0·670, per cent.

Hungarian Wines.

Hungarian wines are red and white ; the red includes Auslese, Erlau, and Karlowitz ; white includes Tokay, Somlau, and Neszmely wines. Karlowitz is the most important, and is of the port-wine type ; others are of the burgundy type. They rank with claret and burgundy, having about the same amount of alcohol, but, being nearly free from sugar, have a somewhat acid taste. They are moderately astringent, but are good table beverages.

Tokay is rich and highly prized, being distinguished by a sweet taste and aromatic flavour, and the proportion of phosphoric acid in it, which is greater than in any other wine. It is produced from white grapes grown on the hillsides in Upper Hungary, never more than 700 feet above sea-level. The grapes are allowed to become dry or nearly dry before they are gathered. It has a low alcoholic strength, matures in three years, and improves by long keeping.

Two classes are sold—"Imperial" and "dry" tokay. Other Hungarian wines are good, but do not come up to the standard of perfection looked for in tokay. Some inferior white wines are sold as tokay, and imitations have been made in France and Germany.

Italian Wines.

The light wines of the Chianti type, produced in Tuscany and other parts of Northern Italy, are of extreme lightness and delicacy; others are of the Bordeaux type; they rival the red wines of France, but do not bear transportation well, and therefore do not compete very much with them. The white wines of Falerno and Capri are exhilarating beverages, and combine a delicate flavour with extreme lightness.

Composition of Italian Wines—Percentages.[1]

	Chianti (Red).	Barolo (Red).	Vatellina (Red).	Capri (White).	Falerno (White).	Egidio-Vitali (Sparkling White).
Alcohol by weight ..	9·36	10·85	9·36	11·62	8·64	10·08
,, by volume ..	11·61	13·43	11·61	14·37	10·73	12·49
Tartaric acid	·60	·45	·41	·52	·66	·79
Acetic acid	·18	·25	·29	·31	·13	·26
Sugar	·17	·18	·13	·76	·11	3·67

Other "Rosso" (red) wines are Sassela, Vesuvio, Vino del Paese, and "Bianco" (white) wines are Asti, Vermouth, Lachryma Christi, and Vino del Paese.

Sicilian Wines.

Marsala is a wine of the sherry type, produced in the district of Marsala in Sicily. It is prepared to some extent from the juice of the *red* grape, and contains more tannin than any other wines of the sherry class. It has less acidity, but greater sweetness and a lower proportion of volatile ethers, than sherry. It contains 16 to 18 per cent. of alcohol, 5 per cent. of extractives, including 3·5 per cent. of sugar, and 0·326 per cent. acidity.

Greek Wines.

They have alcohol varying from 8 to 14 per cent. by weight, are rich in volatile acids and aldehydes, and are plastered.

Malmsey, or malvoisie, is the chief wine of this class. It is a sweet, luscious, rich wine, formerly produced in abundance at Malvasia in the Morea, Candia in Crete, and other Greek islands; also in the Canaries, Madeira, and the Azores. It is a strong white wine of fine aroma and sweet taste, made from grapes which have been nearly dried on the vine. It contains about 19 per cent. of alcohol and 3 per cent. of sugar.

[1] *The Lancet*, January 28, 1899.

Madeira and Canary Wines.

These wines are made in the Madeira and Canary Isles. They belong for the most part to the sherry class. **Bual** is a rich, delicate wine made from the round straw-coloured grape. **Malmsey,** made also in the Greek islands, is derived from a large oval grape of a rich golden colour when ripe. It is one of the most valued wines of these islands. Canary **Sack** resembles sherry ; Canary **Port** resembles port ; **Tinta** is a dark-coloured wine similar to burgundy ; **Sercial** is a light-coloured dry wine.

Spanish Wines.

Next to port and sherry, the best-known Spanish wine is **Tarragona,** already mentioned, a red wine of the port class. **Rioja** wine is of the claret type, and is white or red. **Valdepeñas** are similar white and red wines. There is another class, called **Tent Wines,** which are much used for sacramental purposes ; they are rich, sweet, full-bodied, but light wines, such as **Rota**, **Malaga,** and Gallician wines.

Californian and Ohio Wines.

The red wines of America approximate to the types of claret and burgundy (Beaune and Pommard) ; the white wines are similar to chablis, sauterne, and hock. They are full-bodied wines, rather alcoholic (contain more alcohol than European wines of the same class), but never develop much bouquet.

Australian Wines.

Red wines are produced in Victoria, New South Wales, and South Australia ; they are of the burgundy class (like Beaune and Pommard) and ferruginous. The white wines approximate to the types of chablis, hock, muscat, tokay, and riesling. They are natural wines, superior to young French wines of the same types, but never equal to mature French wines in flavour and aroma.

Sparkling Wines : Champagne, etc.

Sparkling wines are those in which the fermentation is partly completed in the bottle ; carbonic acid gas is therefore dissolved in the liquid, and causes effervescence and sparkling when it is poured out. The class includes champagne, saumur, sillery, sparkling moselle and hock. Minor wines of this class are sparkling burgundy and claret. Each of these wines has the same characteristics as the " still " wine of the type to which it belongs, with the additional effervescence. The most important sparkling wines are the **Champagnes,** which are made chiefly in the departments of Marne and Haut-Marne, the former province of Champagne. The chief centres of the industry are Rheims, Chalons, Épernay, Aij, and Avize. They are divided into river wines, which are usually white, and mountain wines, which are for the most part red. They are

divided into—(*a*) "Natural," or *vin brut*—that is, without any added spirit or sugar, usually containing 9 to 12 per cent. of alcohol, about 2 per cent. of extract, and 0·5 to 0·6 per cent. acidity; it is often very "dry" (*très sec*), and may be somewhat harsh and acid. (*b*) "Sweet" wines are usually very effervescent and sparkling; they contain very little natural alcohol, the fermentation being checked so as to produce an extra amount of carbonic acid gas in the bottle; they are fortified by the addition of liqueur, from 2 to 5 per cent. being added for English markets, 14 or 15 per cent. for Russian, and an intermediate quantity for Germany and America. The amount of sugar varies from 3 to 10 or even 15 per cent. in very sweet wine; the CO_2 is equivalent to 5 volumes per cent., and it nearly all escapes when the cork is drawn. (*c*) "Dry" wines are those containing very little sugar, and they vary from dry (*sec*) to very dry (*très sec*). **Saumur** consists of the sparkling wines produced in the Saumur district of France, in the department of Maine-et-Loire. It is made in the same way as champagne, and is classed as Dry Royal, Brut Royal, and Cuvée spéciale. Of sparkling wines, the slightly sparkling (almost "still") or the "creaming" are more highly valued by connoisseurs than the sweet and highly effervescent kinds. *Vin brut*, being the natural wine, without additional sugar or alcohol, is a good dinner beverage, and when *dry* or nearly so (that is, free from sugar) it assists the appetite, stimulates the circulation, enlivens the mind, and promotes vivacity; it is not any more injurious to rheumatic or gouty people than any other kind of wine. On the other hand, highly effervescent, very sweet or acid wine is not so wholesome; it is this class of wine which is usually most highly fortified by brandy or liqueur.

Manufacture of Sparkling Wines.—The grapes, red, black, or white, are crushed, and the juice drawn off at once, except when coloured wines are desired, to prevent the extraction of colouring matter and tannin from the skins and stalks. The marc—that is, the crushed skins, etc.—is then put under a screw press to remove the remainder of the juice. This latter process is now done in many manufactories by the centrifugalizing machine. The must is fermented in vats for about fourteen days, after which it is racked, the sediment allowed to deposit, and the wine put into casks until the winter. It is then transferred to other casks, some "finings" being added at the same time, and a month is allowed for it to clarify. After this it is blended, some mature wine being put into the mixture, and the amount of sugar in it ascertained. The presence of a definite amount of sugar is necessary to insure the future sparkle. If, therefore, the amount is deficient, some syrup or sugar-candy is added. It is now bottled, and the bottles laid on their sides for a few weeks until the development of carbonic acid gas commences. The wine is then transferred to cellars, some of which are more than 100 feet deep, cut into the chalk, and admirably suited by their uniform temperature to assist in the

maturation of the wine. Here it remains three or four years, during which the same changes go on as in the maturation of other wines. A deposit forms, and, as it is desirable to prevent it adhering to the sides of the bottle, it is agitated now and then. After three years the bottles are placed obliquely, so that the deposit may fall upon and firmly adhere to the cork. Finally the cork is removed, and the deposit with it; the bottle is filled up with liqueur made of old champagne, brandy, and sugar, and it is freshly corked and wired. The secondary fermentation now continues, during which the flavour and aroma of the wine are developed, and the effervescence and sparkle are insured.

Home-Made Wines.

Wines are made on a small scale in many domestic establishments from grapes, raisins, or other fruits and vegetables. These wines are wholesome and very excellent in their way. The only certain distinction between grape and other fruit wines, according to Kuhlisch,[1] is that the latter contain neither tartaric acid nor its salts. Such wines have a fine colour and are brilliant, but do not develop the aroma and bouquet which characterize port, sherry, Bordeaux or Burgundy wines. They, however, are invigorating and enlivening in proportion to the alcohol which they contain; they also have the qualities and properties of the fruit or other substance from which they are made. Natural wines—that is, without additional alcohol—made from red or white currants contain about 13 per cent. of alcohol by weight, and 0·007 per cent. of phosphoric acid. In cider the alcohol ranges from 4·29 to 5·86 per cent., but the extractive and mineral substance ranges higher than in grape wines.[2] Some ciders and perries contain much unfermented sugar. The proportion of alcohol, by volume, in home-made wines is as follows: Raisin wine 18 to 25, currant 13 to 20, gooseberry 11·84, orange 11·3, elderberry 9·3, cider and perry 4·29 to 8·0, mead 7·23, per cent. Examples of their manufacture are as follows:

Raisin Wine.—Take 10 pounds of raisins, pick them from the stalks, chop them into pieces, pour over them a gallon of hot water, and macerate them for twelve hours; strain off the liquid. Pour upon the raisins another half-gallon of hot water, and after a few hours drain it off; express all moisture from the fruit and mingle the liquids together. Dissolve in the liquid a pound of sugar. Put it into a cask (without a bung), and let it ferment, taking care to keep the cask full. When the fermentation ceases, bung it up closely for three months; then pour it into another cask and close it tightly for three months longer. It should then be bottled, and will be in good condition in a year.

Red Currant Wine.—Express the juice from the fruit. To every gallon of juice add 2 gallons of water, the juice from a pound of raspberries, and 9 pounds of sugar. Stir until the sugar is dissolved.

[1] *Chem. Zeit.*, 1896. [2] *Ibid.*

Put it into a cask and allow it to ferment. When fermentation ceases, fix the bung tightly in the cask. After a year the wine is bottled, and develops a fine condition in three months.

Cherry Wine.—The fruit is bruised and allowed to stand twenty-four hours; the juice is then strained through a sieve, the fruit being pressed. In every gallon of juice 2 pounds of sugar is dissolved, and it is allowed to stand for twenty-four hours. It is then transferred to a cask and allowed to ferment. When fermentation ceases, the barrel is closed by a bung for six months, after which the wine is bottled and stored away to mature and develop condition.

Artificial Wine.

The following is an example of artificial wine manufactured for commercial purposes:[1] In a cask having a capacity of 114 litres put 8 to 10 kilogrammes of raisins, 10 to 14 kilogrammes of "glucose" mingled with some water, a little wine vinegar, and a litre of odorous mixture; fill up the cask with water at a proper temperature and ferment it. When the fermentation is complete, colour the wine with magenta. The "odorous" mixture consists of artificial essences mixed with tartaric acid and tannin. With regard to the artificial flavouring essences, Poincaré and Vallois[2] found that they invariably produced grave symptoms when administered to dogs, guinea-pigs, and other animals, in measurable doses; but no danger appeared to arise from their ingestion in the minute doses which would be taken in wines and other preparations.

Cider and Perry.

Cider is an alcoholic beverage made by the fermentation of the juice of apples. Perry is made in the same way from the juice of pears. The manufacture of cider in England began about 1284, when it was called "wine"; and in Normandy, where it takes the place of beer, somewhat earlier. It is probably a far more ancient beverage, but the name was originally applied to the fermented juice of any fruit. Cider is made from varieties of apples which ripen late in the autumn and are specially adapted for the purpose. The usual criterion of the suitability of the fruit, however, is the specific gravity of the must before fermentation. Good cider cannot be made from juice having a specific gravity lower than 1·040; must of this density yields a beverage containing 4·85 per cent. of alcohol and 2·688 per cent. of sugar. As the specific gravity rises, the strength and sweetness of the product rises, so that a juice having S.G. = 1·080 would yield cider containing 11 per cent. of alcohol and 7 per cent. of sugar. But there is something in the climate and soil where the fruit is grown. The strongest and most highly flavoured cider is derived from fruit grown upon a shallow calcareous loam over a subsoil of limestone. Most writers

[1] *Jour. de Pharm. et de Chimie*, vol. ix., February, 1884.
[2] *Ibid.*, vol. x., December 1, 1885.

agree that a calcareous earth should form a part of the soil of a cider orchard. The best cider-producing countries in England are Hereford, Somerset, and Devon. The produce of each variety of apple is usually kept separate, and in large manufactories bears a special name. As the fruit can only be used with advantage when it has attained full maturity and ripeness, good cider can only be produced by using such as are ripe at the same time. Several well-known blends are on the market, as a combination of Foxwhelp and Kingston Black, or Redstreak and White Norman apples. The Cherry, Broad-leaved, Cowarne Red, and others named in the section on Apples, are well-known cider apples.

Fruit which ripens in October is the best for the purpose. Care is taken that the apples are not bruised in gathering them, as moulds grow upon bruised fruit and communicate a *fusty* flavour to the juice. For a similar reason they are gathered on a cool, dry day ; the colder the weather, short of actual frost, the more perfect is the fruit, and the fermentation of the juice will be more quiet, gentle, and equable. The fruit is stored in shady, cool rooms, where the ripening continues, and they acquire a greater proportion of saccharine matter, a diminution of acids, and lose a considerable proportion of water.

Grinding and Fermentation.—The fruit is ground to a pulp or uniform mass between the rollers of a mill. The pulp is called the *pomace ;* it usually consists of the entire fruit, the skin and seeds being scarcely discoverable in the mass, but for certain kinds of cider the seeds are removed. The pomace is exposed to the air for a period varying from six to thirty hours, during which time it absorbs oxygen and loses water, the specific gravity of the must rising from 1·064 to 1·078. The pomace is then put into a hydraulic press, between hair cloths, and the expressed juice run into vats to clear. Very fine cider is made from must expressed as soon as the pomace is ground, the residue being exposed to the air for twenty-four hours, pressed again, and the two liquids mixed together. The *must*, as the liquid is now called, according to Allen,[1] has the following composition :

	Apple Must.	Pear Must.
	Per Cent.	Per Cent.
Total solids	19·70	21·95
Acidity (reckoned as H_2SO_4)	·21	·15
Sugar : Sucrose	2·50	3·67
Glucose	13·58	14·56
Tannin	·29	·18
Albumin and pectin	1·20	1·31

The must is now exposed in large vats in cool cellars, where it undergoes spontaneous fermentation at a temperature about 60° F. The fermentation proceeds somewhat rapidly, and is attended by

[1] *The Analyst*, 1902, 184.

much frothing. Dregs and scum are removed by racking and filtration. Catechu, or substances containing it, is used to precipitate albuminous and gummy matters. At the completion of fermentation the liquor is analyzed to estimate the proportion of sugar, acids, tannin, and alcohol. The ciders of different kinds of fruit or orchards are now blended, if it is desired to produce uniformity or special branded varieties. Undue acidity is neutralized by alkalies. Most makers add a pint of milk to every 9 gallons for "fining," and about 1 ounce of salicylic acid or an equivalent amount of boric acid to every 96 gallons as a preservative. The cider is now put in bottles or barrels and transferred to cool, dry, and airy cellars to undergo maturation.

The products of the fermentation are classified as "sweet," "dry," or "sparkling" cider or perry. When "sweet" cider is desired, the fermentation is checked before it is complete; sugar is sometimes added, and cider brandy or other spirit is also often added to fortify and preserve it. Experiments have been made to stop the fermentation by various means: thus, the wort has been submitted to a temperature of $-18°$ or $-20°$ C.; but Lechartier[1] found that, although this enfeebled the fermentation, it did not sterilize the must, or prevent further fermentation when it was again exposed to the ordinary temperature. But he did find,[2] by raising the temperature of the cider to 60° C., all fermentation is arrested, and the cider, if it contained only 2 per cent. of alcohol, will keep for twelve months without any perceptible change in the proportion of sugar or alcohol. "Dry" cider is that which results from the complete fermentation of the sugar, and, as the sugar averages 16 per cent. in the must, the amount of alcohol cannot exceed 8 per cent. when all the sugar is transformed, and usually varies from 4 to 7 per cent. "Sparkling" or champagne cider is bottled before the completion of the fermentation, which continues in the bottle, as in champagne. When, therefore, the ordinary vinous fermentation goes on to completion, there is produced a "still" dry cider; not so heating as hock, and less acid than moselle. When the fermentation is stopped before completion, the cider contains 3 or 4 per cent. of sugar, and less acidity than in dry cider. When "champagne" methods are adopted, the result is a sparkling and exhilarating beverage, which is made in dry, medium, and fruity varieties.

The original solids in must, according to Allen, average 12·39 per cent., and the sugar 12 per cent. The maximum amount of sugar in apple must is 16 per cent., and when the fermentation is complete about 8 per cent. of alcohol will be produced; but the must of French apples contains only about 12 per cent., and therefore "dry" French cider has only 5·5 or 6 per cent. of alcohol. It may be stated broadly that cider is of about the same alcoholic strength as beer; bottled cider usually contains less alcohol than draught beer. The sugar varies from 0·2 to 0·6 per cent. in "dry" cider,

[1] *Compt. Rend.*, October 24, 1887. [2] *Ibid.*, October 17, 1887.

and is usually 3 or 4 per cent. in sweet or sparkling cider. The *ash* of cider varies from 0·17 to 0·49 per cent. According to Lechartier,[1] from 80 to 90 per cent. is *soluble*, and consists almost wholly of salts of potash ; soda exists only in traces, and lime is absent ; the predominant acids are carbonic and phosphoric ; the *insoluble* ash consists of lime, magnesia, silica, alumina, and ferric oxide.

THE COMPOSITION OF CIDER.—PERCENTAGES.

Variety and Authority.	Alcohol by Volume.	Extract.	Ash.	Acidity as H_2SO_4.	Sugar.	Alcohol after Complete Fermentation.
English ciders (Allen)[2]						
Minimum	3·18	1·71	·17	·27	·350	—
Maximum	8·00	4·50	·35	·71	5·000	8·0
Average	6·00	2·47	·27	·52	2·686	—
French ciders (Grignon)[3]						
Sweet sparkling ..	3·80	6·41	·29	·36	3·470	5·9
Sweet	4·10	6·40	·28	·39	3·750	6·3
Dry	5·40	3·03	·27	·52	·650	5·8
	5·40	2·95	·26	·58	·580	5·7
"Renourri" ..	7·00	2·22	·24	·54	·270	7·1

The *acidity* of cider is an important characteristic ; it is due to malic, tartaric, and other vegetable acids and their salts. The "fixed" acids amount to 0·1 to 0·6 per cent. reckoned as tartaric acid—that is, from ½ to 3 grains, or an average of 2 grains, in an ounce. In sweet cider this is not very perceptible, because the acidity is covered by sugar ; in dry cider it is markedly perceptible, because of the absence of sugar. As a general rule the "volatile" acids are small in amount, and do not usually exceed 0·05 to 0·09 per cent. Cider is very prone to undergo acetous fermentation, which gives rise to a more prominent acidity ; indeed, unless care is exercised, and the secondary fermentation does not proceed regularly, both acetic and lactic acids will be produced, and the liquid will be flat and acid to the taste. It is essential, for this reason, that the must have a proper proportion of sugar before the primary fermentation begins, and the cider a due proportion of alcohol before the secondary fermentation commences. The alkaline salts and vegetable acids impart diuretic and slightly aperient properties to the beverage ; but too great an acidity has a tendency to cause colic and diarrhœa in the consumer. As a general rule cider is a refreshing and invigorating beverage, in which the stimulating and fragrant ethers are developed, as in other wines, in proportion to the age and maturation.

Perry closely resembles cider, but has a sweeter taste, owing to the fact that the fruit and the must contain a smaller proportion of

[1] *Compt. Rend.*, January 31, 1887.
[2] *The Analyst*, 1902, 184.
[3] *Ibid.*

malic acid and a greater proportion of sugar. The following analyses of Worcestershire and Devonshire perry are by Allen, and that of Gloucestershire by Pembrey.[1]

SPARKLING PERRY—PERCENTAGES.

	Worcestershire.	Devonshire.	Gloucestershire.
Alcohol, by weight	4·61	4·81	3·64
Equal to proof spirit ..	10·11	10·54	7·98
Total solids	6·51	6·49	4·50
Volatile acids, as acetic ..	·41	·35	·22
Fixed acids, as malic ..	·25	·20	·24
Glucose	none	·31	—
Ash	·40	·28	·30
Original solids	16·61	16·92	12·33

Both cider and perry contain the stimulating and fragrant ethers found in champagne, and they are developed by maturation and become greater by age. When in cask they must be allowed a week to become clear and transparent after being transferred from the factory to their destination. Air must be excluded, or the beverage will spoil and undergo acetous fermentation. When old in bottle, they accumulate a sediment from precipitation of some of the solids.

Cider-Cup is a beverage consisting of equal parts of sparkling cider and soda-water or lemonade, flavoured by the addition of brandy, gin, or curaçoa, a slice or two of lemon, and sugar to taste ; it is cooled by surrounding it with ice or placing it in a refrigerator.

Salutariness of Cider.—It is generally recommended that *dry* or completely fermented cider, free from sugar, may be taken by persons suffering from gout or goutiness, rheumatism, gravel, stone, kidney diseases, and especially by those having a tendency to obesity. The vegetable acids and the acid salts are transformed into alkaline carbonates, and act upon the skin and kidneys. The question, " Should the gouty drink cider ?" was discussed in the *Lancet*.[2] As a general rule the gouty are better without any alcoholic beverage. But the best test of the suitability of any drink for people of arthritic tendencies is that of experience ; that is, whether the beverage under observation has ever produced in that individual an attack of arthritic gout or any other gouty manifestation. Judged by this test, ordinary " rough " cider, fully fermented and free from sugar, is practically harmless. On the other hand, " sweet " cider, which is only partially fermented and contains 3 or 4 per cent. of sugar, and " champagne " cider, which is frequently artificially sweetened and aerated, may excite gout or rheumatism, and therefore should be prohibited for these people. Unfortunately, rough and dry cider is less palatable than

[1] *The Analyst*, 1902, 184. [2] *Ibid.*, 1902 ii. 234, 246, 314.

sweet cider, and the gouty are often disposed towards sweet beverages. Such people should only drink unfiltered and fully fermented cider. This is essential. It is also the opinion of Haig that cider may be drunk by the gouty. He says : " Good cider has an acidity equal to 58 grains of oxalic acid in a pint ; but it also contains a lot of soda and potash, and the consequence of drinking it, as regards the acidity of the urine, is almost nil ; the acids and alkalies of apple-juice and cider are nearly balanced. . . . Fruits are acid owing to their acid salts ; but these become alkaline carbonates in the body, and act as alkalies rather than acids, and they tend to lower the acidity of the twenty-four hours' urine." He considers the malic acid of cider is an antidote to uric acid, and tends to its reduction, or at any rate its solution and excretion from the body. It is thus beneficial to those who are liable to gout, gravel, rheumatism, and other diseases in which uric acid plays a part. *Sweet* ciders, on the other hand, are injurious to such people, and many of the bottled ciders and perries " faked " to suit the popular taste have a distinct tendency to gout and rheumatism, and people frequently develop these complaints after consuming such beverages in any quantity. Even if such people have not had the gout, the consumption of *sweet* cider or perry will probably cause it.

Meat Wines and Tonic Wines.

These wines consist of a solution of extract of meat, malt, cinchona, calisaya, orange bark, quinine, iron, coca, kola, and other substances, in various kinds of wine. An important account of this class of wines is given in the *British Medical Journal*, from which the following tables are compiled. For the sake of comparison, the strength of a few ordinary wines is attached.

" Bovril wine " consists of Bovril, port wine, and extract of malt. " Lemco wine " is extract of meat and malt dissolved in wine. Wincarnis consists of the same things, but the wine may be different. Glendenning's wine is made of beef jelly, port, and extract of malt. Bendle's wine is guaranteed to consists of " pure meat nutriment (not extractives) "—viz., 3·23 per cent. of protein, or at least 14 per cent. of raw meat substance, made with old tawny port. " Bivo " contains 0·23 per cent. of iron, in addition to extract of meat and malt. " Vin Regno " is port wine containing essence of beef, malt extract, and quinine. In each case the meat extract has been calculated from the total nitrogen on the assumption that such extract is determined by the factor $N \times 8{\cdot}9$. When the wine contains extract of malt, some of the nitrogen would be derived from malt proteins, but the whole of the nitrogen has been calculated as if derived from meat extract. The same remark applies to the wines which contain meat juice, a part of the nitrogen being derived from soluble albumin or proteoses.

The tonic wines are similar to the foregoing, but contain the alkaloids of various drugs—*e.g.*, *Coca* in Armbrecht's, Savar's, Mariani's, Hall's, and Wright's wines ; *kola* in Christy's ; *cinchona*

COMPOSITION OF MEAT WINES—PERCENTAGES.[1]

	Alcohol by Volume.	Extractives.	Sugar.	Meat Extract.	Ash.	Volatile Acids.	Fixed Acids.	Alcohol in a Wineglassful (Drachms).
Port	21·19	9·20	7·56	—	·22	·071	·34	3¼
Sherry	24·80	2·30	4·00	—	·25	·200	·52	3½
Champagne	15·30	3·67	1·92	—	·11	·090	·60	2
Marsala..	21·00	5·36	3·50	—	·26	·120	·20	3¼
Madeira	22·00	4·45	1·95	—	·37	·240	·37	3½
Claret and Burgundy ..	14·00	2·71	·11	—	·25	·080	·25	2
Bendle's Meat Port	20·30	10·90	8·00	2·5	·50	·030	·19	3¼
Bovril Wine	20·15	13·20	10·20	·5	·30	·100	·34	3¼
Burroughs and Wellcome's Bivo	19·20	17·70	11·50	3·4	1·20	·060	·75	3
Coleman's Wincarnis	19·60	20·90	18·20	1·2	·40	·090	·26	3
Glendenning's Beef and Malt	20·80	13·50	10·60	·4	·30	·090	·31	3⅓
Pearson's Vin Regno	16·05	13·46	7·40	·3	·30	·120	·36	2½
Smith's Lemco Wine	17·26	15·70	12·80	·6	·40	·120	·31	2¾

[1] *British Medical Journal*, 1909, i. 796.

COMPOSITION OF TONIC WINES—PERCENTAGES.[1]

	Alcohol by Volume.	Total Solids.	Sugar.	Ash.	Volatile Acids.	Fixed Acids.	Alkaloids.	Other Substances.
Armbrecht's coca wine	15·05	23·5	20·8	·28	·08	·33	·006	Cocaine.
Bandon's wine of phosphates ..	12·75	14·3	13·1	·56	·12	·67	—	Phosphates.
Bugeaud's nutritive tonic wine ..	14·80	21·5	18·9	·40	·13	·33	·010	Cinchona.
Burroughs and Wellcome's Vana ..	19·20	23·9	20·0	·23	·05	·27	·030	Cinchona; glycero-phosphates.
Christy's kola wine	18·85	10·9	8·6	·25	·09	·24	·030	
Dusart's wine: phosphates of iron and lime	16·85	15·4	12·8	·55	·11	·35	—	Iron ·09; calcium ·07.
Fletcher's Vibrona	19·30	16·7	11·6	·27	·07	·28	·028	Cinchona.
Hall's wine	17·85	14·1	11·9	·29	·10	·34	·003	Coca.
Mariani's coca wine	16·40	8·9	6·9	·22	·10	·35	·010	Cocaine.
Nourry's iodinated wine	11·50	27·3	21·4	·36	·06	·39	—	Iodine ·33.
Quina Laroche	16·90	26·9	22·2	·20	·05	·16	·050	Cinchona.
Savar's coca wine	23·40	5·4	2·6	·44	·13	·24	·070	Coca; glycerine 6·1.
St. Raphael quinquina wine.. ..	16·89	14·3	11·8	·25	·18	·19	·008	Cinchona.
,, tannin wine	16·65	16·5	14·0	·29	·11	·41	—	
Serravallo's bark and iron wine ..	17·26	21·2	19·0	·23	·05	·23	·050	Iron ·01.
Wright's Marza wine	17·48	9·4	7·6	·23	·11	·30	·001	Iron ·005; P_2O_5 ·03.

[1] *British Medical Journal*, 1909, ii. 1307.

in Burrough and Wellcome's, Serravallo's, Comar's, Fletcher's, Bugeaud's, St. Raphael; *iron* and *phosphorus* in Wright's, Serravallo's, etc.

With regard to the coca wines, the alkaloid in Armbrecht's corresponded to 14 minims of liquid extract of coca in a wineglassful of wine; in Savar's it represented 21 minims of liquid extract in a dessertspoonful of the wine; but there is very little alkaloid in the others. Christy's kola wine contains 0·03 per cent. of caffein, representing 6½ grains of kola in a fluid ounce. The tonic wines usually contain the bitter principles of cinchona: in the case of Quina Laroche the amount of alkaloid represents 5 to 7 minims of liquid extract of cinchona in an ounce of wine, in Serravallo's the same, in St. Raphael only about 1 minim in an ounce; Vibrona contains the alkaloids of 2½ grains of cinchona in an ounce, in the form of hydrobromides, besides the natural quinates and cinchonates of the bark; Vana contains calcium glycero-phosphate and the alkaloids of cinchona; Nourry's wine contains 1½ grains of iodine per ounce, chemically combined with tannin.

The tonic wines of the British Pharmaceutical Codex, for the most part, consist of detannated sherry, which is considered preferable for the preparation of wines containing alkaloids. Sherry is detannated by adding 1½ grammes of powdered gelatin to a bottle of wine, macerating it for twenty-four hours, with frequent agitation, and decanting it. **Iron wine** is made by macerating 5 per cent. of iron wire in sherry for thirty days. A good sample should contain 0·20 per cent. of iron. In the United States iron wine is made by dissolving 4 parts of ammonio-citrate of iron in white wine, afterwards flavouring it with tincture of orange-peel and syrup. **Quinine wine** is orange wine containing 0·228 per cent. of quinine hydrochloride. **Cinchona wine** consists of 12·5 per cent. of elixir of cinchona in detannated sherry. Ferrated cinchona wine also contains 0·5 per cent. of ammonio-citrate of iron. **Kola wine** consists of 12·5 per cent. of elixir of kola in detannated sherry. It is a stimulant similar to tea and coffee. Its action is due to caffein, and chiefly psychical. **Coca wine** consists of 12·5 per cent. of elixir of coca in detannated sherry. In the United States it is made with red wine and 6·5 per cent. of fluid extract of coca-leaves. Its action is chiefly due to cocain. It excites the whole brain, but chiefly the motor centres. It produces a sense of exhilaration by rousing the cerebral hemispheres, an increased capacity for physical work, and greater power of endurance.

CHAPTER XXXIV

NON-ALCOHOLIC AND LOW ALCOHOLIC BEVERAGES

It is unfortunate that so few non-alcoholic beverages of a reliable character are obtainable. Water is decidedly the best of them, and, when pure, is precisely the thing desired to satisfy the demands of the body. But individuals have a craving for something in the nature of a stimulant, and, of the truly non-alcoholic variety, there is nothing more invigorating than tea or coffee. The people, moreover, demand something which has a taste and flavour, and particularly something sharp. Many attempts have been made by manufacturers to supply this want, without producing an alcoholic beverage. Their attempts hitherto have not met with a great success. The numerous mineral or aerated beverages of the class of soda-water, lemonade, and orangeade, do not satisfy their desires, although an immense quantity of such liquids is drunk. Those beverages which best satisfy the appetite have been slightly fermented, and actually contain as much or more alcohol than the Government will allow to go untaxed. The standard set by the Government is that untaxable beverages shall contain not more than 2 per cent. of proof spirit. A few non-alcoholic beers, such as Kop's ale and Barrie's beer contain only 0·5 to 1·0 per cent. Such beverages can be made having the tonic, stomachic, and invigorating properties of hops, etc. But on the whole the so-called "non-alcoholic beers," such as herb-beer and gingerbeer, contain 2 or 3 per cent. of alcohol *by volume*, and are as strong as some lager and Danish beers ; in fact, one sample of herb-beer was found to contain 5 per cent. of alcohol. As a general rule the mineral waters are poor quenchers of thirst. They vary extremely in character : some are sickly sweet, others are acidulous, others again are insipid ; most of them are flavoured with artificial essences. The fruit syrups, excepting lime-juice cordial, are mixtures of plain syrup, or "glucose," and water, flavoured with ethers and coloured with aniline dyes. They are frequently sweetened with saccharin. The same remark applies to many so-called "unfermented wines"—that is to say, they are artificial mixtures of saccharine substances and organic acids or their salts, flavoured and coloured. The dangers of their consumption arise from the presence of aniline colours, preservatives, and saccharin. The artificial flavourings, although injurious to small animals, are not injurious in the minute traces which are consumed by persons at one time ; they speedily

volatilize. We can only say, with respect to these ethers, that they have no place in the human economy, the small amount in each bottle is useless as a stimulant, but a long persistence in their use may be the cause of disease in the internal organs.

Water.

The amount of water which leaves the human body daily by the skin, lungs, and kidneys, averages about 80 ounces. Probably one-third of the amount lost in this manner is made good by the proportion of water taken in our food ; therefore from 2½ to 3 pints of water must be taken daily in beverages. It is partly taken in the form of tea, coffee, cocoa, or milk ; the remainder consists of other beverages. The composition and food value of milk, tea, coffee, cocoa, ales, beers, wines, etc., has already been considered ; that of water and it variants has to be considered. *Pure water* is by far the best and safest of all beverages. A moderate amount of water, drunk slowly, at the end of each meal, is valuable by stimulating the contractions of the stomach, dispersing wind, or diluting any undue acidity, and thereby promoting digestion. A tumblerful of hot water taken *before* a meal clears away the remnants of the previous meal, removes mucus, and refreshes the gastric mucous membrane. Taken three hours or more after a meal it assists in the final stages of gastric digestion, dilutes acidity, and frequently leads to the eructation of gas. Internally water acts as a diluent of the blood, as a solvent of waste material, promotes metabolic changes, and assists in the excretion of waste substances. It is of great value by flushing the kidneys, dissolving and washing out the waste materials of metabolism, and thereby assisting in the prevention or cure of gout, rheumatism, gravel, liver, kidney, and other diseases. Thin persons may encourage their appetite by drinking frequent sips of water during a meal : they eat more food by its aid ; the water, by its absorption, fills out their intercellular spaces, and thereby increases their bulk, weight, and improves their general condition. Excessive water-drinking may, but very rarely, cause weakly individuals to become thinner and increase their nervous irritability.

The **Classification of Waters** by the Rivers Pollution Commission is as follows :

1. *Wholesome :*	(1) Spring water	Very palatable.
	(2) Deep-well water	
	(3) Upland surface water ..	
2. *Suspicious :*	(4) Stored rain or soft water ..	Moderately palatable.
	(5) Surface water from cultivated land	
3. *Dangerous :*	(6) Shallow well water	Palatable.
	(7) River water to which sewage gains access	

Characters of Water.—A good drinking water should be clear, bright, sparkling, free from smell, and almost tasteless. The purest water is *rain water,* which merely contains a trace of ammonia and

nitric acid derived from the atmosphere in its descent; but the rain water of towns, especially when collected from the roofs of buildings, contains soot, salt, and other inorganic and organic matter, which render it less fit to drink. *Distilled water*, now largely used at sea, is pure, and when aerated forms a pleasant beverage. Various examples of distilled water are prepared commercially, and may be obtained under the names of Salutaris, Puralis, etc.; they are obtainable both "still" and "sparkling" (aerated). *Hard water* is that which has descended upon the earth and flowed over its surface for some distance, or percolated through its strata to some depth, and become impregnated by some of the earthy constituents. It is derived from springs and wells. Such is the ordinary water used for domestic purposes. It should have the following characteristics: It should be clear and bright when viewed in a two-foot tube; it should have a very pale blue or greenish tint of colour; it should have little if any taste, and be agreeable to the palate; it should give off no odour after being agitated; it should contain no more than 8 or 10 grains of solids per gallon, even chalk water should not contain more than 14 grains per gallon; the albuminoid ammonia should be less than 0·08 per million, and the free ammonia less than 0·05 per million, or conjointly 0·13 part per million; the bacteria should be less than 100 per c.c., and they should not be of a pathogenic character.

When considered alone, some of the afore-mentioned characteristics are no proof of the purity of the water. The water from a polluted well may be clear and bright; a very good water may have a yellow or brownish colour, owing to its coming into contact with peat, clay, or ironstone. A good water is usually alkaline from the presence of calcium carbonate, but it may become acid by passing through peat; polluted water may be alkaline from the presence of carbonate of ammonia arising from the decomposition of organic matter, urine, etc. A polluted water may be very palatable, while the presence of a trace of iron in an otherwise pure water will be distinctly noticeable; the presence of 0·034 part of iron per 100,000 gives a pronounced chalybeate taste; while as much as 107 parts of sodium chloride per 100,000 is necessary to give a brackish taste to the water. A good water usually gives little sediment, but there may be a considerable deposit of hydrated ferric oxide when it has passed through ironstone.

It is considered advisable to add a few particulars with regard to bad and suspicious waters, which should by reason of their general character or some particular article in their composition be condemned as unfit for consumption.

The waters whose composition is given in Table II. were all derived from the shallow wells of country districts. Most of them were in regular use for domestic purposes. The mere presence of vegetable débris, or even of living animalcula, such as diatoms and infusoria, is insufficient to condemn the water as unfit to drink. But when these are associated with bacteria, and a pro-

TABLE I.—GOOD WATERS: SOURCE AND COMPOSITION.

	Spring; very Pure.	Spring; *Chalk.*	Deep Well; *Chalk.*	Shallow Well; *Clay.*	Upland Surface Water.	River Water.	Rain Water; *Country.*	City Water Supplies.				
								Chelsea.	Croydon.	Kent Company.	Leicester.	Manchester.
Physical characters : Taste ..	Pleasant	Palatable	Pleasant	Palatable	Little	Pleasant	Pleasant	Palatable	Palatable	Pleasant	Palatable	Palatable
Smell	Nil	Nil	Nil	Faint	Little	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Appearance	Clear; no colour	Clear; no colour	Clear	clear; yellowish	Yellow or brown	Clear	Clear; no colour	Pale green	Bluish-green	Blue-green	Slightly yellow	Yellowish
Aeration	Good	Good	Good	Little	Slight	Fair	—	Good	Good	Good	Good	Good
Reaction	Neutral	Alkaline	Alkaline	Alkaline	Acid	Faintly alkaline	Faintly alkaline	—	—	—	—	—
Saline ammonia per 1,000,000 ..	·02	·01	·08	·0070	·015	·015	·05	·002	·014	Nil	·003	·003
Organic ammonia ,, ..	·04	·03	·03	·0609	·120	·06	·005	·007	·016	·047	·004	·005
Oxygen absorbed in two hours per 1,000,000	·40	·65	·75	·48	3 to 4	·80	·15	·80	Nil	Nil	·720	·17
Total solids per 100,000	8	30	45	19	8	25	3·5	28·4	35·4	47	21	7·3
Volatile, per 100,000	2	6	10	8	5	8	1·5	—	—	—	—	—
Fixed, per 100,000	6	24	35	9	3	17	2·0	16·0	—	21	11	—
Total hardness	8	20	29	8	5	21	1·0	16·0	27·0	21	9	1·5
Temporary	5	13	19	5	1	13	·4	—	—	—	—	—
Permanent	3	7	10	3	4	8	·6	—	—	—	—	—
Chlorine	1·5	2·5	4·5	4·7	1	1·7	·5	1·5	1·7	3·1	2·0	1·0
Equal to sodium chloride ..	2·4	4·1	7·4	7·5	1·6	2·8	·8	2·4	2·8	2·9	3·2	1·6
Nitrogen as nitrates and nitrites	·01	·4	·5	·60	·009	·2	·005	—	—	—	—	—
Microscopic examination ..	Nil	Nil	Nil	Conferv æ; diatoms	Veg. forms and débris	Veg. débris	Nil	Diatoms; infusoria	Nil	Little	Veg. débris	Little deposit

TABLE II.—BAD AND SUSPICIOUS WATERS.

	Appearance in Tube, and Smell when heated to 100° F.							
	Clear Yellow; Faint.	Clear Yellow; Faint.	Clear; None.	Turbid Yellow; Faint.	Clear Yellow; Faint.	Turbid Yellow; Strong.	Clear Yellow; Faint.	Turbid; Offensive.
	1	2	3	4	5	6	7	8
Ammonia per 1,000,000 :								
Free or inorganic	·193	·07	·070	·04	·08	·02	·03	·24
Albuminoid	·124	·01	·090	·16	·77	·14	·12	·26
Oxygen absorbed in two hours	1·460	·50	·678	—	—	·65	—	22·80
Total solids per 100,000 ..	97·000	54·00	68·000	88·00	98·00	87·00	207·00	210·00
Total hardness	15°	7°	14°	17°	14°	16°	32°	87°
Chlorine per 100,000 ..	2·500	13·30	10·300	10·60	5·00	17·50	50·00	22·50
Equal to NaCl per 100,000	4·100	21·60	16·500	17·49	8·20	28·70	30·30	—
Nitrogen in nitrates and nitrites	—	—	—	·09	·10	3·60	Nil	4·00
Microscopical examination ..	Vegetable débris; mineral deposit.	Mineral deposit.	Vegetable débris; infusoria.	Wool, animal and vegetable organisms; bacteria.	Bacteria; vegetable débris.	Vegetable débris.	—	—
Remarks	Totally unfit for domestic use; polluted by urine.	Contains organic matter in solution; suspicious water.	A suspicious water; organic matter in solution.	The high albuminoid ammonia and organisms render it unfit for use.	The enormous amount of organic ammonia renders it unfit to use.	Unfit to drink; probably contaminated by sewage.	Unfit to drink; albuminoid matter and chlorides excessive; much vegetable débris.	Extremely hard water; contaminated by sewage.

portion of albuminoid ammonia exceeding 0·08 part per million, or a great amount of chlorides and nitrites, the water must be condemned. The water should contain very few living organisms, especially bacteria, and Koch formulated the following bacterial standard :

The presence of—

0 to 100 bacteria per c.c. indicates a good potable water.

100 to 500 bacteria per c.c. indicates a suspicious water.

500 to 1,000 or more bacteria per c.c. indicates an impure water.

But the greatest importance naturally attaches to the kind of bacteria, those of the greatest importance being *Bacillus coli communis, B. enteritides sporogenes,* and streptococcus, whose presence gives a dangerous quality to the water.

Some of the points mentioned as characterizing a pure water need further comment. A good water should not contain much either *free* or *organic* ammonia, for its presence is indicative of more or less pollution. It is generally considered that a water is " safe " for domestic purposes if the " free " ammonia does not exceed 0·05, and the " albuminoid " or organic ammonia does not exceed 0·08 part per million of water. Much albuminoid and a small amount of free or inorganic ammonia indicates vegetable contamination, and the indication is supported by the presence of only a *trace* of chlorides and no excess of nitrates or nitrites. When the albuminoid ammonia amounts to 0·05 per million, the proportion of saline or free ammonia becomes a matter of importance ; but if the albuminoid ammonia be nil, or practically so, the water may be passed as organically pure despite the presence of a considerable proportion of *free* ammonia and chlorides. The amount of *free* ammonia being small, the water would be potable unless the albuminoid ammonia amounts to 0·10 per million or more.

A considerable amount of *free* or saline ammonia in conjunction with an excess of chlorine and nitrogen as nitrates and nitrites is always an indication of organic pollution of the water. If the *free* or saline ammonia exceeds 0·08 part per million, or 8·0 per 100 millions, it is considered that such ammonia arises from the decomposition of urea into carbonate of ammonia, and that the water is polluted by urine. But in judging the existence of organic pollution it is always necessary to consider the free and saline ammonia along with the albuminoid ammonia. An excess of free ammonia may exist in rain water, in water which has passed through geological strata containing ammonium salts, or through strata containing reducing agents, such as iron, which will decompose nitrites or nitrates taken up in its passage through other strata.

A very pure drinking water does not absorb more oxygen than about 50 parts per million in four hours, or 40 parts in two hours from permanganate of potash. A water which absorbs more than 200 parts in four hours, or 160 parts in two hours, would be a suspicious water. The estimation is usually made by Forchammer's process ; but it does not give a satisfactory clue as to the origin

of the matter which is oxidized. Again, vegetable matter absorbs more oxygen from the permanganate than animal matter does in the same time. Water which has passed through peat might absorb 600 parts of oxygen per million in four hours, and 450 parts in two hours ; but organic matter of this nature is not usually considered injurious to the health of the consumer. It is necessary, therefore, to have some idea as to the source of the pollution, to remember that vegetable matter is more readily oxidized than animal matter, and that the absorption of oxygen in the first half of the time is mainly due to vegetable matter.

A good drinking water, according to the Report of the River Pollution Commissioners, should not yield more than 0·2 part of organic carbon nor more than 0·02 part of organic nitrogen per 100,000 parts of water. A water which contained 0·6 part of organic carbon and 0·04 part of organic nitrogen would be condemned by most analysts. These items are estimated by the amount of carbonic acid and nitrogen gases evolved from the combustion of the residue obtained by Frankland's process. The actual amount of organic carbon and organic nitrogen being determined, the purity of the water can be decided by their ratio to one another. A very good water contains a low quantity of each, and especially a relatively small amount of organic nitrogen. Much organic carbon and little organic nitrogen indicate an impurity of vegetable origin and of little importance ; but the nearer the amount of organic nitrogen approximates to that of carbon, the greater is the indication that the pollution is of animal origin, and therefore more dangerous to the consumer.

A good water should not contain any *nitrites ;* the presence of the least trace should arouse suspicion. Neither should it contain any *nitrates.* When the water contains more than 0·1 per 100,000 of " nitrogen as nitrates " it should be suspected, unless it is known that it has percolated through strata of the earth which contain the salts. It has been found, however, that water of very good quality which has passed through red sandstone, chalk, lias, or oölite formations may contain as much as 7 parts of nitrates per 100,000. The determination of " nitrogen as nitrites and nitrates " is therefore of importance. The presence of the least trace of *nitrites* is indicative of present or recent organic pollution ; a small amount of *nitrates* may arise from oxidation of nitrites, and very large amounts from salts in the earth.

All waters contain more or less chlorine as chlorides of sodium, calcium, or magnesium ; rain water may contain 0·5 part chlorine per 100,000 ; water which has passed through strata containing these salts may have 15 or 20 parts per 100,000. It is, however, considered by most authorities that the presence of more than 3 parts per 100,000 should be looked upon with suspicion until its source has been ascertained. The most dangerous source is organic matter of animal origin, and is usually urine, which may find entrance to the well from the proximity of a farm crew-yard or stables.

If it be due to animal pollution, the total solid residue of the water will contain much organic matter, the presence of which will be indicated by every step in the analysis. But a high proportion of chlorine may be due to other sources. If it be derived from the earth, through which it has permeated, the total solids from the water will still be high, and when incinerated will be found to consist almost entirely of mineral substances, and an absence of evidence of animal pollution, as in waters from deep wells in the chalk, greensand, sandstone, London clay, and near the coasts.

The total *hardness* should not exceed 14 or 16 parts per 10,000, and the permanent hardness not be more than 7 parts per 100,000. A moderately hard water is more palatable than a soft water. Very hard water is apt to produce gastro-intestinal derangements ; it does not give such satisfactory results in the preparation of food as a soft or moderately hard water : vegetables boiled in it lose colour and flavour, tea and coffee do not yield their soluble extract so abundantly to it, neither are soup, broth, or beef-tea, so strong when made with it.

The " hardness " of most waters is due to carbonates and sulphates of lime, etc., derived from the calcareous strata of the silurian, Devonian, mountain limestone, coal, sandstone, lias, oölite, greensand, and chalk measures. The carbonates of lime and magnesia are almost insoluble in pure water ; but most drinking water is well aerated, and the carbonic acid converts some of the carbonates into *bicarbonates* of lime and magnesia, which are much more soluble in water and considerably increase the hardness of water. When such a water is boiled, some of the bicarbonates are decomposed, and most of the resulting carbonate is precipitated and the water thereby softened ; the amount of hardness lost in this manner is called the *temporary hardness*, and the hardness which remains the *permanent hardness*. The *permanent hardness* is due to the salts which remain in solution—viz., calcium and magnesium carbonates, sulphates, chlorides, and nitrates, with a little alumina and iron. Waters which contain much mineral solids are usually hard, and the hardness is usually in proportion to the amount of such minerals ; but an exception to this rule exists in those waters which contain considerable quantities of sodium bicarbonate. The latter mineral gives the quality of *softness* to such waters, despite the fact that the proportion of total solids is high, and particularly so in the case of the waters from artesian wells.

Natural Mineral Waters.—This name is applied to any water which contains an abnormal amount of inorganic substances in solution, but those only are " natural " which issue from the earth charged with this superabundance. Many of these are bottled at the spring and sold as table waters ; they may be classified as follows, examples of each class being given :

1. *Alkaline Gaseous Waters.*—Apollinaris, Belthal, Chateldon, Condillac, Gerolstein, St. Galmier, St. Galmier-Noël, Perrier, Solms-Gertrudis.

TABLE WATERS—CONSTITUENTS IN GRAINS PER GALLON.[1]

Name.	Situation of Source.	Special Character.	Carbonate of—			Chlorides.	Sulphates.	Free CO_2 (Cubic Inches).	Analyst.
			Soda.	Lime.	Magnesia.				
Bath (Sulis) ..	England	Aerated	—	7·6	·5	30·3	30·0	220·0	Attfield.
Alet	Aude, France	Alkaline	—	19·0	7·0	3·0	2·0	140·0	Filhol.
Chateldon ..	Puy de Dôme, France	Alkaline; chalybeate	27·0	36·0	18·0	2·0	3·5	152·0	
St. Galmier ..	Loire, France	Alkaline	39·0	50·0	50·0	33·0	14·0	High	
Desaignes ..	Ardêche, France	,,	215·0	14·0	10·0	7·0	·3	211·0	Ferrand.
Apollinaris ..	Neuenahr, Germany	,,	88·0	4·0	31·0	32·0	21·0	194·0	Bischof.
Selters	Nassau, Germany	,,	58·0	17·0	14·0	—	163·0	High	Mohr.
Sauerbrunnen ..	Hartz, Germany	Very soft	·2	—	·9	·4	—	—	Attfield.
Taunus	Frankfort, Germany	Saline	1·4	95·0	12·0	197·0	—	202·0	Taylor.
Wilhelmsquelle	Kronthall, Germany	,,	3·5	29·2	6·7	118·0	1·6	157·0	Fresenius.
Ems	Germany	Alkaline	148·0	17·0	15·0	70·0	4·5	83·0	
Gerolstein ..	Eifel Mts., Germany	,,	57·0	40·0	31·0	17·0	7·0	—	
Johannisbrunnen	Nassau, Germany	,,	25·0	51·0	21·0	72·0	2·0	170·0	Plaskuda.
Roisdorf ..	Bonn, Germany	,,	60·0	21·0	30·0	146·0	—	190·0	Bischof.
Rosbach ..	Homburg, Germany	,,	—	25·0	12·0	83·0	—	—	Wanklyn.
Birresborn ..	Prussia, Germany	Alkaline; chalybeate	199·0	19·0	76·0	72·0	13·0	170·0	
Roman Spa ..	Ober-Hessen, Germany	Acid; chalybeate	—	56·0	105·0	133·0	10·0	216·0	Fresenius.
Spa, 'Pouhon'	Belgium	Ferruginous	7·3	9·8	11·2	4·5	1·0	216·0	Struve.
Giesshübel ..	Carlsbad, Bohemia	Alkaline	68·0	15·0	3·0	3·0	—	—	
Orezza	Corsica	Ferruginous	—	42·0	5·0	—	—	75·0	
Poland	Maine, U.S.A.	Alkaline; soft	·1	1·2	·5	·2	·1	—	Chandler.
Sweet Spring .	Virginia, U.S.A.	,,	—	37·0	11·0	·8	36·0	88·0	Rogers.
Clymir Spring	Waukesha, Wis., U.S.A.	,,	1·5	20·0	16·5	1·5	1·2	—	Rathbone.
Soda Spring ..	Alpine Co., California, U.S.A.	,,	11·5	52·0	5·2	31·2	—	186·0	

[1] Tibbles, "Food and Hygiene," p. 322.

2. *Alkaline.*—Bath, Birresborn, Gastein, Giesshubler, Spa, Taunus, Vichy.

3. *Saline Gaseous.*—Johannis, Seltzer.

4. *Saline.*—Kronthall, Malvern, Rosbach, Wilhelmsquelle.

The composition of some of them is given in the table on p. 928.

These waters are all more or less naturally aerated, but some, like Apollinaris, contain a large amount of gas; others, like Seltzer, a much smaller amount: the former are therefore sparkling effervescent waters. They vary from one another by containing different salts or different proportions of the same kind of salts; therefore they differ from each other in their physical characters and effects. Most of them are alkaline, but the saline waters also contain some chloride of sodium. Their bright and sparkling appearance tempts the consumer to drink them freely. This is an advantage with many people. They are valuable by promoting digestion and stimulating the motor activity of the stomach. Those which contain much gas, however, are not suitable for persons with cardiac weakness, as distension of the stomach impedes the action of that organ. Furthermore, the carbonic acid gas, having a high coefficient of absorption, readily passes into the circulation, and for this reason they are unsuitable for persons whose respiration is impeded through cardiac or pulmonary disease. For these classes of people those waters containing little carbonic acid gas, such as those of Bath, Spa, Malvern, and Vichy, are more suitable.

For an account of the numerous medicinal waters the reader is referred to the author's book entitled "Food and Hygiene," and to various works on the spas and waters of Europe.

Artificial Mineral or Aerated Waters.—The chief spa water most frequently imitated is the natural water of Selters or Seltzer water. The composition of the natural Seltzer water, according to Mohr, is as follows:

NATURAL SELTERS WATER—GRAINS PER GALLON.

Bicarbonate of soda	58·49
,, of lime	17·25
,, of magnesia	14·21
Sulphate of potash	163·08
Chloride of sodium	·03
Ammonia, strontia, baryta, iron, manganese, silica	7·30
	260·35

Carbonic acid gas, 91 vols. per cent.

Imitation seltzer water is made with bicarbonates of soda and magnesia, and hydrochloric acid, or simply with bicarbonate and chloride of soda, and magnesia, and contains about 1·25 grains of minerals per pint, whereas the natural water contains 11 or 12 grains in a pint.

The ordinary aerated mineral waters consist of plain water which is charged with carbonic acid gas. The water may be—

1. *Plain carbonated water* charged with CO_2 at 120 to 140 pounds per square inch.

2. *Alkaline waters* charged with CO_2 at 120 to 140 pounds per square inch.

The water contains the following amounts of alkali :

Aerated Water.	Mineral Substance per Pint.
Ordinary soda water	Bicarbonate of soda—5 to 10 grains.
Medicinal soda water	,, ,, 30 ,,
Ordinary potash water ..	Bicarbonate of potash—5 to 15 ,,
Medicinal potash water ..	,, ,, 30 ,,
Lithia water	Carbonate of lithia 10 ,,
Magnesia water	,, of magnesia 24 ,,
Carrara water	,, of lime 10 ,,

3. *Flavoured waters*, containing various essences, charged with CO_2 at 70 to 100 pounds per square inch.

History.—More than two centuries ago attempts were made to imitate the natural mineral waters, especially the aerated and gaseous varieties. This was done by a combination of acid and alkaline solutions, or powders, of which the Seidlitz, Kali, and other effervescing powders are examples. But about the beginning of the eighteenth century the manufacture of aerated waters, bottled ready for use, began to assume a commercial importance. Various machines have been invented for their manufacture. The principle, however, is the same whatever form of machine is used. It is the following : Water absorbs under the normal pressure of the atmosphere about its own bulk of carbonic acid gas ; if pressure equal to that of two atmospheres is applied, the water will absorb twice its bulk of CO_2, its absorbing power increasing in proportion to the pressure. Water thus impregnated has a pleasant sharp and acid taste, to which is added that of the mineral or flavouring agent. The carbonic acid gas is generated by mixing sulphuric acid and chalk or whiting, and the gas evolved is stored in a gasometer, from which it passes to a condenser, and thence to the bottling machine. The bottles usually contain a due proportion of the substance intended to be dissolved in the water, and the water, charged with gas at the desired pressure, is then admitted, and it is mechanically corked and secured. *Natural carbonic acid gas*, obtained from Germany, is used by some makers. This gas contains about 99·5 per cent. pure carbonic acid gas, and is liquefied by a pressure of 800 pounds per square inch. A cylinder containing it is connected with the bottling machine, the pressure removed, and the gas and water mingle in the bottle ; from four to seven times its bulk of gas is taken up by the water.

The flavoured aerated waters are made with a syrup flavoured with various fruit-juices, such as lemon, orange, raspberry, strawberry, currant, tincture of ginger, capsicum, hops, or essences made from various ethers and other flavouring substances, some of which

are named below. When made from genuine fruit-juice and plain carbonated or aerated water they are splendid beverages ; but this variety of aerated waters is scarce. The lemonade, orangeade, raspberryade, etc., are manufactured from acidulated syrups flavoured with the ethereal essences. The acid may consist of tartaric, acetic, or citric acid, in the proportion of 20 grains to a pint, or phosphoric or phosphocitric acid. The syrup is made of 9 or 10 pounds of sugar to a gallon of water, and 1 pint of water contains 1 or 2 ounces of syrup. The following[1] are examples of those used by mineral-water makers :

1. *Lemonade Syrup.*—Plain syrup, 1 gallon ; lemon tincture, 4 ounces ; acetic acid, 4 or 5 ounces ; mix.

2. *Orangeade Syrup.*—Syrup, 1 gallon ; orange tincture, 4 to 6 ounces ; acetic acid, 4 ounces.

3. *Gingerade Syrup.*—Syrup, 1 gallon ; tincture of ginger, 4 ounces ; acetic acid, 4 ounces ; bitter orange tincture, q.s.

4. *Ginger Ale Syrup.*—Syrup, 1 gallon ; compound tincture of ginger, 4 ounces, *or* tincture of capsicum, 1 ounce ; acetic acid, 4 ounces ; burnt sugar, ½ ounce.

5. *Gingerbeer Syrup.*—Syrup, 3 quarts ; boiling water, 1 quart ; oil of lemon, 24 drops ; acetic acid, 4 ounces ; tincture of ginger, q.s.

The best water for the mineral-water manufacturer's purpose is a moderately soft one, having not more than 7 degrees of hardness ; it should contain not more than 0·05 part of organic or albuminoid ammonia per million, and no more than six or seven bacteria per c.c.

Fruit Juices, Syrups, and Vinegars.

Genuine fruit juices, syrups, and vinegars, are among the very best non-alcoholic beverages ever devised. They are cooling and refreshing, but have none of the stimulating and exciting properties of alcoholic beverages ; neither have they the heating principles of those which contain ginger or capsicum. They can be taken with water only, or with iced water, soda-water, or other carbonated liquid. They make a delicious *wine-cup* by combining them with wines and aerated water. By their vegetable acids and salts they produce the same effect upon the blood and general system as fresh fruit. The juice of currants, elderberries, raspberries, blackberries, strawberries, gooseberries, grapes, cherries, plums, peaches, and rhubarb, have a great value when used in those seasons in which the fresh fruit is unobtainable. Currant-juice can be sterilized and kept without sugar, and is thus ready for making beverages and jelly at all seasons. Grape-juice can also be preserved with or without sugar, except when the fruit contains a large percentage of sugar ; in the latter case it is advisable to add more sugar to preserve it ; " a gill of sugar is added to a quart of juice," and it is sterilized by heat. Raspberry, blackberry, and strawberry juices also require the addition of sugar to preserve them, the proportion used being " ½ pint of sugar to a quart of juice," and

[1] *Mineral-Water Makers' Manual*, 1896.

sterilization by heat. Cherry, plum, and peach juices are preserved in the same way, and with the same amount of sugar. Currant-juice may also be preserved by sterilizing it with a pound of sugar to a quart of juice. Lime-juice, lemon-juice, etc., are mentioned in the section on Fruit.

Fruit Syrups differ from juices merely in the proportion of sugar used; it is customary to combine 50 parts of sugar with 100 parts of juice.

Fruit Vinegars are made from raspberries, blackberries, and strawberries. Raspberry vinegar is a good example; it is made from 100 parts of fruit, 75 parts of malt vinegar, and 50 parts of sugar, the liquor being finally sterilized by boiling. Fruit vinegar is a refrigerant; half a wineglassful in a tumblerful of water makes a refreshing beverage which is equally valuable in health and various febrile complaints.

Grape-Juice.—Grape-juice makes a particularly good beverage, and deserves further mention. Unless the beverage is sterilized at once, spontaneous fermentation quickly sets in. Unfortunately, a long exposure of grape-juice to heat destroys the natural flavour of the fruit, and the juice contains spores which are proof against the temperature of boiling water. Kühn, however, has perfected a process by which the must can be preserved indefinitely. It consists in the thorough sterilization of the liquid by submitting it to a temperature of 110° C. (230° F.) *under strong pressure*. It is asserted that the juice retains its natural flavour by this method of treatment, and does not undergo changes in its composition. The result is a pure sterilized grape-juice containing the normal proportion of grape-sugar, tartaric, malic, and succinic acids, with other free acids, bases, and salts. Alcohol is not found. This is a valuable temperance beverage, which can be taken alone or combined with an aerated water. It is held out as a ready means of practising the "grape cure" in the following diseases: In *kidney diseases* it is of value by the diuretic action of the glucose and sulphate and bitartrate of potassium, and is of similar value in the oliguria of cardiac affections and feverish states, and in chronic drug or metallic poisoning. In *acute nephritis* it has a sedative as well as diuretic effect; it increases the urine more than milk does. It may be taken with advantage in *gastro-intestinal* affections; being laxative, it is of value in chronic constipation; it lessens spasmodic constipation in muco-membranous colitis; it is a cholagogue of value in chronic congestion and hyperæmia of the liver; and it reduces hæmorrhoids by depleting the whole portal system.

Unfermented Wines.

These are (1) fruit-juices pure and simple, or (2) artificial concoctions of organic acids, syrup, glucose, and "fruit essences," consisting of various ethers and aldehydes, and colouring matters, usually aniline dyes, mingled with water and preserved with salicylic acid.

All fruit owes its flavour and aroma to various delicate and vola-

tile ethers and aldehydes. The oil of apples is valerianate of amyl, the flavour of pears is due to acetate of amyl, of pineapples to butyrate of ethyl, of greengages to œnanthylate of ethyl, quince to pelargonate of ethyl, mulberry to suberate of ethyl, and melon to subacetate of ethyl. It would be impossible to extract these substances from fruit in sufficient quantity to be of commercial value. But they can be imitated by the chemist, and such imitations are those used to make the fruit essences of commerce. These artificial essences have an aroma and flavour resembling that of the fruit, but they lack the delicacy of the natural product. Some of the commercial essences are as follows :

Pineapple Essence consists of butyric ether dissolved in alcohol. The butyric ether is obtained by mixing together equal parts of absolute alcohol and butyric acid, treating the mixture with sulphuric acid, and distilling it to recover the ether.

Apple Essence consists of amyl valerianate dissolved in alcohol. Amyl alcohol and sulphuric acid are mixed together ; as the mixture cools valerianic acid is added, and it is distilled.

Pear Essence is amyl acetate in alcohol. Amyl alcohol and potassium acetate are mixed together, the mixture treated with sulphuric acid and distilled.

The United States Dispensatory gives the following table from Kletzensky for making various other fruit essences :

Composition of Artificial Fruit Essences—Parts per Cent.[1]

	Strawberry.	Raspberry.	Gooseberry.	Grape.	Cherry.	Plum.	Currant.	Apricot.
Aldehyde	—	1	1	2	—	5	1	—
Acetic ether	5	5	5	—	10	5	5	—
Amyl-acetic ether	3	1	—	—	—	—	—	—
Amyl-butyric ether	2	1	—	—	—	—	—	1
Benzoic ether	—	1	1	—	5	—	1	—
Butyric ether	5	1	—	—	—	2	—	10
Formic ther	1	1	—	2	—	1	—	—
Methyl-salicylic ether	1	1	—	1	—	—	—	—
Nitrous ether	1	1	—	—	—	—	—	—
Œnanthic ether	—	1	1	10	—	—	1	1
Sebaic ether	—	1	—	—	—	—	—	—
Valerianic ether	—	—	—	—	—	—	—	5
Oil of persicot	—	—	—	—	2	4	—	—
Chloroform	—	—	—	2	—	—	—	1
Amyl alcohol	—	—	—	—	—	—	—	2
Saturated alcoholic solution of—								
Tartaric acid	—	5	5	5	—	—	5	1
Succinic acid	—	1	1	3	—	—	1	—
Benzoic acid	—	—	1	—	1	—	1	—
Glycerine	2	4	—	10	3	8	—	4

[1] Rectified alcohol is added to make 100 parts.

Low Alcoholic Beverages.

In the manufacture of ale or beer it was formerly a custom to make a *second* brew of the "grains" after sparging, and the liquid so produced was fermented separately and yielded a beverage called "small beer," which contained some saccharine material and from 1·25 to 2 per cent. of alcohol. It was a refreshing beverage, containing just enough alcohol to keep it, and quite strong enough to satisfy the craving of many people without producing alcoholism. Such beer had not the property of long-keeping; it had to be consumed early. It was very much like a weak lager-beer. Unfortunately, such beer is never produced now, as the "smalls" is added to the "sweet-wort," and the entire ale is fermented at once. It is usually considered that a fluid containing 2 per cent. of absolute alcohol, or about 3·5 per cent. of proof spirit, has sufficient keeping property to be of dietetic value. Genuine malt liquors can be produced of that alcoholic strength, and are practically non-intoxicating. Such beers are made in Denmark. The English Excise authorities only allow liquors containing 1 per cent. of absolute alcohol, or 2 per cent. of proof spirit, to pass untaxed. Now, if the limit had been 3 per cent. of proof spirit, or 1·5 per cent. of absolute alcohol, it would be possible to produce genuine fermented malt liquors, of good quality and keeping fairly well, practically non-intoxicating, which could be sold as cheaply and freely as lemonade or soda-water. The *Lancet* Laboratory[1] issued an analytical report of a so-called *non-alcoholic* malt beer which exceeded the Excise limit, as it contained—Alcohol by weight, 2·44; by volume, 3·07; *equal to proof spirit*, 5·37 *per cent.*; extractives, 3·14; and mineral matters, 0·10 per cent. It was a good beer, but was dutiable.

The Danes have shown that it is possible to produce genuine malt beer of low alcoholic strength, and the same number of the *Lancet* gives the following:

Composition of Low Alcoholic Beers made in Copenhagen.

	Alcohol.		Proof Spirit.	Extractives.	Ash.
	Weight.	Volume.			
No. 1	1·69	2·12	3·71	5·13	·16
No. 2	1·06	1·34	2·34	2·54	·11
No. 3	1·69	2·12	3·71	6·61	·20

These were genuine malt beers, with a flavour like lager-beer, and agreeably charged with the natural gas of fermentation. They contained a fair amount of malt extract, and were of a very satisfactory character.

[1] *The Lancet*, 1902, ii. 1265.

Herb-Beers.—Various beers are made from a decoction of hops, nettles, and other green or dried herbs ; the saccharine material consists of cane-sugar, and the liquor is fermented with yeast. They should not, according to law, contain more than 1 per cent. of absolute alcohol nor more than 2 per cent. of proof spirit ; but the Report of the Principal Chemist of the Government Laboratory for 1909 shows that, out of 805 samples examined, 63 contained 3 per cent. but less than 4 per cent., 30 contained 4 per cent. but less than 6 per cent., 8 contained 6 per cent. or more, 1 contained 9·7 per cent., and another 11·0 per cent., of proof spirit.

Gingerbeer, or " stone ginger," is made in various ways :

1. White sugar, 5 pounds ; lemon-juice, 5 ounces ; honey, 4 ounces ; bruised ginger, 5 ounces ; water, 4½ gallons.

2. White sugar, 20 pounds ; lime-juice, 18 ounces, *or* tartaric acid, 6 ounces ; honey, 1 pound ; bruised ginger, 22 ounces ; gum-arabic, 12 ounces ; water, 18 gallons.

3. Ure's Dictionary gives the following recipe : Barbadoes ginger root, 12 ounces ; tartaric acid, 3 ounces ; white sugar, 8 pounds ; gum-arabic, 8 ounces ; essence of lemon, 2 drachms ; water, 9 gallons. Bruise and boil the ginger in water ; strain it. Add the acid and sugar ; boil again ; remove scum. Dissolve the gum in a separate portion of water ; add to it the essence of lemon. Mix all together. When the temperature reaches 100° F., add yeast and ferment it ; bottle for use.

When made on a large scale the water is boiled in a steam-jacketed pan. It is then run into a mash-tub with the ginger. After the ginger has been infused for one or two hours, the liquid is run off into a settling vat, where citric or tartaric acid, sugar, and honey, are added, and it is allowed to ferment. When honey is added the liquid ferments spontaneously and less violently than when yeast is added ; the honey also gives a peculiar softness to the beverage. Essence of lemon is added for flavouring. Gum is added to give body, and it may be clarified by using isinglass. It is bottled on the fifth day, and becomes well aerated in about ten to fourteen days. It usually contains 0·75 to 1·5 per cent. of alcohol.

Spruce Beer.—This is a fermented liquor made from the leaves and small branches of Norwegian spruce-fir (*Abies excelsa*), or from essence of spruce. The latter is a fluid extract made by boiling the young branches in water and evaporating the liquid to the consistence of treacle. There are two kinds of beer—brown and white. The former is made with molasses, the latter with white sugar. The liquid is fermented with yeast. The proportion of alcohol varies from 7 to 16 per cent. ; some spirit of wine or other preservative is occasionally added to the finished product. Spruce-beer is an agreeable and wholesome beverage having tonic and antiscorbutic properties.

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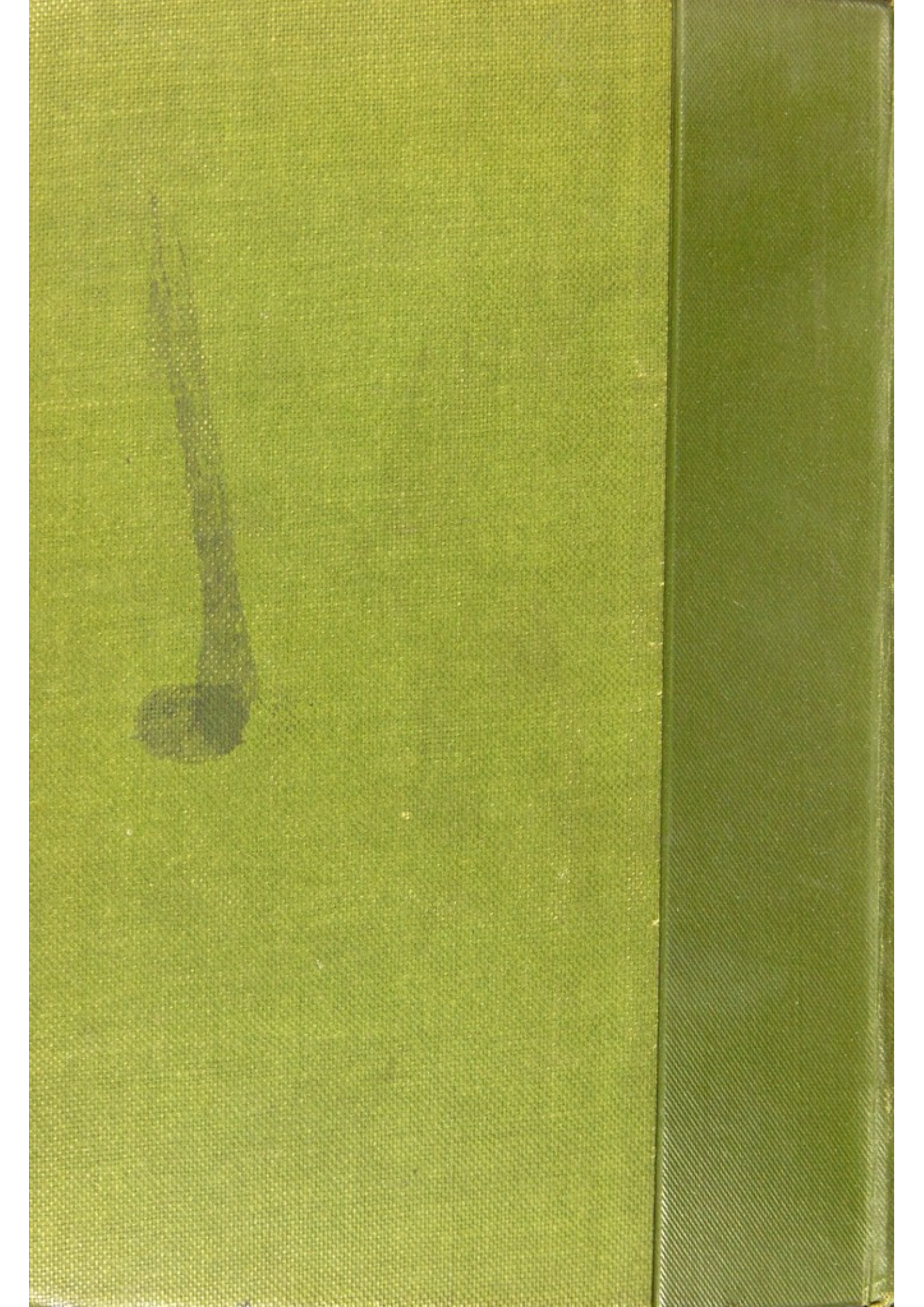
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