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THE
COMPOSITION OF FOOD
AND
HOW IT IS ADULTERATED.



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ON THE

COMPOSITION OF FOOD

AND

HOW IT IS ADULTERATED,

WITH

PRACTICAL DIRECTIONS FOR ITS ANALYSIS.

BY

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LONDON:
JOHN CHURCHILL, NEW BURLINGTON STREET.

MDCCCLVI.

ON THE

COMPOSITION OF FOOD

HOW IT IS ADULTERATED

ESPECIALLY WITH REGARD TO THE ANALYSIS

BY HARRIS W. H. B.

LONDON:
J. E. ADLARD, PRINTER, BARTHOLOMEW CLOSE

INTRODUCTION.

FEW questions have lately engrossed so large a share of the public attention, as that which relates to the adulteration of our aliments. The time has now arrived when, thanks to the progress of chemical and microscopical analysis, the attempts so frequently made to adulterate food, are no longer capable of concealment, and we hail with gratitude and satisfaction, the recent efforts of Parliament to put a stop to a practice, so injurious to the best interests of the country.

With the view of attaining an end so important to the health of the population at large, but more particularly to that of the labouring classes, it appears to me that the first step to be taken, is to investigate carefully and without any exaggeration, the different modes employed for adulterating our food, with their effects upon health; and next to determine the causes which have led to these

fraudulent practices. For, as a skilful physician, having to treat a dangerous disease, must, before he attempts to cure it, look carefully into its nature and principle, and ascertain the circumstances to which it owes its origin, so should the Government, before deciding on the legislative measures necessary for putting an end to the adulteration of food, first make itself thoroughly acquainted with the nature, extent, and cause of this most injurious practice. Then, only, can it expect to find a practical and effectual remedy.

Adulterations of food may be classed under three different heads :

1. An inferior kind of food may be mixed with a superior quality of the same article.
2. One or more of the constituents of an article of food, may be artificially increased or diminished.
3. An entirely foreign substance may be added to the genuine article.

The first class of adulterations, consists in the conversion of a better into an inferior article of food, and the greatest ingenuity is displayed in order to give to this often fraudulent mixture, the appearance of the genuine article, and thus enable it to be sold for much more than its real value. The result of this practice, is to supply

the market with a less nutritious and less valuable article of diet ; still no poison has been added to it, nothing that is likely to produce disease ; and, as Nature has ordained that there must be different classes of people, and different qualities of food, if the less opulent classes can live and thrive upon inferior bread and inferior meat, the mixture of these, with food of a superior quality, although in many cases contrary to the principles of a sound morality, can hardly be considered as seriously detrimental to the general health of the population.

The second mode of adulteration, that of increasing or diminishing one or more of the constituents of an article of food, is, no doubt, in all cases, objectionable ; still we must sometimes submit to it, on account of the impossibility of its being removed. Thus it is difficult, not to say impossible, to procure certain wines entirely free from alcohol added previously to importation ; the only inconvenience of the practice, in this case, when confined within certain limits, is that of altering, and in general deteriorating the taste and flavour of the wine. But, unluckily, this mode of adulteration is carried on to a considerable, and, in some cases, frightful extent, with other and more important articles of food within our own immediate reach ; and, though not introducing into the food any element of an actually deleterious nature, gives rise to fraudulent practices well deserving the attention of the Legislature.

The third class of adulterations is more important in a sanitary point of view. It frequently happens that certain substances, sometimes highly poisonous, are added to our food, with the view of increasing its weight, or imparting to it a bright and pleasing colour or aspect; and this fraud has become in some cases so extensive, that very dangerous symptoms and even death, may supervene from the improper use of the very means, Providence has placed at our disposal for maintaining the body in a healthy condition. It also frequently happens that foreign ingredients find their way into our food, on account of some imperfection in the method employed for their manufacture or preparation, or from want of sufficient attention on the part of the manufacturer. This source of adulteration, although highly reprehensible, as denoting carelessness or want of skill, can hardly be viewed under the light of a fraudulent, and, still less, of a criminal practice.

The Analytical Sanitary Commission of the 'Lancet' has shown the public how different our daily bread is, from what it ought to be; and the book recently published on the subject by Dr. Hassall, chief analyst to the Commission, is full of extensive and useful information. The time and labour expended on his work must have been very considerable, and the country is greatly indebted to his efforts for having placed, in so prominent a view, before the eyes of Government and of the public, the present impure

condition of various articles of food. Still, I may perhaps be allowed to add, after having perused Dr. Hassall's book with attention, that some of his descriptions appear to me rather exaggerated. It is of the utmost importance, that the author of a work such as his, should not only be perfectly impartial, but most carefully avoid overstating his case ; he must remember that in no country in the world, has trade acquired such an extension as in Great Britain, and that many honest tradespeople might be seriously injured by an overcharged statement. Besides, Dr. Hassall's book, valuable as it will prove as a reference, and in any step the Legislature may think fit to adopt on this important subject, is rather to be considered as a collection of voluminous reports, than as a guide for the medical practitioner. It is under this impression, convinced by personal experience of the want of a text-book, containing the simplest, and, at the same time, most efficacious methods for detecting the nature of the adulterations, to which our food is daily exposed, and encouraged, moreover, by a few medical friends, that I beg leave to offer this little work to the public. It claims no originality, beyond the introduction of some chemical methods not hitherto employed in the analysis of food ; but I have endeavoured, as much as possible, to adopt a careful, and, I trust, clear and satisfactory classification of the subject, and, above all, to observe the most scrupulous accuracy in every statement of facts.

The woodcuts, with but very few exceptions, have all been carefully drawn from nature, with the camera lucida, and under my direct superintendence, by Mr. Lens Aldous, and engraved by Mr. Hart.

LABORATORY OF PHYSIOLOGICAL AND PATHOLOGICAL CHEMISTRY,

8, Chapel Place, Belgrave Square ;

July, 1856.

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ERRATA.

Page 13, line 13, for "Payne" read "Payen."

„ 125, „ 3, for "left-hand" read "right-hand."

OUR FOOD,

AND

HOW IT IS ADULTERATED.

CHAPTER I.

ON FARINACEOUS AND SACCHARINE FOOD AND ITS ADULTERATIONS.

I. FLOUR AND BREAD.

By far the most important article of food is *bread*; meat being denied to thousands who, in this country, live upon little more than bread and butter, potatoes, and tea. This valuable food can be prepared from the seeds of various plants, as wheat, oats, rye, barley, Indian corn, potato, rice, &c.; but, from its peculiarly nutritive and wholesome qualities, wheat is most generally—I might say, all but exclusively—employed for the manufacture of bread, properly so called.

Oat bread is much used in Scotland and the north of Ireland, in the form of oat cake; *rye bread* is an important article of food in Russia, but we seldom meet with it in

England; *Indian corn* is sometimes made into bread by English bakers; *rice* flour is scarcely ever used for that purpose. But let it be understood that if bread generally consists of wheaten flour, wheaten bread is liable to be adulterated by every one of the meals just mentioned.

I purpose in the following pages—

1. To allude shortly to the manufacture of flour from grain, and its conversion into bread.

2. To give an account of the chemical composition of flour and its chemical analysis, both as to the quality and quantity of its constituents; and to describe the microscopical appearance of the different flours.

3. To insist more particularly on the adulterations which wheaten flour, and consequently bread, is subject to, and show the most practical and correct methods of determining the existence and nature of this fraudulent practice.

1. *Manufacture of flour.*—Wheaten and other flours are prepared from the grain, in the flour-mills; the grain is thereby reduced into a very fine powder, which, being sifted by a special mechanical contrivance, is separated into pure flour, bran, and impurities. With the view of obtaining the flour as free as possible from extraneous substances, modern mills are provided generally with three kinds of cleansing apparatus. The first consists of a series of sieves, which separates the coarser foreign particles (stones, straw, &c.) from the grains and finer impurities. The second is a sort of mill work, the stones of which are so far separated from each other that the sharp points of the grain alone are ground off, which in themselves contain no flour. The third is intended to free the surface of the grain, by attrition, from dust and dirt; and this is effected by a cylinder lined with brushes, which scrubs the grains

against the cylindrical file-like surface of the box in which it moves. The dirt is then blown away from the clean grains by means of a current of air produced by a fan.

The meal upon leaving the stones is always hot, in consequence of the friction to which it has been exposed. Warm meal heaped up is sure to spoil; it is therefore cooled by machines, which spread out the ground flour into thin layers, and constantly stir it about with a species of rake.

Another circumstance pernicious to the quality and durability of the meal is the moistening of the grain by the miller, as very dry grain is much more difficultly ground than moist. This very slight degree of dampness has a tendency to produce decomposition, and thereby the formation of a small quantity of sugar, in meal which would nevertheless be generally considered of very good quality; but this influence is sufficient to extend the decomposition to the entire destruction of the meal, which turns mouldy and acid. The mass of flour becomes acid chiefly in the centre, and in this state has a tendency to ball together in lumps, acquiring a rough nature, like coarsely ground gypsum, and is much less fit for bread.

The facility with which flour is spoiled by heat and moisture, particularly at sea, is the reason why the trade in corn is not universally superseded by the trade in flour. By drying the grain, as in England, at a low temperature in a kiln, the flour is rendered more fit for keeping; but in other respects the practice has disadvantages, which are obvious when English is compared with American flour that has been ground from undried grain. English flour is not so white, often spotted (partly from the dust of husks or from the grains being imperfectly cleansed), but it is dryer, and keeps better. American flour is the whitest of

all; prepared in better sifting machines, it has a soft, not gritty feel like the former; it is cooled in especial apparatus, whilst the former is allowed to cool in sacks.

The only method of securing flour of the quality of the American and the durability of the English, would be to grind unmoistened, or, when the stones are soft, slightly moistened grain, but at all events undried grain, and to dry it at a low temperature before packing, as has been practised in some places for sea-transport with the best results.

The quantity of the various mechanical constituents of wheat grain exhibited in the following analysis was obtained from flour manufactured in a new mill at St. Maur, near Paris :

Flour of first quality	.	.	.	.	72 lb.
„ second „	.	.	.	.	3
„ third „	.	.	.	.	3
Coarse bran	.	.	.	.	7
Fine bran	.	.	.	.	10
Black bran meal	.	.	.	.	3
Separated by sieves	.	.	.	.	1
Lost	.	.	.	.	1
					<hr/>
					100

Baking.—When meal is worked up with water, and exposed to a heat of 100° C. (212 F.), the starch which forms the greatest part of the flour becomes converted from the insoluble into the soluble state; but the cake is firm, dense, and compact, and very difficult of digestion. When the heat is such that the surface only attains the above temperature, the mass is in general doughy internally; this kind of bread was universal in former times, and is still eaten in Scotland, the north of India, and Affghanistan. The art of baking bread consists in producing a crust or roasted portion, and a crum. For ensuring the porosity of the

bread, the dough is made to ferment by the action of leaven or yeast, previous to its introduction into the oven. Three materials, therefore, are indispensably necessary to bread, namely, *meal*, *leaven* or *yeast*, and *water*. To these *salt* may be added as equally essential.

Leaven, much used in France, Germany, and Switzerland, consists of a portion of the dough already undergoing fermentation; and, according to Liebig's views, it has the property of inducing by its presence a similar molecular change and chemical decomposition in the fresh dough with which it is mixed. Yeast, employed in England instead of *leaven*, is obtained from the fermentation of the wort in the manufacture of beer; its chemical composition bears a strong analogy to that of leaven; and it possesses the same power of inducing the fermentation of the dough. Fermentation raises the dough by the evolution of gas through its entire mass, the gas in question being carbonic acid; a small quantity of sugar and some alcohol also result from the same process, these various products owing their formation to the decomposition of a part of the starch, and a little sugar preexisting in the flour, from the action of the ferment. During the process of baking, the whole of this alcohol and some carbonic acid are given out by the dough, and consequently a loss of flour is incurred. The reader will be astonished at the amount of alcohol, or spirits of wine, dissipated by the heat of the oven; thus, in London, the quantity of bread consumed annually, supposes the evolution of about *three hundred thousand gallons* of spirits, which, at the price of nineteen shillings per gallon, would be worth *two hundred and eighty-five thousand pounds*. All the experiments undertaken with the view of preventing the loss of this alcohol have failed; and in the military bakehouse at Chelsea, twenty thousand pounds have

been expended in vain upon a collecting and condensing apparatus.

For the purpose of avoiding the loss of substance resulting from the fermentation of the dough, the addition of carbonate of soda and hydrochloric acid were recommended first by Henry, as a substitute for fermentation, and the process was patented, in 1837, by Whiting. Some time afterwards, Dr. R. Thomson observed, that a sack of flour yields only one hundred loaves, by the fermentation process, while, on the improved system, it would yield one hundred and seven loaves. According to other experiments by Frickinger, the saving would not be so considerable; but still it would be sufficient to cover the cost of the new raising material. The chemical action resulting from the addition of bicarbonate of soda and hydrochloric acid to the dough, is interesting; the bicarbonate of soda is decomposed, yielding free carbonic acid, which, from its gaseous form, permeates and raises the mass, and chloride of sodium or common salt, a substance added at all events during the baking in the fermentation process. In Germany, carbonate of ammonia is occasionally used, instead of hydrochloric acid and bicarbonate of soda. The heat of the oven induces the escape of this substance in the form of a gas, and it is entirely volatilized after the baking, leaving wide interstices in the dough. Unfortunately, bread prepared by this method is tough, and unequally inflated; and consequently heavy and difficult to digest.

During the process of baking, the dough becomes much lighter from the loss of water; when, therefore, the bread is required to be of a certain weight, this loss must be calculated upon in forming the loaf. According to Accum, seven pounds of flour yield ten pounds of dough, and eight pounds three quarters of bread.

According to Herbstädt, three pounds of flour yield four pounds of bread. In the military bakehouse at Hanover, eight pounds five ounces of dough are required for a seven pounds loaf. I might add many interesting details upon the manufacture of bread, but they would be altogether misplaced in this little work, where I propose to call the attention of the reader more particularly to the adulteration of food.

Flour may be obtained from any kind of seed containing much starch, and in the majority of cases, the different meals thus prepared will exhibit the same characters to the naked eye. It is obvious, therefore, that the methods we possess for detecting the characteristic properties of different flours are of the highest value, as they enable the observer not only to determine which is the flour under examination, but also to find out with the greatest accuracy if a particular flour is perfectly pure, or has been mixed up with other meals previous to its being converted into bread.

Moreover, not only are flours to be met with fraudulently mixed together, but also entirely foreign substances are occasionally added to them; both these adulterations escape completely the scrutiny of the naked eye, and would remain unknown, were it not for the methods of investigation we possess, depending upon the following chemical and microscopical properties of flour.

2. *Chemical composition and analysis of flour.*—The normal constituents of any kind of flour are *water, starch, gluten or fibrin, lignine* from the bran, a small quantity of *albumen*, of *sugar*, of *dextrine*, and finally, *inorganic or mineral salts*.

The qualitative analysis of flour, or the determination of

the presence of the substances just enumerated, is best effected as follows :

A sample of the flour being gently heated in a glass tube, water will be disengaged, and the vapours by collecting on the cold upper part of the tube, will show that it contains more or less moisture. The flour is next to be kneaded with enough water to make it into a semifluid paste, and tightly tied up in a towel or piece of clean calico ; this dough when squeezed in pure water, with the thumb and index-finger, will give out starch under the form of a granular substance, falling down to the bottom of the vessel. On boiling this, or any other fluid which contains starch in suspension, the granules will be noticed to swell and finally dissolve, yielding a solution, which if considerably diluted with water and mixed with weak nitric acid and iodide of potassium, acquires a blue colour.

The dough having been thoroughly expressed under water, nothing is left in the calico but the *fibrin* or *gluten*, (with perhaps a few particles of bran,) whose chemical properties may now be examined ; its fibrinous consistence will suffice, however, to show its presence ; after a few hours the starch obtained by the above process, and suspended in the water with which the flour has been washed, subsides to the bottom of the vessel ; the upper part of the fluid, now become clear, is decanted and tested, first, for *albumen* ; for this purpose, heat is applied to a sample of the clear fluid and when boiling it will become turbid and deposit flakes, owing to the presence of this substance. The above result is confirmed if a few drops of nitric acid added to the turbid liquid do not dissolve the deposit. The fluid also usually contains a little *grape sugar*, which substance is detected by means of sulphate of copper and caustic potash,

dissolved in water. Enough sulphate of copper is added to a sample of the clear aqueous extract to give it a decidedly blue colour; the potash solution poured into this mixture will first induce a precipitate, disappearing, however, when an excess has been used, and a dark blue fluid is thus prepared, which is now to be heated; as soon as it commences to boil (if any sugar be present,) a red precipitate will occur in the liquid, subsiding to the bottom of the test tube, and consisting of suboxide of copper.

In order to avoid the trouble of preparing solutions of sulphate of copper and caustic potash as often as a test for grape sugar is wanted, a test fluid can be conveniently made by adding, first, a small quantity of potash to a solution of sulphate of copper, and then adding enough tartaric acid to dissolve the precipitate thus obtained. By mixing, subsequently, a large quantity of potash with this solution, it will acquire a deep blue colour, and may be preserved in this state as an excellent means of detecting the presence of grape sugar.

Another sample of the clear fluid extract from the flour deprived of albumen by boiling and subsequent filtration, is now evaporated to dryness, and the residue boiled with alcohol to remove all the sugar; the substance insoluble in alcohol consists of *dextrine*, which differs but slightly from gum, or mucilage. When dissolved in water, and boiled with a diluted mineral acid, dextrine as well as gum is converted into grape sugar; thus, with the tartrate of copper and potash test, the presence of these substances may also be determined. A small quantity of *bran* is usually found in flour; it is obtained by mixing the flour with a large quantity of water, and then decanting the fluid before the starch has time to subside. The bran will then be observed settled at the bottom of the vessel.

The *fats* contained in flour are best separated by treating the meal with cold ether, and evaporating the ethereal extract to dryness. Finally, the inorganic salts or *ashes* are obtained by incinerating the flour in a platina capsule. The analyst having proceeded so far, and convinced himself of the presence or absence of the normal constituents of the flour under examination, is to continue his investigation with regard to the quantitative composition of the meal; he now requires a balance, but a very delicate instrument is not absolutely necessary. The process to be followed is much the same as that recommended for the qualitative analysis; a weighed sample of the flour, say two grammes (about 30 grs.), is dried in the water bath and re-weighed, the difference showing the quantity of water present. The same sample of flour, or another weighed quantity, if preferred, is now tied up in calico and expressed under distilled water with the thumb and index finger until it does not yield any more starch. This operation must be performed very carefully, lest any of the fluid should be lost; it will be found necessary to wash the flour with small successive quantities of pure water, collecting the whole fluid into the same vessel. This part of the analysis will last about two hours; when finished, the analyst may throw a little pure water on his fingers with a pipette and add this fluid to the main solution. The string binding the calico bag being now unfastened, the gluten will be found comparatively pure, and by scraping the cloth carefully with a blunt knife it may be removed and conveyed to a watch glass to be dried on the water bath and weighed.¹

¹ The weight of fibrin obtained by this method is rather below the true estimate; the result would be somewhat more accurate by weighing the dried calico without and with the dry fibrin, and calculating the difference between the two weights, care being taken to wash the calico thoroughly before using it.

The starch is determined as follows : ascertain the weight of the fluid obtained by the above process, and allow it to stand undisturbed for some hours in a beaker covered with a glass plate, to enable the starch to subside ; then, let a certain amount of the clear liquid be decanted in a weighed capsule, and weigh the capsule again with the fluid ; it is next to be evaporated to dryness on a water bath, the residue obtained thoroughly dried and then weighed, the quantity of water being thus determined. Whilst this operation is proceeding the analyst will evaporate also to dryness the remainder of the fluid containing the starch, whose weight has already been ascertained, and this residue, when dry, is also to be weighed. The amount of the starch may be calculated by the following proportion : The weight which the clear fluid lost by evaporation is to that of the solid residue it contained, as the weight of the water lost by the evaporation of both fluids is to x or the weight of the whole residue soluble in water ; by calculating this proportion, and subtracting the result from the sum of the weight of both residues, *the amount of starch* will be obtained. I have employed repeatedly this method, and believe it to give correct results.

To determine the amount of sugar in the sample of flour examined, the dry residue from the clear fluid is boiled with alcohol, and the solution decanted ; the residue being again dried, and weighed, and subtracted from the weight of the residue previous to the addition of alcohol, the difference between the two weights will represent the quantity of sugar. By calculating the following proportion the total amount of sugar is ascertained. The weight of the residue in the clear fluid is to the weight of the sugar obtained, as the weight of the residue of the whole clear fluid, the result of a previous calculation, is to x .

The weight of the dextrine has been already determined: it is the difference between that of the sugar and the weight of the residue left by the evaporation of the clear fluid; the total amount is to be calculated by a proportion similar to the above. The albumen of flour is usually weighed with the dextrine.

The quantity of fatty matters contained in a given amount of flour can be ascertained by treating a weighed quantity of flour with ether, evaporating this extract to dryness, and weighing the residue.

The weight of the inorganic salts is determined by burning a known quantity of the flour.

For the determination of the quantity and quality of gluten, an ingenious contrivance has been invented by Mr. Hubart, and termed the aleurometer, which is described in Dr. Hassall's book. It consists of a hollow copper cylinder, about six inches long, and from three quarters of an inch to an inch in diameter. It has two principal parts, the one, about two inches long, is closed at one end, forming a kind of cup capable of containing about 200 grains of fresh gluten; it screws into the remainder of the cylinder. The cylinder being charged with gluten, is heated to about 420° in an oil bath; by this treatment the gluten swells more or less in the tube according to its quality; its increase or decrease in bulk may be measured with a graduated stem. Good flours furnish a gluten which augments to four or five times its original bulk; but bad flour gives a gluten which does not swell, becomes viscous and nearly fluid, adhering to the sides of the tube, and giving off occasionally a disagreeable odour, whilst that of good flour merely suggests the smell of hot bread. To this we may add, that the practical importance of the instrument is diminished by the necessity of separating the gluten from the flour pre-

vious to its introduction into the test-case; moreover, this method is calculated to show rather the quality of the gluten than its quantity.

The corn-chandlers and bakers, to determine the quality of their flour, make a sample into a paste with a little water, and draw it into a thread, or spread it out into a thin sheet with the thumb and index finger, and they judge of the quality of the dough from the length to which it may be drawn or spread out.

The chemical composition of flour of the same kind may vary between certain limits, so that a slight increase or diminution of its constituents is not an indication of its being adulterated. Thus, Payne found the amount of gluten to vary in four varieties of wheat from nine to twenty-two per cent., and, what is of interest in reference to the bran, a diminution of gluten towards the internal part of the seed, so that the proportion of flour which remains in the bran is richest in gluten. Analogous results were obtained from Fürstemberg in wheat bran.

According to Dumas, the composition of wheat flour is as follows :

	Wheat Flour.	Odessa flinty.	Odessa soft.
Water . . .	10.00	12.00	10.00
Gluten . . .	10.96	14.55	12.00
Starch . . .	71.49	56.50	62.00
Sugar . . .	4.72	8.48	7.36
Dextrine . . .	3.32	4.90	5.81
	<hr/> 100.49	<hr/> 96.43	<hr/> 97.17

The following is the mean between two analyses of the same flour which I performed in my laboratory :

100 parts of the dry flour contained—

Starch	82.043
Gluten	8.950
Sugar	5.200
Dextrine	3.002
	<hr/> 99.195

The average composition of bran is represented as follows, by Johnstone :

Water	13.1
Gluten and albumen, coagulated	19.3
Oil	4.7
Husk and a little starch	55.6
Saline matter (ash)	7.3
	<hr/> 100.0

From the large quantity of gluten known to exist in bran, it may be concluded that, in the present system of grinding, the most nutritious portion of the grain is not contained in the flour. The husk in good wheat amounts on an average to fourteen or sixteen per cent. of the entire weight, though the quantity separated at the mill is often not more than one-ninth or eleven per cent.

Microscopical characters of flour.—The microscope affords means of detecting readily any kind of flour from the form of its starch corpuscles. Wheaten flour is often adulterated with an inferior farina, so that it is of the greatest importance that the analyst should be acquainted with its microscopical character. The accompanying woodcuts show the forms of the starch of *wheat flour*, *potato flour*, *barley flour*, *rye flour*, *Indian corn flour*, *rice flour*, *arrowroot*, *sago*, *bean*, *oat*, and *pea*.

To obtain the starch for examination, let the flour be kneaded into a thin paste with water, and then squeezed through calico. To extract potato starch, pound the raw potato in a mortar, and then strain the pulp through a cloth ; in every case the starch will fall to the bottom of the fluid, in a state fit for microscopical examination. If the observer should wish to see the starch granules in the vegetable cells, he must prepare a very thin section of the grain with a sharp knife or a razor ; place the section on the



Wheat Starch.
(Magnified 290 diam.)



Potato Starch.
(Mag. 290 diam.)



Barley Starch.
(Mag. 290 diam.)



Rye Starch.
(Mag. 290 diam.)



* Indian-Corn Starch.
(Mag. 290 diam.)



Rice Starch.
(Mag. 290 diam.)



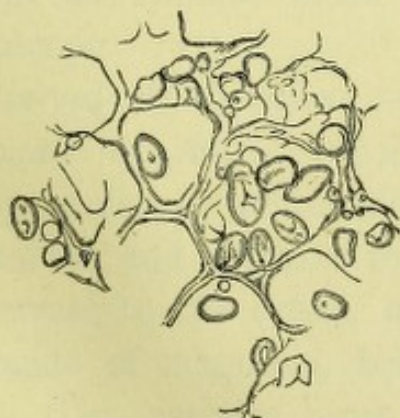
Arrowroot Starch.
(Mag. 290 diam.)



Sago.
(Mag. 290 diam.)



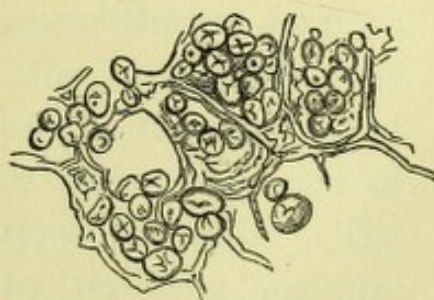
Bean.
(Mag. 290 diam.)



Section of the Pea (internal structure).
(Mag. 220 diam.)

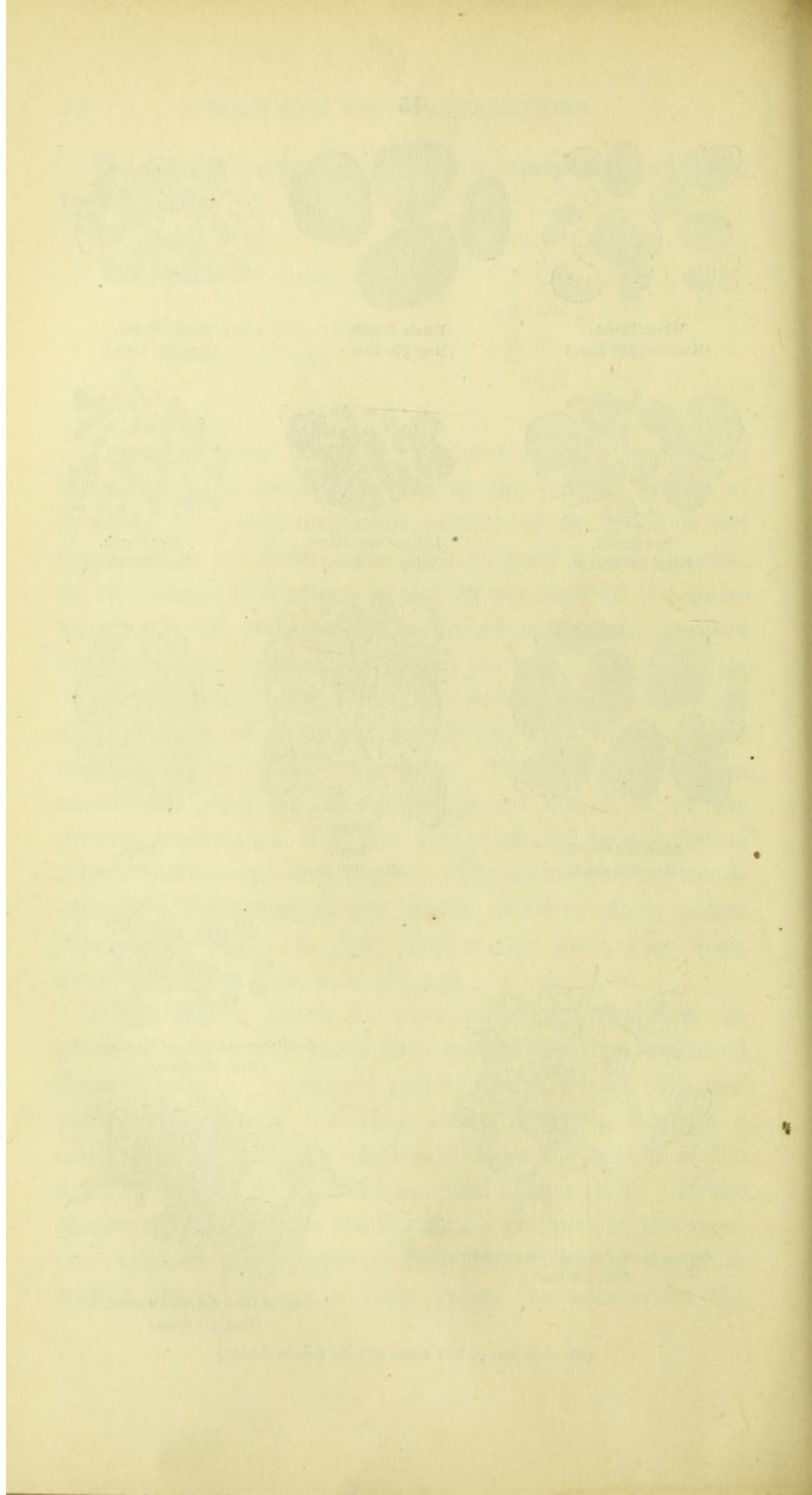


Substance and Hair of the Oat.
(Mag. 290 diam.)



Section of Bean (internal structure).
(Mag. 110 diam.)

(The above have all been drawn with the Camera Lucida.)



microscope glass, moisten it with a drop of water, and cover it with a piece of thin glass, when, if the section is sufficiently thin, the structure will, under a low magnifying power, be beautifully displayed. Starch corpuscles, boiled in water, swell, and finally burst, losing their original structure, so that, when intended for microscopical examination, it is important not to extract them with hot water. A glance with the microscope will therefore enable the observer to ascertain at once whether a sample of any kind of flour be pure, or mixed with other farinæ.

3. ADULTERATIONS OF WHEAT FLOUR.—The substances principally employed for the purpose of adulterating genuine wheat flour are *potato starch*, *bean flour*, *Indian corn flour*, *rye flour*, *rice flour*, *alum*, *chalk*, *carbonate of magnesia*, *silica*, *clay*, *bone dust*, and *plaster of Paris* (sulphate of lime). I have already given the reader illustrations of the microscopical characters of the various kinds of starches (see p. 15), and shall add no more to this subject at present.

To determine the nature of the mineral substances with which wheaten flour may be admixed, the analyst must have recourse to chemical methods; still, in many cases, he will also obtain much valuable information from the microscope.

Mineral Adulterations.—1. *Carbonate of magnesia and carbonate of lime.*—When added, together or individually to new or inferior flours, these substances improve the colour and increase the yield; the adulteration may be carried to the extent of from ten to forty grains of carbonate of magnesia, being mixed with one pound of flour. This practice must be injurious to health. The microscope will aid in this case, by revealing the presence of small specks mixed with the starch corpuscles,

and insoluble in water; if dilute hydrochloric acid dissolves entirely these particles with the evolution of carbonic acid, carbonate of lime or carbonate of magnesia are present. To distinguish between them, burn a sample of the flour to a white ash on a foil of platinum, dissolve the residue in dilute hydrochloric acid, and filter; finally, add to the filtered fluid ammonia and phosphate of soda; the occurrence of a crystalline precipitate will be a proof that the amorphous particles seen with the microscope, consist partly if not entirely of carbonate of magnesia. If no crystalline precipitate be formed, to another sample of the original solution add ammonia and oxalic acid, the appearance of a precipitate insoluble in acetic acid will show the presence of lime. If the co-existence of lime and magnesia or their carbonate be suspected in flour, the ashes of the incinerated meal, being dissolved in weak hydrochloric acid, are tested first with ammonia and carbonate of ammonia, which throws down all the lime in the form of carbonate of lime; the fluid filtered from this precipitate is now mixed with phosphate of soda and more ammonia, when the magnesia will be precipitated in the crystalline combination known as the phosphate of ammonia and magnesia.

To determine the amount of lime and magnesia contained in the ashes of a weighed quantity of adulterated flour, the analyst must proceed as directed for the qualitative analysis just described; the lime and magnesia precipitates are to be collected on separate filters, and subsequently burnt and weighed.¹ This method does not yield chemically exact results, they can only be considered as approximations, but will suffice for all practical purposes.

¹ 100 parts of the burnt magnesia, precipitate or pyrophosphate of magnesia, contain	} Phosphoric acid, 63·36. } Magnesia, 36·64	
		<hr/> 100·00

Bone dust, or phosphate of lime.—For the detection of this adulteration a knowledge of the structure of bone-tissue and a microscope may suffice; in case the reader should not be acquainted with microscopical physiology, he may again call in aid chemical analysis, and by a very short and easy process detect the adulteration; this is done by burning the suspected flour to a white ash, a portion of which is subsequently treated with water, and filtered; if the substance on the filter dissolves by the addition of dilute hydrochloric acid, without the evolution of carbonic acid; and if in this solution, neutralised with ammonia, oxalic acid produces a granular precipitate, insoluble in acetic acid, and molybdate of ammonia with nitric acid, a yellow precipitate when the mixture is heated, the foreign substance is proved to consist of phosphate of lime. Another short method is alluded to in the synoptical table of the adulterations of flour. (See page 22.)

Sulphate of lime.—When sulphate of lime (*gypsum*, or *plaster of Paris*) has been added to flour, the operator is first led to suspect the fraud by the appearance under the microscope of small amorphous particles having no organized structure, and mixed with the starch corpuscles; if the addition of hydrochloric acid does not decompose them, with evolution of carbonic acid, these molecules consist of sulphate of lime, or silica (sand). A sample of the flour is now burnt on a charcoal support, mixed with a little carbonate of soda and borax, and fused. The fused mass being placed upon a clean silver surface, say a bright shilling, and a drop of water being added, if sulphate of lime is present a black stain will be produced on the shilling, with the evolution of sulphuretted hydrogen. On washing the silver, the spot becomes evident.

Silica (sand) may exist in flour from its being added

with the view of adulterating the meal, or perhaps being detached accidentally from the millstone. Its presence can be detected, along with that of clay, by the occurrence of small particles in the field of the microscope mixed with the starch corpuscles, and which, by the application of the above-mentioned tests, are not found to consist of bone dust, carbonate or sulphate of lime, and carbonate of magnesia. A better means, however, for discovering the existence of silica in flour is to fuse a sample of the ashes of the farina with a small quantity of microcosmic salt (phosphate of soda and ammonia), and then expose the mixture to the blowpipe flame on a platina wire, a bead will thus be formed, remaining perfectly transparent if no silica be present, and exhibiting opaque specks if it should exist therein, even in the smallest quantity. (Plattner, 'On the Use of the Blowpipe,' p. 239.)

Clay, or Silicate of alumina.—The presence of this adulteration may be detected by treating the ashes of the flour with water; an insoluble residue will thus be obtained, which, when placed on the charcoal support, moistened with nitrate of cobalt, and exposed to the blowpipe flame, assumes a beautiful sky-blue colour. As a further proof, let the insoluble residue be tested with microcosmic salt in the blowpipe flame, for the detection of silica.

Alum (sulphate of alumina and potash, or sulphate of alumina and ammonia) is very often employed for the adulteration of flour, with the view of increasing the white appearance of the bread, and its power of retaining water. As alum is soluble in water, its presence is to be looked for in an aqueous extract of flour. If a sample of the meal be mixed with water, the fluid expressed through a cloth, and allowed to stand for

some hours, a comparatively clear liquor is obtained. A small quantity of the fluid being decanted, if a precipitate is induced therein by ammonia and chloride of ammonium, with the application of heat, alum is very probably present; for a confirmatory test, the precipitate may be collected on a filter, dried, and burnt on a charcoal support with the blowpipe flame; a few drops of a solution of nitrate of cobalt are added to the substance, which, being again heated with the blowpipe, exhibits a blue colour if alumina be present.

For sake of practical convenience, I have condensed the methods of analysis, for the detection of the adulterations of flour, into the following synoptical table—

SYNOPTICAL TABLE, showing how to analyse Flour with the view of detecting its Adulterations.

<p>FLOUR, kneaded in water and strained through a cloth, yields—</p>	<p><i>Gluten.</i> Nature determined by drawing into threads.</p> <p>A Solution, containing { <i>Alum</i> (adulteration), precipitated by the addition of ammonia and chloride of ammonium, with the applica- <i>Albumen</i>, precipitated or coagulated by boiling. <i>Sugar.</i> Gives an orange-coloured precipitate with sulphate of copper and potash. <i>Gum or Dextrine</i>, transformed into sugar by boiling with dilute sulphuric acid.</p>	<p>Other adulterations, indicated by the microscope and chemical reagents</p>	<p>Starch, microscopical examination effects the detection of the following adulterations:</p>	<p>Potato Starch Barley " Rye " Oat " Indian } Corn } Rice " Other legumi- nous Seeds</p>	<p>Carbonate of Magnesia</p>	<p>Microscopical examination—Small amorphous specks. Chemical examination—Dissolved by the addition of dilute hydrochloric acid, with the formation of small bubbles, and precipitated crystallised by phosphate of soda and ammonia.</p>	<p>Carbonate of Lime</p>	<p>Microscopical examination—Small amorphous specks. Chemical examination—Dissolved by the addition of dilute hydrochloric acid, with the formation of small bubbles, and precipitated by ammonia and oxalate of ammonia.</p>	<p>Bone-dust</p>	<p>Microscopical examination—Not entirely soluble in dilute hydrochloric acid.</p>	<p>Sulphate of Lime</p>	<p>Microscopical examination—Small amorphous particles. Chemical examination—Not entirely soluble in dilute hydrochloric acid. The ashes of the flour leave a black stain on silver when burnt in blowpipe flame with carbonate of soda and borax.</p>	<p>Sand</p>	<p>Microscopical examination—Large amorphous particles, of an angular form. Chemical examination—Insoluble in hydrochloric acid; an opaque bead when ashes of flour are fused in blowpipe flame with microcosmic salt.</p>	<p>Clay</p>	<p>Microscopical examination—Amorphous particles. Chemical examination—A blue colour produced when ashes are treated with nitrate of cobalt and fused with blowpipe.</p>

DISEASES OF CEREAL GRASSES LIABLE TO ADULTERATE
WHEAT FLOUR.

A short account is given here of the diseases of cereal grasses: as every kind of meal, whether diseased or healthy, may be employed to adulterate flour, it is important to be acquainted with the microscopical appearance of the affected grains.

The Ergot.—In this case the diseased grain becomes white and spongy in the interior and purplish-black on the exterior; its structure is destroyed, and in its place may be observed a tissue formed of very minute and angular cells, containing one or more small corpuscles.



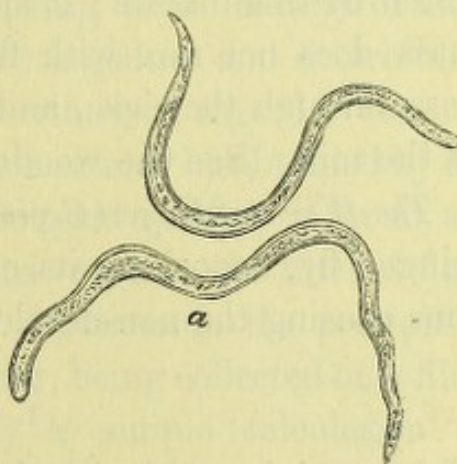
Ergot of Rye.
(Mag. 290 diam.)

The Bunt, Smut Rolls, or Pepper Brand (Uredo caries), confined to wheat, can be detected by the microscope, and the disgusting odour of the affected grain (Hassall); wheat thus adulterated is occasionally purchased by vendors of ginger-bread.

The Smut or Dust Brand (Uredo segetum, b), is comparatively rare in wheat, but very common in barley, and even more so in oats; rye does not appear to be subject to it; it has been observed in several grasses.

The Rust, Red-rag, Red-robin, Red-gum (Uredo rubigo, Uredo

a. *Vibrones Tritici.*



c. *Uredo Caries.*



b. *Uredo Segetum.*

(From Dr. Hassall's book.)

linearis), is an orange powder exuding from the inner surface of the chaff scales, but scarcely if ever to be seen in the skin of the seed; it exists also in patches beneath the epidermis of the straw; and is a common fungus of corn and grasses. This vegetable product is not so injurious as the true mildew.

The Mildew (Puccinia graminis).—The ripe spores of this fungus are little, intensely dark-brown, club-shaped bodies, having the thicker end divided into two chambers well filled with sporules; they taper gradually at the base into a fine stalk.

Parasitic animal productions (Vibrio tritici).—Upon opening the blighted wheat grains, they are found to be filled with a moist cottony substance, consisting, when viewed with the microscope, of a multitude of eel-shaped animalcules, endowed with an active movement; the grains containing no flour. Samples of wheat are often much infested by this disease; it appears probable that the cottony mass does not mix with flour, from its not being able to pass through the sieve, and remains behind with the bran at the mill. (See the woodcut.)

The Wheat Midge (Cecidomyia tritici) is a minute two-winged fly, depositing its eggs in the wheat blossoms, and thus causing the non-development or abortion of the grain.

I. BREAD

May be adulterated with the substances above mentioned in regard to the adulteration of flour. It is more difficult to detect the form of the starch corpuscles in bread than in wheat flour. Rice flour and mashed potatoes are the meals most frequently added to wheat flour by the baker.

Alum.—The method for detecting the presence of alum in bread is the same as that described in the

case of flour, *i. e.*, the bread may be kneaded in water, the fluid filtered, the clear filtrate mixed with ammonia and chloride of ammonium, and boiled; if a precipitate appear, the presence of alum is probable; let the precipitate be now collected on a filter, dried, moistened with a solution of nitrate of cobalt, and then burnt with the blowpipe flame; the appearance of a blue colour will be a satisfactory proof of the presence of alum. For a quantitative determination, ascertain the quantity of water present in the bread by desiccation, incinerate the dry mass, and digest it with dilute hydrochloric acid; then add ammonia, and apply heat to the mixture for some time, when the alum is precipitated in the form of alumina, which is collected on a filter, dried, and weighed.

Hards and stuff.—Some bakers buy rock alum in powder, and mix it up in certain proportions with salt, the majority, however, make use of an article known in the trade as hards and stuff, consisting of a mixture of alum and salt. The method for detecting alum and determining its quantity has already been described; in regard to common salt, or chloride of sodium, its amount may be obtained by dissolving in water the ashes of a weighed quantity of bread, and adding nitrate of silver and nitric acid to the filtered fluid, until no further precipitate be occasioned; the precipitate, which consists of chloride of silver, being collected on a filter, dried, and weighed, shows by a simple calculation the quantity of chlorine present corresponding to the chloride of sodium.¹

Sulphate of copper.—This adulteration has not yet been detected in English bread; it is employed on the

¹ 100 parts of chloride of silver contain	} Silver . 75·28 } Chlorine 24·72	100 parts of chloride of sodium contain	} Sodium . 39·63 } Chlorine 60·37
	100·00		100·00

Continent, and chiefly in Belgium, to improve the colour of bread, and its power of retaining moisture. To detect this poison, let the analyst macerate a sample of the suspected bread in water, evaporate the water nearly to dryness, and then add a solution of caustic potash or ammonia in excess; if a blue colour be obtained, it results from the presence of sulphate of copper.

Accidental adulteration with arsenic.—Arsenic has been detected in bread, on which occasion Dr. A. Taylor narrowly escaped being poisoned. In his case, the only one I am aware of where bread was found accidentally adulterated with arsenic, the loaves had been placed whilst hot, by the baker, on newly varnished shelves; the varnish was green, and consisted of arsenite of copper; it had been fused by the hot bread, and absorbed by the crust, which was in contact with the shelf; fortunately the adulteration was perceived in due time.¹ Let the reader, therefore, be cautious if he should meet with bread accidentally coloured. It would take too much space to describe minutely the methods employed for the detection of arsenic, and I must beg to refer the reader to the fourth edition of Fresenius's book on 'Qualitative Analysis' (translated by L. Bullock), where he may find a very correct and clear account of the best means to effect this purpose. (See also page 43.)

Water.—Flour, in its ordinary state, is supposed to yield about 17 per cent. of water;² bread contains a much larger amount of this fluid; when mixed with alum and salt, it absorbs still more; and when, besides these ingredients, rice flour is used, the quantity of water imbibed and retained is even greater. From some experiments instituted by the Commission of the 'Lancet,' it

¹ 'How Families are Poisoned,' &c., by Dr. A. Taylor, 'Medical Times and Gazette' for 1854, page 326.

² This quantity is, perhaps, rather above the average.

appeared that a loaf, consisting of two pounds of flour, and a sufficient quantity of water and German yeast, weighed two pounds eight ounces and a half when removed from the oven, so that it had taken up eight ounces and a half of water additional; a second loaf containing, in addition, two scruples of alum and half an ounce of salt, weighed, when taken from the oven, two pounds and ten ounces; its weight having increased by nine ounces and a half (deducting the alum and salt); and a third loaf, consisting of the same ingredients, but half a pound of wheat flour being replaced by the same quantity of rice flour, was found to weigh, when baked, two pounds ten ounces and a half; thus containing nearly two ounces of water, in addition to the seventeen per cent. belonging to the flour from which the bread was made.

II. COCOA.

This important article of food is prepared from the seeds of *Theobroma Cacao*, which grows in the West Indies and parts of South America.

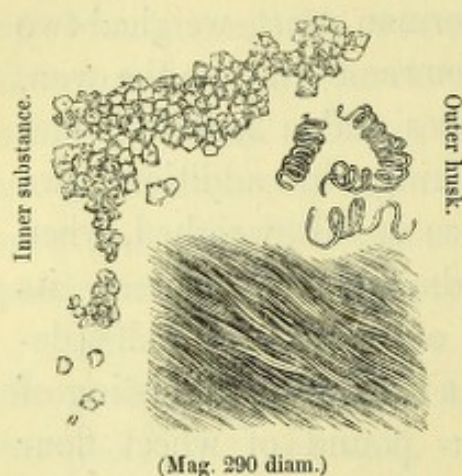
Composition of 100 parts of the seeds of West India Cacao, according to Lampedius:

Fatty matter	53.10
Albuminous brown matter, containing the aroma	
of the bean	16.70
Starch	10.91
Gum	7.75
Lignine	0.90
Red pigment	2.01
Water	5.20
Loss	3.43
	<hr/> 100.00

The shells or husks form about twelve per cent. of the weight of the bean, they contain but little fat, some lignine and some mucilage.

Structure of the Cocoa seed (see the woodcut).—The

husk may be observed, under the microscope, to consist



especially of tubular fibres, whilst the substance of the seed is composed of minute cells, the cavities of which are filled with starch corpuscles and fatty matters. Cocoa is sold in this country, under the names *flake*, *rock*, *granulated*, *soluble*, *dietetic*, *homœopathic*, &c.

Adulterations of cocoa.—*Chocolate or Cocoa* is adulterated (according to Mitchell) with *flour*, *potato starch*, and *sugar*, together with *cocoa-nut oil*, *lard*, and *tallow*. Even the so-called finest chocolate is occasionally made up with *clarified mutton suet* and *common sugar*, together with ordinary *cocoa*. The mineral substances employed in preparing chocolate may be red and yellow ochre, minium (red lead), vermilion, sulphate of lime, chalk, &c.

Normandy has known cocoa powder made of potato starch, moistened with a decoction of cocoa-nut shells and sweetened with treacle, and also chocolate, made of the same materials, with the addition of tallow and ochre; he has also met with chocolate in which brick dust and red ochre had been introduced to the extent of twelve per cent., another sample contained 22 per cent. of peroxide of iron, the rest being starch, cocoa-nuts with their shells, and tallow.

Animal fats and oils.—Method employed by the Commission of the 'Lancet'¹ for their detection: boil the cocoa in water and examine the quantity and nature of the fatty substance floating on the surface, when cool. If half an ounce of cocoa boiled for ten minutes with ten ounces of water, in an open vessel, yields more than sixty-five grains of con-

¹ See 'Food and its Adulterations,' by Dr. Hassall, p. 213.

crete fat, it is probably adulterated with fatty matters. In cases where no excess of fats is observed, let the appearance of the fat globules be examined; if these are numerous, firm, shot-like, and globular, (except on the upper surface, which is slightly flattened,) and very small, rarely exceeding the twelfth of an inch in diameter, there is no doubt but that the globules in question consist of the fat or butter proper to cocoa. If the globules be large, flat or disc-like, and exceed considerably the above size, some of them attaining to one fourth of an inch, and even more in diameter, then animal fat or oil is probably present, a conclusion which may be still further confirmed by keeping the fat for some time exposed freely to the air, and observing whether it becomes rancid or not.

From experiments instituted by the Analytical Commission of the 'Lancet,' it appears that the presence of neither sugar nor starch modifies very considerably the size and form of the fatty globules of cocoa, although less fat, especially when starch is used, collects on the surface.

Starch.—If the amount of starch in cocoa be very great, a cold decoction of cocoa will be thick or jelly-like. The nature of the starch will be determined at once by the microscopical examination of the substance which is deposited in a cold infusion of cocoa. (See page 15.) The Commission of the 'Lancet' proposes to obtain an estimate of the quantity of starch by the thickness of the clear stratum occurring in a decoction of cocoa when cold; it is, however, evident that such measurements can only be considered approximately correct. The analyst ought first to make the experiment with a known quantity of pure cocoa mixed with a given amount of starch. In the investigations instituted by the Commission of the 'Lancet,' five tubular glasses each seven inches and a half in height, three fourths of an

inch in diameter, and holding twelve drachms of water, were filled with five different cold decoctions of cocoa, containing respectively 50, 40, 30, 20, and 10 per cent. each of starch; in the first, the thickness of the clear stratum was one inch; in the second, one inch and a half; in the third, two inches; in the fourth, two inches and a half; and in the fifth, two inches. The proportion of the ingredients forming each decoction was 220 grains, by weight, of a mixture of cocoa and potato flour, to eight ounces of water, the boiling being continued for five minutes in each case.

Sugar.—Should the cocoa contain sugar as well as starch this must be first removed by means of cold distilled water, and its amount ascertained. The Commission of the 'Lancet' recommends the following short and practical method of determining the quantity of sugar in cocoa. Dissolve in cold water a weighed quantity of dry cocoa containing sugar; filter, dry the residue by means of blotting-paper and heat, weigh; the loss will indicate very nearly the amount of sugar with which the sample of cocoa operated upon was admixed. Of course this method of analysis supposes that cocoa contains no other principle soluble in water than sugar; this appears to be the case, from the Commission having observed that pure cocoa when immersed in cold water for some minutes, loses only about 3 per cent. of its weight. A rough way of testing the presence of sugar in the cold extract of cocoa would be to evaporate it nearly to dryness, and taste the few last drops; this experiment can be made at any time on the breakfast table: let a teaspoonful of cocoa be scraped with the knife or crushed with its handle, if in the form of nibs, place it for five minutes in a cup containing a tablespoonful of cold water, and strain through the corner of a napkin into another clean tablespoon; finally, evaporate the fluid by heating

the spoon over a few red hot ashes, or upon a spirit lamp ; when only a few drops of it remain in the spoon, ascertain, by tasting, whether the extract be sweet. (See also the article on Alcoholic Beverages.)

Mineral Substances.—The mineral substances employed for the adulteration of cocoa are carbonate of lime or chalk, sulphate of lime or plaster of Paris, red earth, red ochre or Venetian earth, the three latter being chiefly employed to colour the cocoa. To detect these adulterations, the cocoa may be incinerated, and the ashes tested ; but I think it will be found preferable to scrape the falsified sample, or crush it into a fine powder ; boil it thoroughly with water until nothing more be dissolved from it, and decant the fluid. Let the insoluble residue be now tested for *carbonate of lime* by pouring dilute hydrochloric acid upon a sample of the undissolved powder, and noticing whether any carbonic acid be evolved (see also page 18) ; for *sulphate of lime*, by fusing a sample of the residue with nitrate of potash, dissolving the fused mass in water, and testing this solution with oxalate of ammonia for *lime*, and with chloride of barium for *sulphuric acid* (see also page 19) ; and for *red earth*, or mineral substances containing iron, by adding an excess of potash to the residue dissolved in hydrochloric acid, when a dirty red precipitate will appear if iron be present, the addition of ammonia and sulphide of ammonium to the solution will give a black precipitate. Ferrocyanide of potassium and nitric acid are sure to yield a blue colour in the acid fluid, iron being always present in vegetable substances, though in minute quantities, so that this test is not available.

III. SAGO

Is the starch from the pith of palms, and is imported from

the Maldives, Sumatra, New Guinea, the Moluccas, &c. Many species of palms are capable of yielding starch; amongst these are *Sagus rumphii*, *Cicas inermis* and *revoluta*, *Coryota urens*, *Borassus gomato*, several species of *Zamia*, *Corypha*, and *Mauritia*.¹ The starch is contained in the pith-like substance, which forms the chief bulk of the entire stem, often attaining the thickness of the human body in seven years. A single stem of this kind is said to yield three hundred-weight of sago. To obtain it, the pith separated from the stem, is washed upon sieves, and the starch collected. The granulation is performed upon sieves in such a manner that the little lumps which pass through the meshes, fall upon a hot plate of copper. Each lump is thus converted into paste, the starch granules immediately swelling up in the hot liquid; these dry into the irregular roundish translucent masses which constitute the sago of commerce.

A distinction is made between white, red, and gray sago; the red variety being often converted, by the process of manufacture, or by natural change, into the gray modification.

A considerable quantity of sago is now made from potato starch, in the same manner as that from the palms. It is difficult, however, to communicate the same degree of hardness to potato sago, as is possessed by the foreign product; it has a greater or lesser tendency to become pasty when boiled, which is not the case with the genuine article; moreover the starch granules of sago (see woodcut, page 15) are ovate, rounded at one extremity, the other being truncated; the hilum is usually surrounded by a distinct ring.

This starch or meal is frequently employed in the adulteration of arrow-root.

¹ Knapp's 'Chemical Technology,' v. iii, p. 230.

IV. ARROW-ROOT.

The term of *arrow-root* is usually applied to almost every farina bearing any resemblance to the true or *Maranta* arrow-root; each packet is generally labelled with the name of the place from which it is obtained; thus, there are the West Indian, Jamaica, Demerara, Bermuda, St. Vincent, East Indian, Brazilian, African, Guinea, Sierra Leone, Portland, British, and a variety of others; a great objection to this nomenclature, arises from the fact that several different names often apply to the same kind of arrow-root. Dr. Hassall proposes to name them according to their species: these are *Maranta*, *Curcuma*, *Tacca*, *Arum*, *Manihot*, *Potato arrow-root*, &c. In every case, the part of the plant constituting the commercial arrow-root, is the starch, and is extracted by crushing the starchy part of the plant, washing it with water, and allowing the particles in suspension to subside; these particles form a thick deposit, which, being dried, assumes the form of arrow-root.

1. *Maranta*, called commonly *West India arrow-root*.—Its colour, when pure, is a dull and opaque white; if pressed between the fingers it crepitates, and when treated with about twice its weight of concentrated hydrochloric acid, it should yield an opaque paste becoming transparent after a few minutes. Under the microscope, the starch corpuscles (woodcut, see p. 15) of arrow-root are seen to have an ovate and sometimes mussel-shape form; they exhibit a distinct mark, usually placed at their broadest end, and which may be either triangular or stellated; in some cases it is reduced to a single line. The corpuscle is, moreover, surrounded by concentric rings.

2. *Curcuma*, or *East India, arrow-root* is distinguished from the latter by the size and form of the granules, the

position of the sharp line, and the incomplete rings seen on the surface of the corpuscles.

3. *Tacca oceanica*, *Tacca arrow-root*, or *Tahiti arrow-root*.—Its granules resemble somewhat those of sago meal, but are very much smaller; when seen endways, they exhibit a circular and occasionally an angular or polyhedral form; when viewed sideways, they appear to have truncated bases.

4. *The Arum arrow-root* is obtained from the tubers of the *Arum maculatum*; it is chiefly prepared in Portland Island, hence it is generally called *Portland arrow-root*. Its starch granules are very small, and, except in size, they resemble very closely those of *Tacca arrow-root*.

5. *The Manihot arrow-root*, or *Tapioca*, the starch of the *Manihot utilissima*, is sometimes imported into this country under the name of Brazilian arrow-root. The starch granules of tapioca resemble those of *Tacca arrow-root*, but are considerably smaller, with a larger proportion of granules which exhibit a circular outline in the field of the microscope; the hilum or mark is usually fissured.

6. *Potato arrow-root*, or *Potato starch*.—See potato flour (woodcut, p. 15).

Adulterations of arrow-root. — 1. *With potato flour*, (p. 15). In this case, the potato flour may form the largest portion of the article.

2. *With Sago starch* (p. 15), or *Tapioca*.—These, with potato flour, have been observed, by the Commission of the 'Lancet', as the only adulteration of *Maranta arrow-root*.

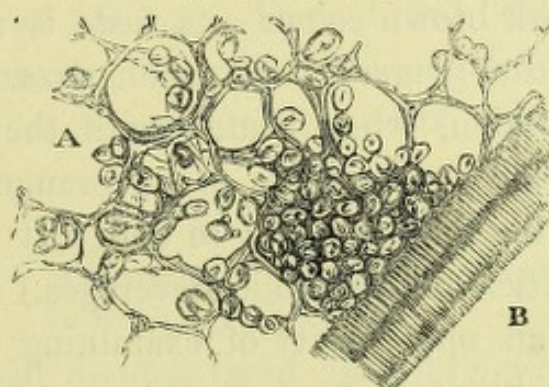
Out of fifty samples of arrow-root submitted to analysis by the Commission, twenty-two were found adulterated. In ten samples the adulteration was carried to such an extent, that they contained scarcely a particle of genuine *Maranta* or West Indian arrow-root, for which they were sold. One

consisted almost entirely of Sago meal; two of Potato flour and Sago meal; two of Tapioca, Sago meal, and Starch; one of Tapioca starch; and four were composed entirely of Potato arrow-root.

V. REVALENTA

Consists of the starch of French lentils, and probably mixed with Indian corn meal (p. 15).

Section of Lentil Seed.



A Cellular structure of inside substance. B. Structure of outer membrane.
(Mag. 220 diam.)

VI. SEMOLINA

Consists of wheat gluten, with a certain proportion of starch.

VII. SUGAR; AND ITS ADULTERATIONS.

There are two different kinds of sugar met with in commerce—1st, cane sugar; and 2d, grape sugar; the first being obtained from the sugar cane, the maple, beet-root, and some other plants; and the second prepared from grapes and figs; it can also be obtained by a chemical process, *i. e.*, from the action of dilute mineral acids on starch or woody fibre. Grape sugar is frequently found in

the brown sugars of commerce in considerable quantity, and is sometimes introduced therein for purpose of adulteration.

Tests.—1. *Cane sugar* crystallizes in a prismatic form, does not deliquesce when pure, if exposed to moisture. Its solution gives no immediate precipitate, when boiled with a solution of sulphate of copper and an excess of potash. It is very sparingly soluble in alcohol.

2. *Grape sugar* does not crystallize readily; is very apt to deliquesce, especially when kept in a damp place, and has usually a dark brown colour; its taste is not so sweet as that of the cane sugar; it is peculiarly cooling to the mouth. Its solution, when heated with the copper test (see page 9), yields a precipitate of an orange colour, appearing just as the fluid is about to boil. It is soluble in alcohol. (See article on Alcoholic Beverages.)

I have had an opportunity of examining a few of the most important kinds of cane sugar, and the reader will notice in the following report that in general the whiter the quality the less water it contained.

1. *Java sugar*.—White, with a tinge of brown; rather small-grained; crystals appear dry, and have a light structure. Three grammes contain 0.007 grammes of water, or 100 parts of sugar yield 0.233 of moisture.

2. *Havannah sugar* has a slightly darker brown colour; crystals not so well formed; grains of the same size as those of Java sugar; appears dry. Three grammes yield 0.037 grammes of water, or 100 parts of sugar contain 1.233 of moisture.

3. *Sugar of Brazil*.—Rather darker coloured than Havannah sugar; crystals of the same size, but of a somewhat heavier structure, and slightly damp. Three grammes yield 0.082 of water, or 100 parts contain 2.733.

4. *Sugar of Bengal* (Benares).—More coloured and damper than the last; crystals much finer. Three grammes yield 0·110 of water, or 100 parts contain 3·666 of moisture.

5. *Sugar of Mauritius*.—Brown coloured and damp; crystals large. Three grammes yield 0·115 of moisture, or 100 parts contain 3·833 parts of water.

6. *Sugar of Cuba*.—Same colour as preceding; grain smaller; appears damp. Three grammes yield 0·094 of moisture, or 100 parts contain 3·133 of water.

7. *Sugar of Madras*.—Dark brown colour; grain very small, very heavy, and wet. Three grammes yield 0·269 grammes of moisture, or 100 parts contain 8·966 parts of water.

IMPURITIES OF CANE SUGAR.

Dr. Hassall divides them into *organic* and *inorganic*; for the sake of practical utility, I propose to classify them according to the methods employed for their detection.

1. *Mechanical impurities*, or those which do not dissolve in a solution of sugar, and can be seen with the microscope, as fragments of cane sugar, blood, an animalcule peculiar to sugar, fungi, woody fibres, starch globules, sporules of fungi, carbonate of lime, and sand.

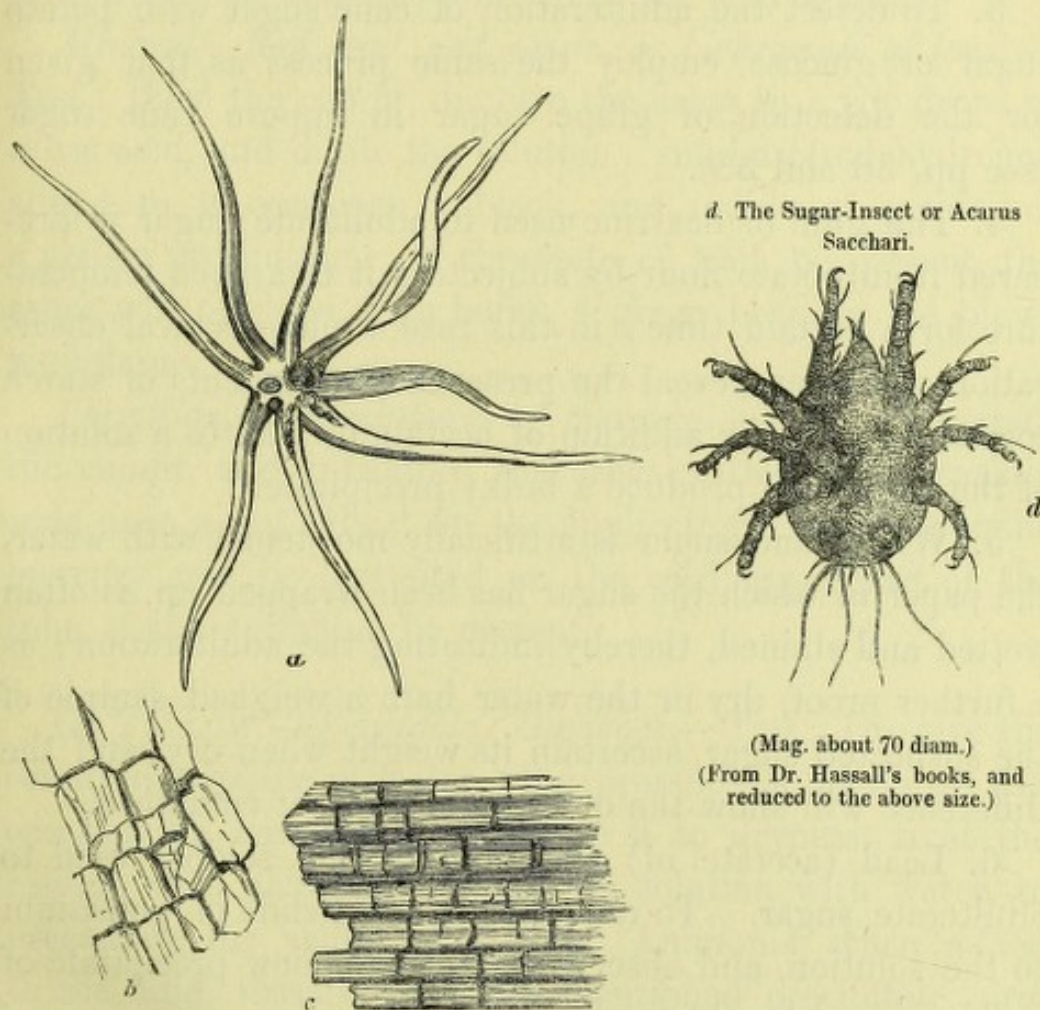
2. *Chemical impurities*, or those dissolving in a solution of sugar, and in this form escaping the scrutiny of the microscope, which are grape sugar or glucose, and vegetable albumen.

Mechanical Impurities.	<i>Fragments of Sugar-Cane</i>	Microscopical examination—Cells and bundles of woody fibres. Chemical examination—(Not required).
	<i>Blood</i>	Microscopical examination—Small round globules, of a yellowish colour. Chemical examination—A scum or coagulum appears when the solution is boiled. It is very apt to turn acid when left in a warm place.
	<i>Animalcules</i>	Microscopical examination—The sugar insect. (See the woodcut.) Chemical examination—Ammonia is evolved from the presence of nitrogen when the deposit is heated with lime. ¹ No coagulum on boiling the solution, unless albumen be also present.
	<i>Woody Fibres (accidental)</i>	Microscopical examination—Fibres (of the fir) exhibiting externally a number of small rings or circles. Chemical examination—Transformed into grape sugar when boiled with dilute sulphuric acid.
	<i>Starch Globules</i>	(See "Flour and its Adulterations.")
	<i>Sporules of Fungi</i>	Microscopical examination—Minute bodies of an oval form, becoming developed into fungi when the solution is left in a warm place. Chemical examination—Solution of sugar ferments, and turns acid very readily.
	<i>Carbonate of Lime</i>	Microscopical examination—Light amorphous particles floating on the solution. Chemical examination—Dissolved with the evolution of carbonic acid, when mixed with hydrochloric acid on the microscope glass.
	<i>Sand</i>	Microscopical examination—Small bodies, having a sharp angular structure. Chemical examination—Insoluble in dilute hydrochloric acid. (See also page 20.)
Chemical Impurities.	<i>Grape Sugar</i>	Chemical examination—Yields a red precipitate with the copper test. For rough quantitative analysis, treat the sugar with alcohol, evaporate to dryness, and weigh the residue.
	<i>Vegetable Albumen</i>	Chemical examination—An amorphous deposit appearing when the solution is boiled, and insoluble in nitric acid.

¹ For the application of this test, let the solution of sugar be filtered; dry the filter, and cut it into small pieces; then mix it with lime; introduce the mixture into a test tube and heat; if any ammonia be given out, a piece of paper, moistened with a solution of sulphate of copper, will turn deep blue when placed before the opening of the test tube. If the solution of sugar should contain vegetable albumen, it will be necessary to wash the filter with cold water, until a sample of the filtrate evolves no more ammonia when boiled with lime. Sporules of fungi also contain a little nitrogen, but in so small a proportion that I do not think it could be easily detected by the method just described.

Most of the brown sugars imported into this country are subject to these impurities, and may be seen with the microscope to contain fragments of cane, woody fibres and grit, occasionally acari, and sporules of fungi. Sugars of this kind are imperfectly crystallized, small-grained, often presenting an earthy appearance, damp and heavy. White or pure sugar is light-coloured, highly crystalline, and very dry.

Residue from Madras Sugar.



d. The Sugar-Insect or Acarus Sacchari.

(Mag. about 70 diam.)

(From Dr. Hassall's books, and reduced to the above size.)

a. Stellate hair of a plant. b and c. Fragments of sugar-cane.
(Mag. 80 diam.)

Adulterations of sugar.—Sugar may be adulterated with *impure and small-grained sugar*, with *flour*, *potato sugar* or *glucose*, *gum* or *dextrine*, and finally with *water*, *lead*, and *iron*.

1. The inferior kinds of sugar are liable to be adulterated by the addition of a still more impure quality, and other inferior kinds of small-grained sugar; a close examination with the naked eye will suffice in many cases to detect the fraud.

2. To determine the presence of flour in sugar, let a sample of the sugar be dissolved in water, and the insoluble residue examined with the microscope (see p. 15).

3. To detect the adulteration of cane sugar with potato sugar or glucose, employ the same process as that given for the detection of grape sugar in impure cane sugar (see pp. 36 and 38).

4. The gum or dextrine used to adulterate sugar is prepared from potato flour by subjecting it to a fixed temperature for a certain time; in this case a microscopical observation will often reveal the presence of fragments of starch corpuscles, and the addition of acetate of lead to a solution of the sugar will produce a bulky precipitate.

5. When cane sugar is artificially moistened with water, the paper in which the sugar has been wrapped up, is often wetted and stained, thereby indicating the adulteration; as a further proof, dry in the water bath a weighed sample of the suspected sugar, ascertain its weight when dry, and the difference will show the quantity of water it contained.

6. Lead (acetate of) and iron are but seldom used to adulterate sugar. To detect *lead*, add iodide of potassium to the solution, and observe whether a yellow precipitate of iodide of lead be obtained.

Iron is precipitated by treating the solution with ammonia; the precipitate has a reddish-brown colour.

HOW ARTICLES OF CONFECTIONARY ARE COLOURED AND POISONED.

The following colours are employed in confectionary :

I. RED OR PINK.—*Vegetable* : *Solution of cochineal or Coccus lacti*.—Test : Immerse a small portion of the comfit in caustic potash, and another in acetic acid ; it will become purplish in the alkaline, and red in the acid solution.

Mineral : *Red lead, red oxide, or bichromate of lead*.—Test : Burn the comfit, dissolve the ashes in a few drops of nitric acid, and dilute the solution ; sulphuretted hydrogen added to it occasions a black, and iodide of potassium a yellow precipitate. If chromate of lead be present, the ashes will produce, with borax, a green bead in the blow-pipe flame.

Vermilion, or bisulphuret of mercury.—Test : Incinerate the comfit, and introduce the ashes with a little caustic soda, into a test-tube ;¹ on the application of heat, metallic mercury will be deposited on the cold upper part of the tube, if any vermilion be present.

II. YELLOW.—*Vegetable* : *Gamboge*.—Test : Dissolve the comfit if possible in water ; the presence of gamboge will occasion an emulsion ; evaporate it to dryness, treat the residue with alcohol, and mix the solution with water, to precipitate the yellow gamboge. Ammonia, when added to the fluid, dissolves the last-mentioned precipitate, producing a blood-red colour ; the addition of nitric acid to this solution yields a pale yellow precipitate.

Turmeric.—Test : Does not form so decided an emul-

¹ It is better to pound the comfit, treat it with water, and filter ; the filter is to be dried at a low temperature, cut into small pieces, and introduced inside a test tube with a little caustic soda.

sion with water as gamboge; much care is requisite to discriminate between the two.

Mineral: Chromate of lead.—Test: In some cases sulphuretted hydrogen applied to the comfit turns it black or brown; try also the tests recommended for the detection of red lead and bichromate of lead (red) (see p. 41).

Naples yellow, or a mixture of lead and antimony.—Test: Incinerate in a test-tube; antimony volatilizes, and is deposited in the metallic form in the cold part of the tube; this bright ring is insoluble in liquor sodæ chlorinatæ. Test for lead as above.

III. BLUE.—*Vegetable: Litmus.*—Test: Becomes red by the action of a weak acid on a solution of the comfit.

Indigo.—Test: Sublimes in dense violet vapours when the article of confectionary is burnt.

Mineral: Prussian blue.—Test: Comfit immediately discoloured when immersed in caustic alkalies.

Antwerp blue, or Prussian blue made lighter by the addition of some colourless substance.—Test: The same as above.

*The two verditers: 1st, carbonate of copper; 2d, carbonate of copper made lighter by the addition of lime.*¹—Test: Insoluble in water; soluble in sulphuric acid, with evolution of carbonic acid; ammonia added to this solution produces a blue colour. The pale verditer is not entirely soluble in sulphuric acid, the residue containing sulphate of lime (see p. 19.)

Cobalt.—Test: Incinerate the comfit, dissolve the ashes in nitric acid, and add a few drops of the solution to a little

¹ Pound the comfit, or a sample of its coloured sugar, exhaust it with distilled water, and the insoluble residue, if it consist of one of the verditers, will be found to possess the above characters.

alum; when exposed to the blowpipe flame on a charcoal support, the alum will assume a sky-blue colour.

Smalt (a glass of cobalt powdered).—Test: The same as above.

Ultramarine, found in nature, and consisting of phosphoric acid, alumina, magnesia, lime, protoxide of iron, and water; it is also made artificially. Test: With blowpipe the residue of the comfit insoluble in water gives a slightly green flame, and is discoloured.

IV. GREEN.—*Vegetable*: *Sap green*, prepared from the green berries of buckthorn (*Rhamnus catharticus*); seldom employed.

Mineral (simple): *Acetate of copper, or verdigris*.—Test: Dissolve the comfit in water and add ammonia, a blue colour appears; then heat the solution with sulphuric acid, and notice the smell of vinegar.

Arsenite of copper, Emerald green, or Scheele's green.—Test: Burn the coloured sugar-plum in a small glass tube; a metallic ring, soluble in liquor sodæ chlorinatæ, will appear on the cold part of the tube.¹

Mineral (compound): *Brunswick green*, or a mixture of Antwerp blue, sometimes ultramarine, and pale chromate of lead. Test the part of the comfit insoluble in water for these substances separately, as directed above.

V. BROWN.—*Vandyke brown and burnt umber*, both iron compounds.—Test: Incinerate, dissolve the ashes in hydrochloric acid, and add ammonia; the appearance of a dirty red precipitate, not soluble in an excess of ammonia, shows the presence of iron.

¹ The analyst will also perceive a smell similar to that of garlic being evolved from the test tube.

VI. PURPLE.—Usually a mixture of Antwerp blue and some vegetable pink, as rose pink and lakes or cochineal.

Articles of confectionary are also liable to adulteration by admixture of starch, chalk, sulphate of lime, and clay.

Starch.—Test: For microscopical characters, see p. 15.

Chalk, or carbonate of lime. Test: Treat the pounded comfit with water, and add dilute hydrochloric acid; the insoluble residue is partly or entirely dissolved with evolution of carbonic acid. Ammonia, and oxalate of ammonia, added to the solution, give a crystalline precipitate of oxalate of lime.

Sulphate of lime.—Test: Pound the comfit and treat it with water, collect the insoluble part on a filter, then wash it into a platina capsule with distilled water, and fuse the dried substance with nitrate of potash; dissolve the fused mass in water, and test for sulphuric acid with nitrate of baryta and nitric acid, and for lime with oxalate of ammonia (see also p. 19).

Clay. (Silicate of alumina.)—Test: Treat the pounded comfit with water, collect the residue on a filter and dry it; moisten it with a drop of solution of nitrate of cobalt, and expose it to the blowpipe flame on a charcoal support; a sky-blue colour is produced.

CHAPTER II.

ON SPICES AND THEIR ADULTERATIONS.

I PROPOSE, in this chapter, to give a short account of those spices which are most commonly used, and to show how far they are adulterated; I shall also make the reader acquainted with the best and easiest methods of detecting these adulterations.

From their peculiar stimulant and tonic properties, I beg to introduce *Pepper*, *Cayenne pepper*, and *Mustard*, among the spices; and in the present chapter the following substances will be alluded to:

- | | |
|--------------------|-------------------|
| 1. Pepper. | 8. Nutmeg. |
| 2. Cayenne Pepper. | 9. Mace. |
| 3. Mustard. | 10. Cloves. |
| 4. Ginger. | 11. Allspice. |
| 5. Turmeric. | 12. Mixed Spice. |
| 6. Cinnamon. | 13. Curry Powder. |
| 7. Cassia. | |

. PEPPER.

The natural family *Piperaceæ* includes the *Piper nigrum* or black pepper, and the *Piper longum* or long pepper.

The pepper of commerce is furnished by *Piper nigrum*, which grows both in the East and West Indies, in Sumatra, Java, and other islands; it is a shrubby, climbing plant, attaining the height of from eight to twelve feet. The berries or peppercorns grow on terminal flower-stalks; they are at first green, but change subsequently to red, and then to black; when they have begun to turn red they are gathered, dried in the sun, and the stalks separated by the hand. In drying, the succulent part of the berry becomes contracted and wrinkled, forming a hard covering, the corrugations being much raised, and describing a kind of elevated network. Those berries are the best which are not too small nor too much corrugated, which are heavy and sink readily in water.

The two varieties of pepper, known as black and white pepper, are both obtained from the same plant; black ground pepper is the entire berry reduced to powder, while the white consists of the same berry deprived of its outer black husk or covering.

We learn from Pareira that three kinds of black pepper are distinguished by wholesale dealers:

1. *Malabar pepper*.—The most valuable; brownish black, free from stalks, and nearly free from dust.

2. *Penang pepper*.—Brownish black, larger, smoother, free from stalk, but very dusty.

3. *Sumatra pepper*.—The cheapest; black, mixed with stalks and much dust.

There are also three kinds of white pepper:

1. *Tellicheri pepper*.—Large and fine, is the whitest and the most valuable.

2. *Common white pepper*—comes from Penang, by Singapore; is round, and not shrivelled.

3. *English bleached or white pepper*—is the brown Penang pepper bleached.

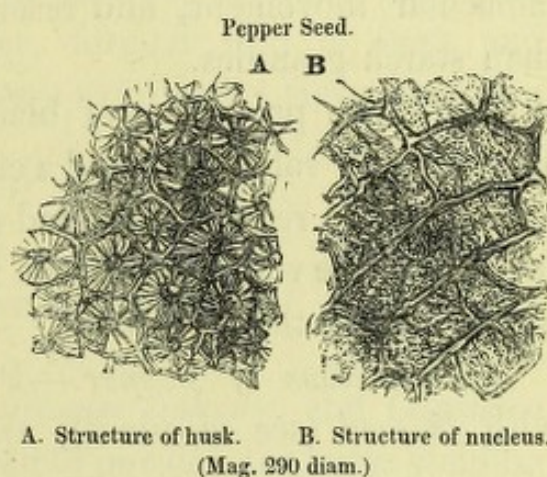
I shall proceed at once to describe the microscopical appearance of the pepper berry, though not with unnecessary minuteness; the accompanying woodcut shows its chief structures, and will suffice to enable the reader to recognise its presence with the microscope.

The pepper berry consists of a cortical or dark external substance, and a hard white and brittle nucleus in the centre; the covering separates without difficulty from the proper seed after maceration in water for some hours.

A thin section of the cortical substance is found, with the microscope, composed of different kinds of cells and of fibres;

some cells being elongated, and enclosing lines which radiate from their centre to their circumference; others being larger than the above, and forming about one half of the thickness of the cortex; and others containing the essential oil of the fruit, under the form of small globules. Finally, a very thin layer is found, consisting of woody fibres, bundles of spiral vessels of small size and formed of single threads. The central part of the berry consists of large angular cells, about twice as long as they are broad, and often crumbles into a powder resembling flour.

Ground black pepper contains the various above-mentioned



structures; but in white pepper we may expect to find principally the large angular cells which form the central substance. It may be observed that in the black particles of ground pepper little evidence of structure is in general to be noticed; it is necessary, to obtain a view of their microscopical appearance, that they should first be discoloured with chlorine, and separated into pieces with needles.

Genuine white pepper, consisting exclusively of the central part of the seed, exhibits under the microscope a number of cavities filled with starch granules; these granules are so very small that they possess, generally, a state of molecular movement, and resemble spherules of oil rather than starch granules.

The active properties of black pepper depend upon an acrid resin, a volatile oil, and a crystallizable substance called piperine; the resin is situated chiefly in the outer part of the cortex, the volatile oil in the inner part, and the piperine in the cells of the seed itself.

Adulterations of pepper.—Pepper may be adulterated with *linseed* (see woodcut), *mustard seed* (p. 54), *wheat*



A. Outer shell of linseed.

B. Transverse section of substance of linseed.
(Mag. 290 diam.)

flour (p. 15), and *ground rice* (p. 15). It is also said to be adulterated with burnt crust of bread

(M'Culloch's 'Commercial Dictionary') and with oil cake. (Normandy.)

The sweepings of the floors of the spice-warehouses, or the siftings of the whole pepper berry, are known in the trade as pepper dust, or P. D., or H. P. D., hot pepper dust. This substance is used to mix with ground pepper, and thus alters its quality without, however, adulterating it.

Pepper husks.—The cortex of the pepper berry is occasionally ground and made into black pepper. In this case the particles of pepper are much larger; the microscope will help to detect the fraud.

A spurious or factitious kind of pepper is alluded to by Accum, consisting of pressed linseed, common clay, and a portion of Cayenne pepper, formed into a mass and granulated, by being first pressed through a sieve, and then rolled in a cask.

CAYENNE PEPPER

Consists of the seeds of *Capsicum annuum* and *Capsicum frutescens*, ground and reduced to powder, the latter yielding the best description of cayenne pepper.

Capsicum annuum is a native of America, but is also cultivated in the West and East Indies, and to some extent in green-houses in England and other European countries. It is one of the most productive plants of the tropical climates. When immature the berries are green, they gradually become red on ripening; in this country the plant flowers in July, and ripens its pods in October. The berries are used both in the green and red states. In the recent state they are employed for pickling; when dried and reduced to powder they constitute *cayenne pepper*.

The dried berries are commonly sold under the name of *chillies*; in this condition they are more or less shrivelled, oblong, broad at the base, pointed at the extremity, the stalk being usually adherent to the broad end. They vary much in size and form; the largest are two or three inches long, and at the base are an inch or more wide; they are distinguished, according to their size and shape, into long-podded, short-podded, and heart-shaped. The pods of this capsicum are hot and pungent, but have no aroma.

The pods of the *Capsicum frutescens* constitute what is known as the *Guinea* or *bird pepper*, and, when ground, furnish the best description of cayenne pepper. They are small, scarcely an inch in length, a line or two broad, and of a deep orange-red colour. Each berry incloses usually about a dozen flattened reniform seeds. The pods are hotter and more fiery than those of the *Capsicum annuum*; they are likewise to some extent aromatic.

Two other species of capsicum have been denominated, from the form of the fruit—1st, *cherry chilly* or *cherry pepper*, or *Capsicum cerasiform*; and 2d, *bell pepper*, or *Capsicum grossum*.

The following analysis of the capsicum berries gives an idea of their chemical composition:

BRACONNOT'S ANALYSIS.

Acid oil	.	.	.	.	.	1.9
Wax with red colouring matter	.	.	.	.	.	0.9
Brownish starchy matter	.	.	.	.	.	9.0
Peculiar gum	.	.	.	.	.	6.0
Animalized matter	.	.	.	.	.	5.0
Woody fibre	.	.	.	.	.	67.8
Salts : Citrate of potash	.	.	.	.	6.0	} 9.4
Phosphate of potash and chloride of	.	.	.	.
potassium	.	.	.	.	3.4	
						<hr/> 100.0

Capsicin, the active principle of cayenne, is obtained by digesting its alcoholic extract in ether and evaporating the ethereal solution. It is a thick fluid, of a reddish-brown colour. Half a grain of it, volatilized in a large room, causes all who inspire the air of the room to cough and sneeze. By exposure to air and light it solidifies; it is slightly soluble in water and in vinegar, but very much so in alcohol, ether, oil of turpentine, and the caustic alkalies.

Each capsicum berry is made up of three parts.

1. An outer skin or epidermis.
2. The parenchyma.
3. The seed.

The *epidermis* is composed of a single layer of flattened cells, and contains numerous oil globules of an orange colour. The *parenchyma* consists of smaller and rounder cells than the preceding, and their cavities exhibit also a very large quantity of oil. A vertical section of the outer

Outer Surface of Capsicum.



(Mag. 220 diam.)

Epidermis of Capsicum Berry.



(Mag. 220 diam.)

surface of the *seed* furnishes a number of tooth-like processes, having a somewhat radiate disposition and surmounted by a layer of tortuous cells; the *seed proper* consists of minute angular cells, the cavities of which are filled with globules of oil.

The accompanying woodcut shows the structure of the

smaller red particles of pounded cayenne pepper; a sample of this spice was placed on the microscope glass, the larger particles blown off, and the dust placed under the microscope previously moistened with water, and covered with a thin slip of glass.

Adulterations of cayenne pepper.—1. *Red lead.*—Test: agitate the powder in a phial with sulphuretted hydrogen water; the cayenne will assume a dark black colour. A solution of the adulterated cayenne, in dilute nitric acid gives, with iodide of potassium, a yellow precipitate of iodide of lead.

2. *Common salt.*—Test: treat the pepper with distilled water, filter, and test the fluid with nitrate of silver; an abundant precipitate is produced, insoluble in nitric acid.

3. *Brick dust.*—Test: burn the pepper, treat the ashes with water; add a drop of nitrate of cobalt to the insoluble residue, and heat it with the blowpipe on a charcoal support; the mixture will turn blue from the alumina, if brick dust be present.

4. *Red ochre. Venetian red, or colours containing iron.*—Test and quantitative determination: treat the ground pepper with dilute hydrochloric acid; filter, and add ammonia in excess to the acid solution, when a red-brown precipitate will appear if iron be present. Collect the precipitate upon a filter, wash with distilled water, dry and burn the filter in a weighed platina or porcelain crucible. The weight of the ashes shows the quantity of iron (in the form of anhydrous peroxide) contained in the pepper; 100 parts of the ashes correspond to 70.00 parts of iron.¹

¹ When very accurate results are required, subtract the weight of the ashes of an empty filter (similar in size to that employed above) from the weight of the burnt filter and iron precipitate.

5. *Cinnabar, vermillion, or sulphuret of mercury*.—Test : dissolve the cayenne in aqua regia, (a mixture of nitric and hydrochloric acid); the filtered mixture is evaporated nearly to dryness, and the residue diluted with water, to be subsequently tested with iodide of potassium, which produces a red precipitate. Sulphuretted hydrogen will throw down a black precipitate in this solution. (See also page 41.)

6. *Ground rice* (page 15). 7. *Turmeric* (page 58).
8. *Husks of white mustard seed* (page 54).

MUSTARD.

The plants which yield mustard are the *Sinapis nigra*, or black, and *Sinapis alba*, or white pepper (natural family, Cruciferae). The seed-vessels of the black mustard seed are smooth, and the colour of the seeds reddish or blackish-brown. The pods or seed-vessels of the white mustard plant are clothed with hairs, and the seeds are yellow. The black mustard seed is more pungent than the white; it contains, moreover, (black mustard seed,) several distinct chemical compounds, of which the principal are a volatile and a fixed oil.

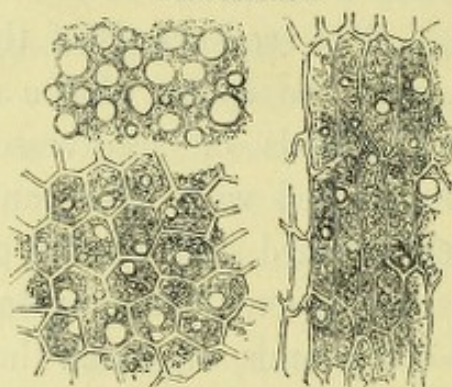
The fixed oil of mustard is usually produced from the siftings or dressings of mustard, which consist mainly of husk; it is stated to constitute about 28 per cent. of the seed.

The *white mustard* yields no volatile oil, but owes its properties to a non-volatile acrid principle; it contains, moreover, a substance called sulpho-sinapisin. Sesquichloride of iron strikes a deep red colour in an infusion of white mustard, and merely communicates an orange tint to an infusion of black mustard. Finally, the seeds of white mustard, when digested in cold water, give a thick, mucilaginous liquor, which is not the case with the black variety.

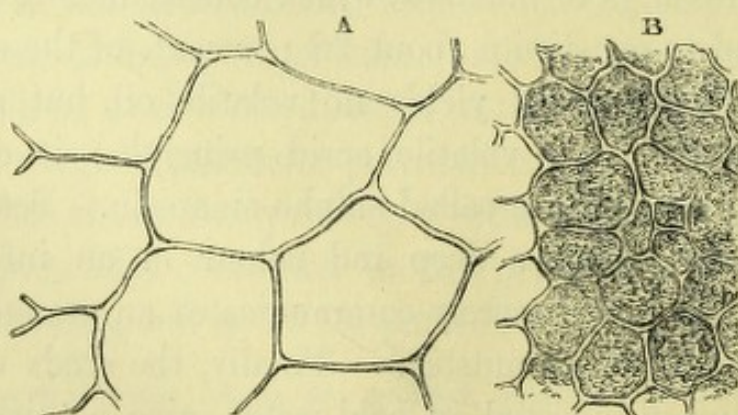
English mustard is principally raised in the neighbourhood of York, and afterwards sold under the name of Durham mustard. The black variety is extensively cultivated in Bengal and other Eastern countries, for the purpose of yielding oil. Flour of mustard is prepared by a process analogous to that employed for making wheaten flour; the siftings or dressings of the mustard correspond to the bran.

Microscopical structure.—The entire seed consists of the *husk* and *seed proper*. The husk of white mustard is formed of three cellular membranes. The cells of the *first membrane* are hexagonal, and perforated in their

White Mustard.



Cellular structure and oil globules.
(Mag. 290 diam.)



A. Outer shell of mustard seed.

B. Inner membrane of shell of mustard seed.

(Mag. 290 diam.)

centre, other cells occupying these apertures, and being themselves traversed by a somewhat funnel-shaped tube.¹ (Dr. Hassall.) The *second*, or *middle tunic*, is the main seat of the colouring matter, and consists of very minute angular cells. The *third*, or *inner membrane*, is formed of angular cells, several times larger than those of the middle tunic.

The *seed itself* is bright yellow, and of a soft, waxy consistence; it is composed of very minute cells, in the cavities of which are contained the active principles. Ripe mustard seed does not contain a single starch granule.

In *black mustard seed*, the outer membrane consists only of the large hexagonal, transparent cells, not being perforated in the centre like those of the white mustard. In other respects its structures resemble those of the white mustard.

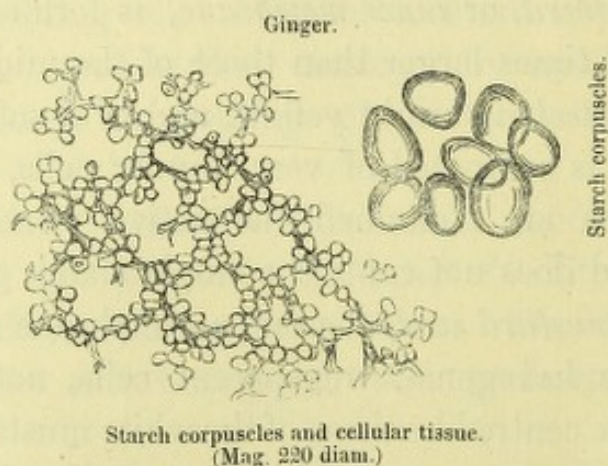
Adulterations.—The vegetable substances liable to adulterate mustard flour are *pea flour* (p. 15); *linseed meal* (p. 48); *ordinary wheaten flour* (p. 15); and *turmeric powder* (p. 58). The mineral adulterations are not frequent; *chromate of lead* (p. 41), in small quantities, may be employed to increase the colour.

GINGER.

The ginger plant (*Zinziber officinale*) is cultivated in the tropical regions of Asia, America, and Sierra Leone. Its stem reaches usually three or four feet in height. The root is the part known as ginger; it is dug up, washed, and in some cases (especially with the better kinds) the outer coat, or epidermis, is stripped off; hence the division of ginger into white, scraped or uncoated, and into black, unscraped or coated. The rhizomes, or

¹ I have failed to detect the funnel-shaped tubes in question.

roots, of ginger of good quality have no epidermis, are plump, of a whitish or faint straw colour, soft and mealy in texture, with a short fracture, exhibiting a reddish resinous zone round the circumference.



The principal uncoated sorts of ginger, according to Pareira, are—

1. *Jamaica ginger*.
2. *Uncoated Malabar ginger*, or new sort of Malabar ginger ; Tellicheri ginger, Calicut ginger, or Cochin ginger.
3. *Uncoated Bengal ginger*, scraped Bengal ginger, new sort of Bengal ginger, Calicut sort of Bengal ginger.

The chief coated gingers are—

1. *Barbadoes ginger*.
2. *Malabar ginger*, unscraped Malabar, old sort of Malabar ginger, common Malabar ginger, Bombay ginger.
3. *Bengal ginger*, common Bengal ginger, old sort of Bengal ginger.
4. *Sierra Leone ginger*, African ginger.

To the two kinds of ginger above noticed may be added—

The *green ginger* sometimes imported from Jamaica,

consisting of the roots and seeds, and appearing to have undergone but little preparation beyond picking and washing; and also—

The *preserved ginger*, consisting of the young spring shoots of the rhizome, preserved in jars with syrup (Dr. P. Browne), the finest being imported usually from Jamaica.

According to Morin's chemical analysis of ginger, it contains a volatile oil, an acrid soft resin, a resin insoluble in ether, and oils, gum, starch, woody fibre, vegeto-animal matter, osmazone, acetic acid, acetate of potash, and sulphur. The *ashes* consist of carbonate and sulphate of potash, chloride of potassium, phosphate of lime, alumina, silica, and oxides of iron and manganese.

Adulterations of ginger.—Ginger is frequently rubbed over with lime, to improve its colour and protect it from the attack of insects. Sometimes it is washed in chalk and water, when it is called *whitewashed ginger*; lastly, the surface of the ginger is occasionally bleached with chloride of lime, and sometimes even by exposing it to the vapours of burning sulphur. These adulterations are easily detected by scraping the ginger and observing if the newly exposed surface is darker than the former; or by submitting the scrapings to chemical analysis. For this purpose they are burnt, the ashes are dissolved in weak hydrochloric acid, and the solution is tested with oxalate of ammonia and ammonia.

Powdered ginger is said to be sometimes mixed with flour, or other amylaceous substance, which the microscope can readily determine. In the case of East India arrow-root, however, their particles are so similar to those of ginger that no microscopical difference can be easily detected.

From the examination of various samples of ginger by the Analytical Commission of the 'Lancet,' it appears that this substance is occasionally mixed with *sago meal* (p. 15), *potato flour* (p. 15), *wheat flour* (p. 15), *ground rice* (p. 15), *cayenne pepper* (p. 51), *mustard husks* (p. 54), and *turmeric powder*.

TURMERIC.

Turmeric powder consists of the ground tubers of *Curcuma longa*, a plant which is extensively cultivated in the neighbourhood of Calcutta, in Bengal, as also in China and

Turmeric Powder.



(Mag. 220 diam.)

Cochin China. The tubers are yellowish externally, and internally more or less orange coloured, passing into reddish brown. The odour is peculiar, though somewhat analogous to that of ginger; the taste is aromatic; when chewed, it tinges the saliva yellow. Its powder is orange-yellow; the tubers are frequently wormeaten.

The following varieties of turmeric are known in the English market, and described by Dr. Pareira:

1. *China turmeric*. 2. *Bengal turmeric*. 3. *Madras turmeric*, the most showy of all kinds of turmeric. 4. *Malabar, Bombay turmeric*. 5. *Java turmeric*.

The epidermis is made up of a single layer of transparent cells.

The tuber consists of transparent and colourless cells,

containing in their interior large masses of a yellow colour, which in most cases fill up the cavities of the cells. When broken up, these masses are found to consist not only of colouring matter, but also of numerous starch corpuscles. *Lastly*, scattered among these cells are a few coloured oil globules, numerous deep reddish-brown masses, and also dotted ducts.

CHEMICAL COMPOSITION (JOHN'S ANALYSIS).

Yellow volatile oil	.	.	.	.	1
Curcumin	.	.	.	.	10 to 11
Yellow extractive	.	.	.	.	11 to 12
Gum	.	.	.	.	14
Woody fibre	.	.	.	.	57
Water and loss	.	.	.	.	7 to 5
					<hr/> 100

Curcumin enters largely into the composition of curry powder and some other condiments. According to the investigations of the Analytical Commission, Turmeric is not subject to adulteration.

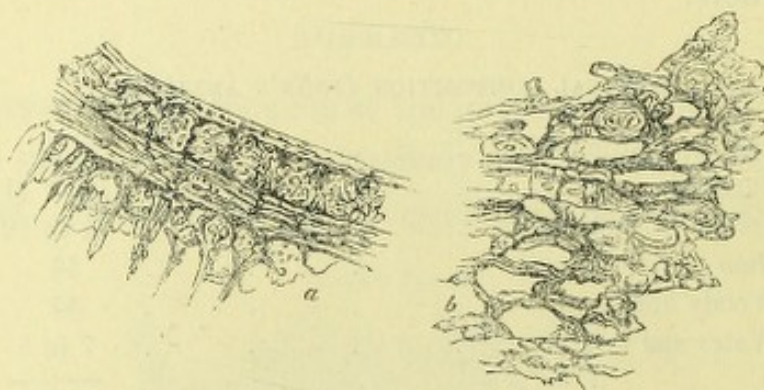
CINNAMON.

Cinnamon, the bark of *Cinnamomium zeylanicum*, is cultivated principally in Ceylon; the main Cinnamon-gardens lie in the neighbourhood of Colombo. The peeling of the bark from the tree is effected by making two or more longitudinal incisions, and then elevating the bark by introducing the peeling knife under it; the bark is then dried in the sun, and afterwards made into bundles with pieces of bamboo twigs.

Four kinds of Cinnamon are distinguished in the London market—the *Ceylon*, *Tellicheri*, *Malabar*, and *Java*; a fifth

kind, the *Cayenne*, occurs in the French commerce. The Ceylon is the most esteemed, and is characterised by being cut obliquely at the bottom, whereas the other kinds are cut transversely.

When examined with the microscope, a longitudinal section of the bark is seen to consist of cells and fibres, with



a. Longitudinal section of cinnamon bark.
(Mag. 110 diam.)

b. Transverse section of cinnamon bark.
(Mag. 220 diam.)

a few starch granules; and lying in the cavities of some cells are deep cinnamon-coloured masses of granular texture. Some of these cells have a peculiar stellate structure.

Adulterations of cinnamon, and their detection.—It is known that cinnamon bark, deprived of its volatile principles by distillation in the preparation of cinnamon water and oil, is often redried, and offered in the market as ordinary cinnamon. To detect this fraud, nothing more is necessary than to powder a portion of the cinnamon in a mortar, and examine carefully with the microscope the condition of the starch granules; if they are larger than natural, not properly formed, and distorted and irregular, the cinnamon has been subjected to the action of boiling water, for the purpose of extracting its essential oil. If the cinnamon has been exposed to the prolonged action of boiling water, the starch

granules become so broken up and dissolved, that they can no longer be detected.

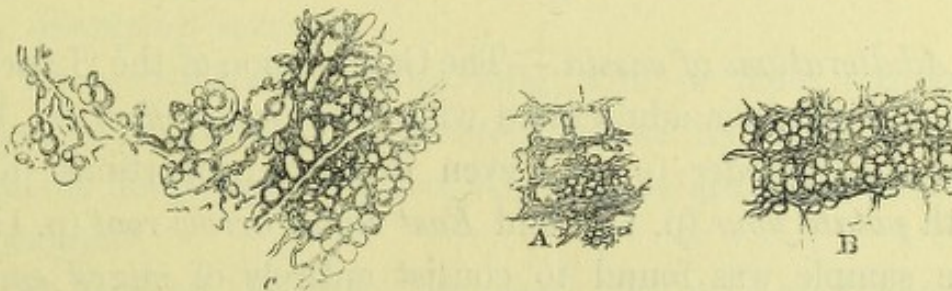
A very common practice is to substitute Cassia for Cinnamon, either in the bark or in powder; the following is a short account of this substance:

CASSIA.

Cassia bark is much stouter than cinnamon; it breaks short and without splintering; moreover, cinnamon is paler and browner than cassia, which is usually redder and brighter; the taste of cinnamon is sweet, mild, and aromatic, whilst that of the other is less sweet, stronger, and followed by bitterness. It is, however, difficult to distinguish them



a and *b*. Longitudinal section of cassia bark. (Mag. 110 diam.)



c. Transverse section of cassia bark.
(Mag. 220 diam.)

A. Cellular tissue and starch corpuscles of cinnamon.
B. " " " " of cassia.

from each other by the above means, when in the form of powder; and the analyst must have recourse to microscopical examination. Sections of cassia bark, when viewed under the microscope, differ from those of cinnamon in the greater width and relative proportions of the several structures,

particularly in the size and number of the starch corpuscles. The cells of cassia are much more commonly, than those of cinnamon, filled with well-developed starch corpuscles, which are considerably larger than those of cinnamon, and many times more numerous; the woody fibres appear similar in both cases. Of the entire thickness, about one fourth is formed by stellate cells; the remaining three fourths being made up of the starch-bearing cells.

Powdered cassia may, therefore, at all times be discriminated from powdered cinnamon, by the size and abundance of the granules of starch.

Different kinds of cassia :

1. *China cassia lignea*, or sometimes Cassia cinnamon, the best kind of Cassia, and usually imported from Singapore; it is warted externally, and covered with crustaceous lichens.

2. *Malabar cassia lignea*, imported from Bombay, is thicker and coarser than that of China.

3. *Manilla cassia lignea*, is usually sold in bond for Continental consumption.

4. *Mauritius cassia lignea* is but occasionally met with.

Adulterations of cassia.—The Commission of the 'Lancet' has found cassia adulterated with *baked wheat flour* (p. 15) and *sago powder* (p. 15), even in large proportions; also with *potato flour* (p. 15), and *East India arrow-root* (p. 15); one sample was found to consist entirely of *mixed spice*, probably, however, sold by mistake.

NUTMEGS.

There are three species of *Myristica* which furnish nutmegs; the best description is obtained from the *Myristica*

fragrans, which resembles the pear tree. The fruit consists, first, of an outer fleshy covering, called the pericarp, separating when ripe into nearly equal longitudinal parts or valves ; secondly, of the aril or mace, which, when ripe, is of a bright scarlet colour ; and thirdly, of the seed proper or nutmeg. This is inclosed in a shell made up of two coats : the outer is hard and smooth ; the inner is thin, closely investing the seed, and, sending off prolongations, which enter the substance of the seed, imparting the mottled or marbled appearance characteristic of nutmeg.

Nutmegs are cultivated in the Molucca Islands, and also in Java, Sumatra, Penang, Singapore, Bengal, Bourbon Island, Madagascar, and certain of the West India Islands.

There are two kinds of nutmeg met with in commerce : the *first* is the *Myristica fragrans*, or true or female nutmeg, known by its large size and delicate and aromatic flavour ; the second is a small variety, not larger than a pea, called the royal nutmeg.

Three varieties of true nutmeg are distinguished by dealers, and described in Pareira's 'Materia Medica :'
1. *Penang nutmegs.* 2. *Dutch or Batavian nutmegs.*
3. *Singapore nutmegs.*

The *second kind*, the false, long, wild, or male nutmeg, is chiefly the produce of *Myristica fatua* ; its seeds are about half as long again as the others, they are paler and less aromatic.

To prevent the attack of insects, the nuts are frequently limed. The Dutch lime them by dipping them into a thick mixture of lime and water ; but this process is considered to injure their flavour. Others rub them with recently prepared, well-sifted lime ; a process which is sometimes practised in London.

Microscopical appearance.—This spice may be distinguished with the microscope, even in powder, from most other vegetable productions. A thin section is seen to

Nutmeg.

Cellular structure.
(Mag. 220 diam.)

consist of minute angular cells, containing much starch, in the form of small but distinct granules, mostly of a rounded shape; occasionally, a few of the granules are angular. The cells forming the dark vein-like portion of the nut differ from the others in colour, they are destitute of starch,

and contain apparently but a small quantity of oil.

Nutmegs yield a fixed and a volatile oil, which are extracted and sold separately.

The *fixed oil* is obtained by pressure and straining; it is imported in the form of cakes, which have the shape of common bricks, and are covered with leaves.

The *volatile oil* is procured by distillation in water. The produce thus obtained is usually from 4 to 5 per cent.

Adulterations of nutmegs.—Nutmegs are frequently deprived of a portion of their essential oil by distillation; and, after being well-limed, are again sent into the market. Thus in want of their most valuable properties, they feel light, are dry and brittle; and if on the surface small punctures appear, it is certain that a great portion of their essential oil has been abstracted. The work of Mr. Chevalier, treating of nutmegs, contains the following observations:

“Nutmegs are sometimes mixed with riddled nuts, eaten by insects and become brittle; the small apertures are then closed by a kind of cement, formed of flour, oil, and

powder of nutmegs ; a paste which has even served to fabricate false nutmegs. The spice in question, at Marseilles, has been made of bran, clay, and the refuse of nutmegs. These nutmegs placed in contact with water soften down in that liquid.”¹

From the examination of eighteen samples of nutmeg in the laboratory of the Commission of the ‘Lancet,’ it appears that nutmegs, as they reach the consumer in London, are not generally deprived of their essential oil ; and that they are *seldom limed*.

MACE.

Mace consists of the shell of the nutmeg ; it is fleshy, and, when recent, has a bright scarlet colour ; in the process of drying it changes to yellow, orange yellow, or, what is considered the best, golden yellow, and becomes transparent and horny.

This shell is sometimes flattened out and dried in a single layer ; but frequently it is pressed together, in which case it forms two layers. The Dutch sprinkle mace with salt water, prior to packing it in sacks.

The London dealers distinguish three sorts of true mace :

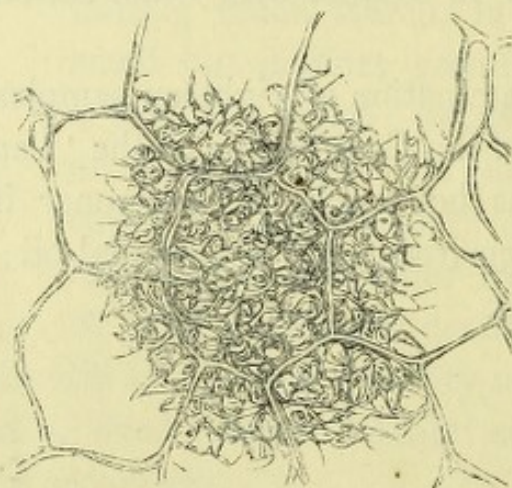
1. *Penang mace*, which fetches the highest price.
2. *Dutch or Batavian mace*.
3. *Singapore mace*.

Structure.—The microscopical structure of mace is very distinct from that of the nutmeg.

The chief substance is made up of cells containing fixed oil and much starch ; imbedded in the midst of these cells

¹ ‘Dictionnaire des Alterations et Falsifications des Substances Alimentaires Medicamenteuses et Commerciales,’ by M. Chevallier.

are others, which, in thin sections, whether made cross-wise or lengthwise, appear as apertures; these contain the essential oil of mace. Scattered here and there may be



Transverse section of mace.

(Mag. 290 diam.)

Cells and starch corpuscles.

seen small bundles of woody fibres, of a brownish colour, enclosing one or two small spiral vessels.

The samples of mace examined by the Commission of the 'Lancet' proved to be unadulterated.

CLOVES.

Cloves are the unexpanded flower-bud of *Caryophyllus aromaticus*, a tree from fifteen to thirty feet in height. Its native country is the Molucca Islands; but it is now cultivated in Sumatra, Mauritius, Cayenne, Bourbon, Martinique, and St. Vincent. When of good quality, cloves are dark coloured, heavy, aromatic, pungent, and, if strongly pressed upon with the nail, the oil should exude freely.

The varieties of cloves depend on the place where they are produced; those of Amboyna and Bencoolen, two of the

Spice Islands, are the most esteemed, especially the Bencoolen variety. Bourbon and Cayenne cloves are smaller. Cayenne cloves are the least valuable; they are smaller, somewhat shrivelled, and yield less oil.

The volatile oil of cloves is extracted by repeated distillation; the yield, on an average, is said to be from 17 to 22 per cent. It consists of a light, colourless oil, and of another which is heavier, and combines with alkalies to form crystalline salts. Protosulphate of iron, when added to the latter, produces a lilac, and persulphate of iron a red colour, becoming violet, and afterwards blue; sesquichloride of iron gives with this heavy oil a vinous colour, which turns red.

Structure.—A transverse section is seen to consist of cellular tissue, in the midst of which are numerous receptacles for the essential oil; and a transverse section of the



Transverse section of stalk.
(Mag. 290 diam.)

flower-stalk, viewed with a low power, is found to be formed externally of receptacles, then of a narrow circle of woody fibre, and finally of numerous tubular cells containing oil.

Adulterations of cloves.—The quality of cloves is sometimes impaired by the abstraction of their essential oil. They are distinguished in this case by being light and shrivelled, not yielding oil when pressed upon, possessing little aroma or taste, and by the stalk being frequently

deprived of the flower-bud. This fraud used to be extensively practised in Holland; for more effectual concealment, the *drawn* cloves being mixed with others of good quality, and even in some cases being rubbed over with some common oil.

The volatile oil itself, as imported into this country from India, has been found adulterated. Mr. M'Culloch, on the authority of Milburn, states that it contains nearly half its weight of an insipid expressed oil, which is discovered by dropping a little into spirits of wine; on shaking it the genuine oil mixes with the spirit and the insipid oil separates.

Cloves readily imbibe moisture, their weight becoming thereby increased, of which dishonest dealers have not failed to avail themselves.

There is reason to believe, according to the Commission of the 'Lancet,' that the clove-stalks, deprived of their essential oil, are occasionally ground up and mixed with the powder of genuine cloves. As the stalks are provided with an epidermis or coating of cells having a peculiar stellate character, this structure, when found to exist in considerable abundance in any sample of powdered cloves, shows beyond doubt that a proportion of ground stalks has been introduced. (Dr. Hassall.)

From the analysis of cloves by the Commission of the 'Lancet,' and reported in Dr. Hassall's book, it appears that they are not usually deprived of any portion of their essential oil. There is little doubt, however, that this fraud is practised in some cases, but it does not prevail to any considerable extent. The whole of the powdered cloves examined by the Commission of the 'Lancet' were free from adulterations; one of the samples contained, however, a proportion of ground clove-stalks.

PIMENTO, OR ALLSPICE.

Pimento, Jamaica berry, or allspice, is the berry or fruit of the *Eugenia pimento*, one of the Myrtaceæ. It grows in the West Indies, principally in Jamaica, and forms a beautiful tree, which attains some thirty feet in height. It is planted in regular walks, called pimento walks. A single tree has been known to yield 150 lb. of the raw fruit, or 100 lb. of the dry spice.

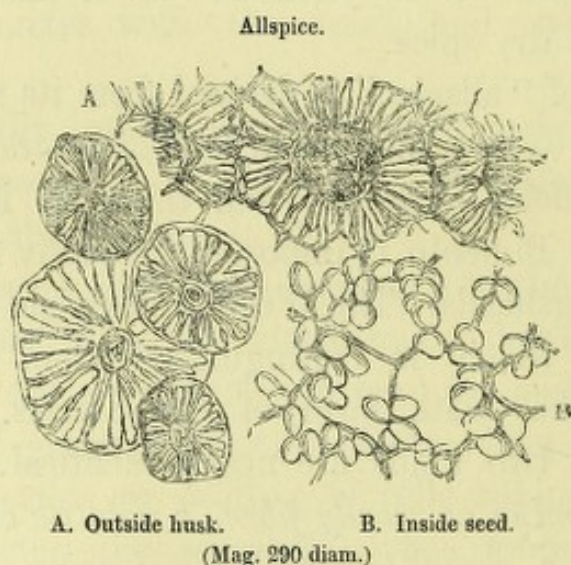
The name of "allspice" is derived from its flavour, which is considered to be a mixture of that of several of the other spices; it differs, however, from them all in its greater astringency. Pimento is imported generally from Jamaica in bags or hogsheads. The West Indies yield another kind of pimento, which is distinguished from the common allspice by the ovate form of the berries. The properties of the two kinds are nearly identical. This spice consists of *lignine* or *woody fibre*, a *volatile oil*, an *astringent extract*, a *green oil*, and a *colouring matter*, with a small quantity of *uncrystallizable sugar* and of *malic* or *gallic acid*. Braconnot detected, moreover, the presence of starch in these berries, in the proportion of 9 per cent.

By distillation with water, allspice yields two volatile oils, the one lighter and the other heavier than water. The pimento oil of the shops is a mixture of them; except in odour, its properties are almost identical with those of oil of cloves. Mr. Whipple estimates that pimento seed yields about 4.37 per cent. of oil.

The allspice berry can be divided into husk, seed, and seed proper. A vertical section of the husk, viewed under

the microscope, presents the following structures: 1. Large cells or receptacles for the essential oil. 2. More internally, numerous stellate cells, attached to and imbedded in cellular tissue. 3. Bundles of woody fibre and delicate spiral vessels. 4. The deepest and innermost part of the section consists of cellular tissue only.

The structure of the seed proper, as displayed in vertical sections, is as follows: 1. A thin layer of large receptacles, running round the outer part of the section. 2. Angular



and transparent cells, making up the remaining of the thickness, their cavities being filled with well-developed starch granules.

In powdered pimento the whole of the above structures become disunited and variously intermixed.

Adulterations of pimento. — According to the Commission of the 'Lancet,' this spice is very seldom adulterated. In one sample a small quantity of mustard was detected.

MIXED SPICE

Consists, as its name implies, of a mixture of the spices above described. Out of twenty-six samples examined by the Commission, no less than sixteen, or considerably more than one half, were found adulterated; the foreign substances added being sago meal (p. 15), ground rice (p. 15), wheat flour (p. 15), a substance resembling linseed (p. 48), and potato flour (p. 15).

CURRY POWDER.

Curry powder consists of a mixture of several ingredients; good genuine curry powder is usually composed of *Turmeric*, *Black pepper*, *Coriander seeds*, *Cayenne*, *Fænugreck*, *Cardamoms*, *Cumin*, *Ginger*, *Allspice*, and *Cloves*. *Turmeric*, *Coriander seeds*, and *Black pepper*, form the larger proportion of the powder.

Having previously described and illustrated turmeric, black pepper, cayenne, ginger, cloves, and allspice, I now beg to give a brief account of *coriander seeds*, *cardamoms*, *fænugreck*, and *cumin*.

Coriander seeds (*Coriandrum sativum*, Umbelliferæ), an annual plant of a foot and a half in height, is cultivated in Essex, and frequently met with growing wild in the neighbourhood of Ipswich. The fruit or seed-vessel is globular, about twice the size of white mustard seed, and of a light brown colour; it consists of two hemispherical portions, each of which is a seed.

The fruit possesses an outer covering, epidermis, or husk, which is thick and brittle; it is seen with the microscope to consist of narrow fibres, which cross each other, and are

disposed in a wavy manner; it is united to the seed by loose cellular tissue, which is torn on the removal of the husk. Underneath this cellular tissue is a delicate fibrous membrane, and to this succeeds a layer of deeply coloured cells, merging into the cells which form the substance of the seed; these are angular, with well-defined parietes, their cavities enclosing oil in a molecular condition. The mature seed does not contain starch.

Coriander seeds possess the property of a mild aromatic and stimulant; they yield, upon distillation, a volatile oil, upon which these properties depend.

Cardamom seeds (*Elettaria cardamomum*, Zingiberatiæ), a native of the mountainous parts of the coast of Malabar.

The seeds are contained in pods, which have a triangular form, and consist of three valves; the seed-vessel is thick, tough, and fibrous, consisting of cellular tissue and bundles of woody fibre. The seed-vessel is divided into three compartments, each of which contains several hard seeds of a reddish-brown colour, and exhibiting upon the surface peculiar markings; the seeds are united together by a substance which presents under the microscope delicate tubules filled with oily and granular matter.

The cells, which constitute the principal part of the seed, resemble closely the cells of pepper, being very angular; but they differ in their more delicate and transparent appearance and in being minutely dotted. The presence of cardamom seeds in curry powder is most easily determined by means of this structure. Cardamom seeds have a warm, sharp, aromatic taste, and very like camphor. They contain a fixed and volatile oil, to which their properties are chiefly due.

Cumin seeds, from the plant *Cuminum cyminum*, nat.

order Umbelliferae, a native of Upper Egypt, is extensively cultivated in Sicily and Malta.

Cumin seeds have some resemblance to caraway seeds, but they are larger, straighter, and of a lighter colour. The fruit is double, consisting of two seeds; it is furnished with very fine hairs or prickles.

Transverse sections of the cumin seed exhibit the following structure :

The hairs are composed of cells, the long diameter of which are arranged in the long axis of the hairs.

The husk or covering of the seed is made up of numerous rounded or angular cells. The surface of the seed is of a pale brown colour, and its interior whitish and transparent. The external part consists of elongated and flattened cells of a brownish colour; whilst the interior and chief substance is formed of numerous distinct angular cells, with perfectly transparent, thick walls. Their contents consist principally of oil. No starch can be detected in the seeds.

Cumin possesses a peculiar medicinal taste and smell, and imparts to curry powder a great part of its characteristic flavour and smell.

Fœnugreek seeds, the produce of the plant *Trigonella Fœnum Græcum*, family Leguminosæ. It grows principally in *India, Arabia, Sicily*, and at *Montpellier*.

The seeds contain a great quantity of mucilage, imparting demulcent properties to their decoction.

Structure.—The *husk of the seed* consists of three membranes. The outer is formed of a single layer of cells, bearing considerable resemblance in shape to a short-necked bottle. The second membrane consists of a single layer of cells, two or three times larger than the former, very much flattened, and having their margins regularly and beautifully crenate. The third and innermost membrane

is made up of several layers of large transparent cells, filled with mucilage, and expanding greatly when immersed in water.

The *seed itself* consists of two lobes formed of numerous minute cells, those in the outer part of each lobe are of a rounded or angular form, while the innermost become much elongated, the axes of the cells being placed transversely in each lobe ; the entire seed is covered with a single layer of small angular cells.

Adulterations of curry.—Curry powder may be adulterated with *lead* (pp. 41 and 42), *mercury* (p. 41), and *iron* (p. 52), with a view of obtaining a better colour for the market ; it is also often mixed with *salt* (p. 25), *ground rice* (p. 15), and *potato flour* (p. 15).¹

¹ The above account of the microscopical structures of the various spices is mainly abstracted from Dr. Hassall's valuable work. The woodcuts are all original.

CHAPTER III.

ON INFUSIONS OF VEGETABLE SUBSTANCES.—OTHER FLUID VEGETABLE FOOD, AND THEIR ADULTERATIONS : TEA, COFFEE, SAUCES, OLIVE OIL.

FROM the importance and peculiar interest connected with this subject, I beg leave to enter into some details, relating to the growth and preparation of the various kinds of tea, previous to giving an account of their adulterations.

The tea plant is a hardy evergreen, attaining the height of from three to six feet and upwards (nat. family *Columniferæ*). It comes to maturity in from two to three years, yielding in the course of the season three, and sometimes four crops of leaves.



Inside structure of tea-leaf.
(Mag. 110 diam.)

The leaves vary considerably in size and form : the youngest are narrow, convoluted, and downy ; the next in age are larger, and their edges are delicately serrated with the venation or fibrinous markings, scarcely perceptible. In those of the third crop, the size is found increased, and the venation well marked, the serrations are stronger and deeper, and placed at greater intervals.

The principal kinds of black tea are, first, the Bohea, of

the coarsest description, then the Congou, Souchong, Cape and Padre Souchong, and Pekoe.

The principal varieties of green tea are Twankay, Hyson-skin, young Hyson, Hyson, Imperial, and Gunpowder. The Hyson-skin is separated from the Hyson by a winnowing machine, and is in considerable demand among the Americans.

According to most writers, the various kinds of tea are obtained from the same plant ; and their different qualities depend upon the soil, climate, age, and mode of preparation.

The following is a description of the preparation of tea extracted from Knapp, Reynolds, and Richardson's 'Chemical Technology :'

According to Bell, most of the Chinese accounts agree that the gathering of the tea-leaves commences with the Pekoe tea, and lasts from the 5th to the 20th of April. This tea consists of the convoluted leaf-bud. The first gathering of the expanded leaf begins between the 20th of April and the beginning of May ; the second about the 5th of June ; the third after the 24th of June ; and the autumnal gathering in August and September. The coarse leaves, which form the common Bohea, are collected in September and October ; in the other gatherings the young and succulent leaves only are chosen. According to Mr. Jacobson, of Java, the stalks of the leaves of black tea must be detached from the tree along with the leaves, as they improve the flavour of the tea ; but green-tea leaves must be gathered without the stalks. The gatherers carry a small basket in front of them fastened round the body, thus they are enabled to gather the leaves with both hands and to throw them quickly into the basket. The baskets containing the leaves for black tea may be left open and exposed to the sun, to hasten the withering ; but the leaves

for green tea must not be exposed to the sun or kept long in the garden.

Mode of preparing black tea.—According to older accounts, black tea is the result of drying and roasting the tea-leaves over the naked fire, whilst green tea is obtained by withering the leaves in steam, and simply drying them afterwards.

The leaves intended for the production of black tea are first exposed to the rays of the sun in bamboo sieves; the finest Souchong and Paochong tea, which are prepared from the most delicate young leaves, become sufficiently dry by mere exposure to the air in the shade. Leaves of inferior quality require to be dried before a fire previous to being roasted. These primary operations are considered very essential to the quality of the tea. The roasting takes place in a hollow, remarkably thin iron vessel, called a *kuo*, which is of a circular form, and fitted horizontally into a stove. The roaster takes about half a pound of leaves in his hands, throws them into the *kuo*, and draws them across the bottom of the vessel from its opposite side to the side nearest to himself; he next turns the leaves over and throws them back again, repeating the operation until they give a fragrant smell and become quite soft and flaccid; they are then immediately rolled or kneaded with the hands. It is in this part of the process that they become twisted; the juices expressed from the leaves are sufficient to maintain them in the twisted form. The leaves are now submitted to a second roasting, at a low temperature, and frequently shaken, to accelerate the evaporation of the steam by the admission of air; they are subsequently rolled as before, and again roasted and rolled as long as any juice can be freely expressed. In this state, the

leaves are in a condition to undergo final desiccation, a process which is conducted in open sieves over a bright charcoal fire; the sieves are placed in a tubular piece of basket-work, opened at both ends, called a poey long; this instrument, containing a certain quantity of tea ready for drying, is placed upon a low stove, over a small quantity of burning charcoal, where the leaves lose their moisture. After their removal from the sieves, they are rubbed between the hands, and then returned to the drying apparatus; and this operation is repeated until they have become dry and crisp. The tea is then sifted, again placed over a very slow fire for about two hours, and then packed in chests or baskets for sale; the Pekoe tea is very slightly rolled, if at all.

For the purpose of scenting black tea, certain kinds of flowers are used, being previously dried and powdered; they are sprinkled over the tea before it undergoes the last process of roasting. Souchong tea is sometimes scented with the flowers of *Gardenia florida*, *Olea fragrans*, and *Jasminum sabac*.

Mode of preparing green tea.—The leaves intended for the production of green tea are spread out in layers upon hurdles, in a kind of box made of bamboo, the bottom of which forms¹ a water-boiler. The aqueous vapour passing through the leaves soon withers them, they are now rolled and placed at once in an iron pot to dry; the subsequent rolling and kneading is performed in precisely the same manner as in the case of black tea. The process of steaming prevents the leaves from turning black, and they retain their original green colour. Green tea gives up much less of its juice in the drying process, a circumstance which explains its more energetic action upon the nervous system.

¹ It probably means "fits upon."

Chemical composition of tea, and its chemical analysis.—According to Mulder's analysis, 100 parts of tea consist of—

	<i>Green.</i> Hyson.	<i>Black.</i> Congou.
Essential oil (to which the flavour is due)	0.79	0.60
Chlorophyle	2.22	1.84
Wax	2.88	—
Resin	2.22	3.64
Gum	8.56	9.28
Tannin	17.80	12.88
Thein	0.43	0.46
Extractive	22.30	19.88
Colorable matter, separable by hydrochloric acid	23.60	19.12
Albumen	3.00	2.80
Vegetable fibre	17.80	28.32
Ash	5.56	5.24
	<hr/> 100.00	<hr/> 100.00

In order to detect the adulterations of tea, it is necessary that the reader should be acquainted with the methods to be employed for its chemical analysis. I beg, therefore, to direct his attention to this important subject.

The principal substances to be determined, and contained in the infusion of tea, are *gum*, *glucose* or *sugar*, *tannin*, and a peculiar principle called *thein*. To estimate the amount of gum and tannin, let 100 grains of tea, dried in the water bath, be boiled for some time in about one quart of distilled water; the gum and tannin are dissolved out. The lignine, or remaining exhausted tea-leaves, are separated from the solution by decanting the latter, they are to be washed with hot water, and finally dried and weighed. To obtain the tannin, mix the above washings with the solution, and add to it a solution of gelatine; the precipitate, being collected on a filter and washed, is dried in the water bath, and finally weighed; 100 grains of the precipitate containing 40 grains of tannin. To determine the

gum and *saccharine matter*, evaporate to dryness the decoction of 100 grains of tea, dry the residue thoroughly, and weigh it; then treat this substance with hot alcohol, which dissolves out the tannin and sugar, and leaves the gum, which may be dried and weighed; the weight of the tannin having previously been ascertained, by adding it to the weight of the gum, and subtracting this sum from the weight of the residue, the amount of sugar will be readily ascertained.

To detect the *thein*, add acetate of lead to a decoction of tea, evaporate the filtered liquid to a dry extract, and expose this extract to a subliming heat in a shallow iron pan, whose mouth is covered with porous paper, glued to the rim of the vessel, and surmounted by a strong paper cap to act as a receiver for the thein. By this method Dr. Stenhouse obtained 1.37 per cent. of thein. The following process enabled Peligot to extract a larger proportion of this substance: a hot infusion of tea was mixed with subacetate of lead and ammonia, the liquid was filtered, and the lead precipitated by means of sulphuretted hydrogen; after a second filtration the clear liquid, being evaporated at a gentle heat, afforded, on cooling, an abundant crop of crystals. By further evaporation of the mother-liquor, more crystals are obtained, amounting altogether to from 4 to 6 per cent.¹

Adulterations of tea, and their detection.—1. *Adulterations of black tea.*—The principal adulterations of black tea consist in the addition of leaves not belonging to the tea plant, and in the fraudulent conversion of exhausted tea-leaves into the apparently genuine article; in either case

¹ Messrs. Graham, Stenhouse, and Campbell adopted this method, slightly modified, for the detection of caffein in coffee.

foreign substances being employed to impart colour and astringency to the infusion of the leaves.

The Chinese not unfrequently make use of the leaves of the *Camellia Sasanqua* and *Chloranthus inconspicuus* for the fabrication of tea; and, according to Dr. Dixon, many millions of pounds of the leaves of various plants are dried annually to mingle with genuine tea, as those of the ash, plane, &c. It has also been ascertained that the leaves of several British plants are sometimes used in this country for the adulteration of tea, as those of the beech, elm, horse-chestnut, plane, bastard plane, fancy oak, willow, poplar, hawthorn, and sloe (see woodcuts, page 85). The leaves are dried, broken up into pieces, and usually mixed with a paste made of gum and catechu; afterwards they are ground and reduced to a powder, which, being coloured with rose-pink, is mixed either with dust of genuine tea or with inferior descriptions of black tea.

The reader may refer to the adjoining woodcuts for the shape and appearance of the above-mentioned leaves.

Besides the physical structure of the leaves, their chemical properties may help to detect their nature. Thus, the prune tribe of plants, including the sloe, cherry, laurel, &c., the seeds of which yield prussic acid, all contain amygdaline, or some similar principle. Now, all of these, when oxidized with sulphuric acid and peroxide of manganese, give oil of bitter almonds, and can be thus recognised.

The willow and poplar tribe, on the other hand, yield oil of Spirea Ulmeria (salicylous acid), a very characteristic substance.

On exhausted tea-leaves.—Not many years ago, an extensive business was carried on, consisting in the conversion of tea-leaves which had been used into an apparently good quality of tea. It was supposed that, in 1843, there were

eight manufactories in London alone for this purpose, and several besides in various parts of the country. Persons were employed in buying the exhausted leaves at hotels, coffee-houses, and other places, at $2\frac{1}{2}d.$ or $3d.$ per pound. These were taken to the factories, mixed with a solution of gum, and re-dried. After this, the dried leaves, if for black tea, were mixed with rose-pink and black lead, to face them, as it is termed by the trade.

The best method of detecting this fraud is by chemical analysis.

The annexed are analyses of samples of black tea manufactured from exhausted tea-leaves, and seized at various periods by the Excise authorities. They were furnished to the Commission of the 'Lancet' by Mr. Phillips, with the sanction of the Board for Inland Revenue.

Seized in London, 24th of August, 1843 :

BLACK TEA.			
Lignine	.	.	78.6
Gum	.	.	15.5
Tannin and colouring matter	.	.	5.9

Seized in London, 2d of March, 1843 :

BLACK TEA.			
		No. 1.	No. 2.
Lignine	.	81.3	72.9
Gum	.	18.0	19.9
Tannin and colouring matter	.	0.7	7.2

Seized in London, 15th of February, 1843 :

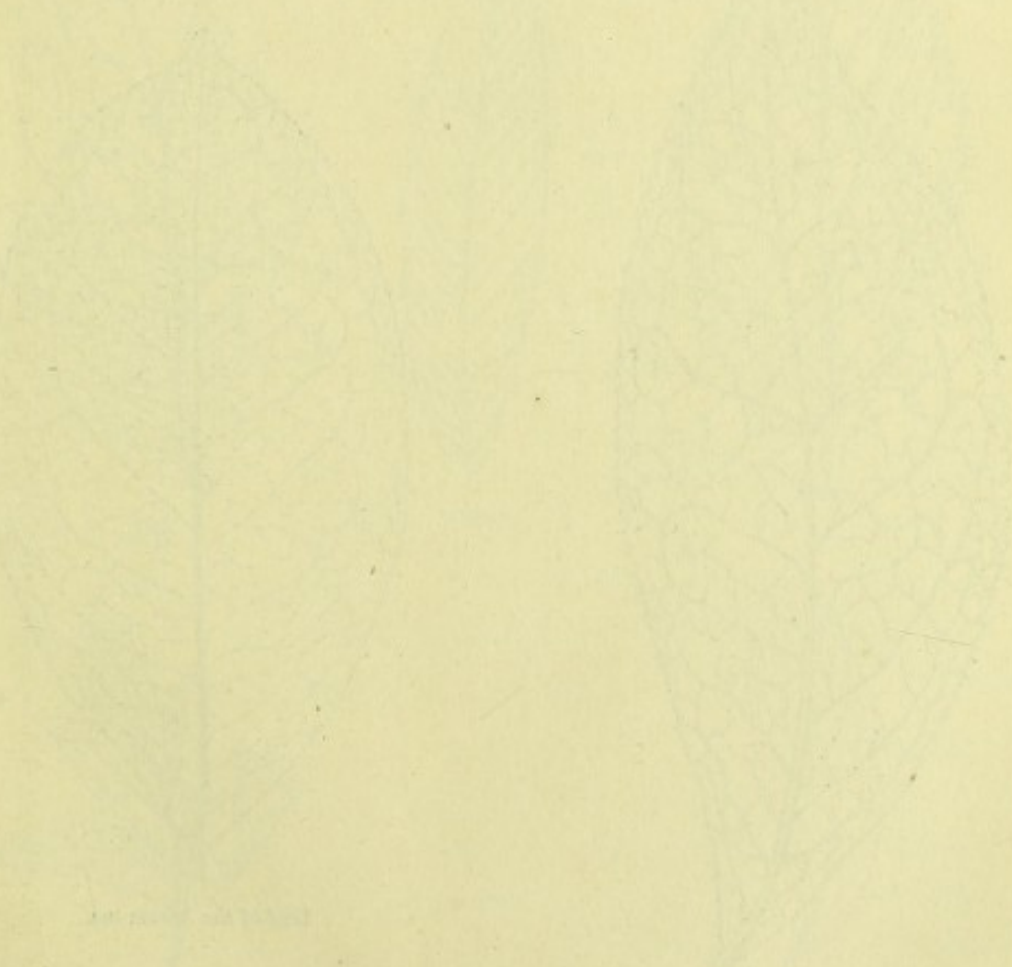
BLACK TEA.			
Lignine	.	81.1	78.1
Gum	.	15.5	20.5
Tannin and colouring matter	.	4.4	1.4

Other analyses are given in Dr. Hassall's book which need not be here recorded.

PLANTAS DE LA ZONA DE MONTAÑA



Leaves of the plant

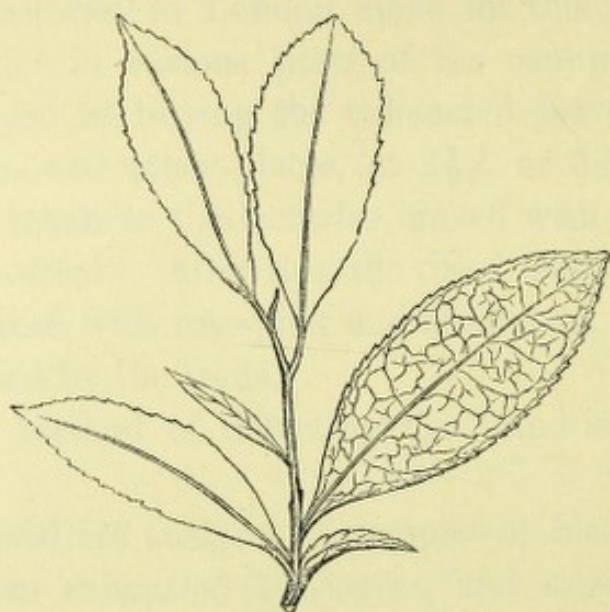


Leaves of the plant

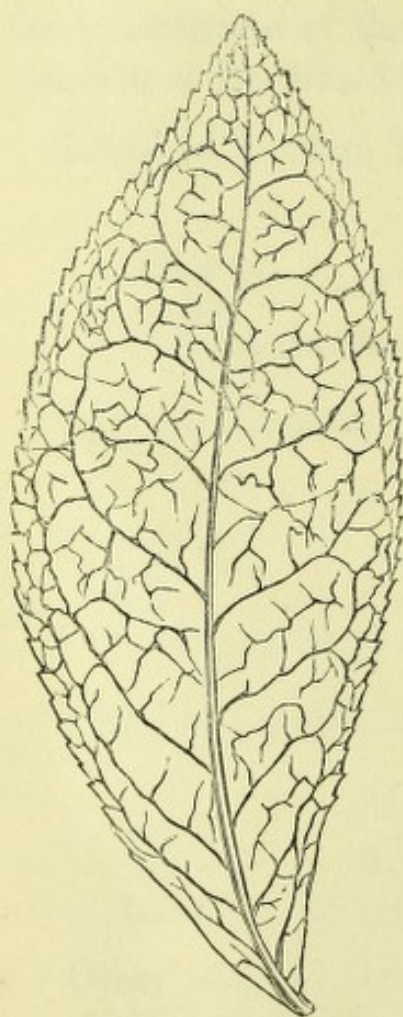
Leaves of the plant

PLANTAS DE LA ZONA DE MONTAÑA

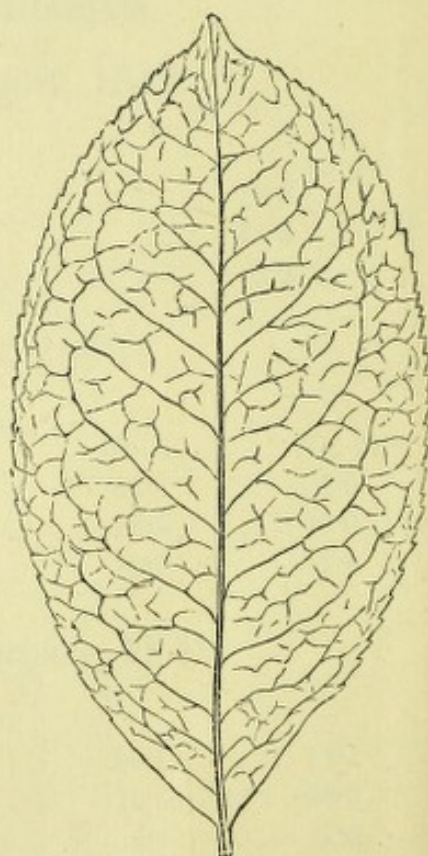
ILLUSTRATIONS OF THE TEA-LEAF.



Leaves of black tea.



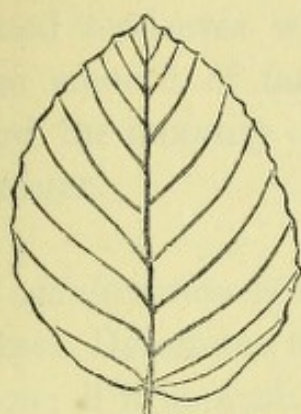
Leaf of the green variety of the tea-plant.



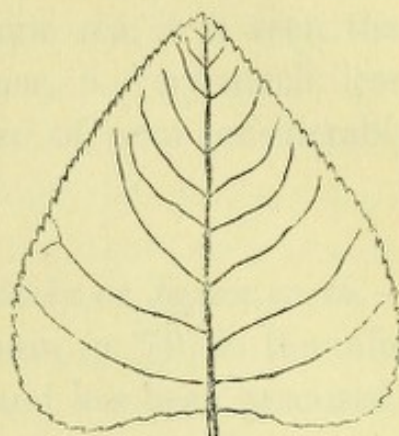
Leaf of the Assam tea.

(Dr. Hooker kindly supplied me with leaves of the tea-plants, cultivated in the Kew Gardens, from which these illustrations have been taken.)

LEAVES USED TO ADULTERATE TEA.



Beech.



Poplar.



Oak.



Willow.



Elder.

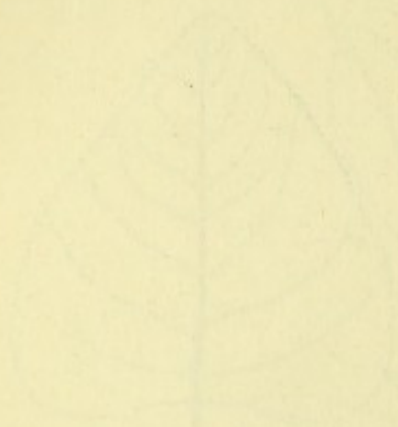


Hawthorn.



Sloe.

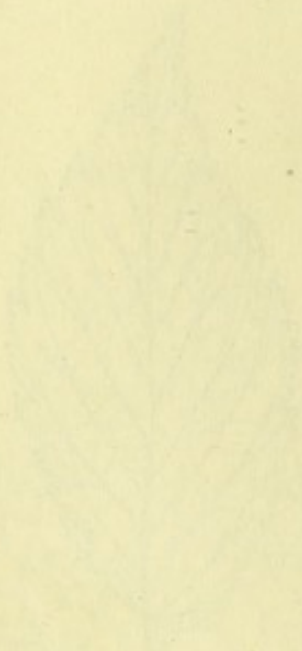
LEAVES OF THE WHITE OAK



Leaflet



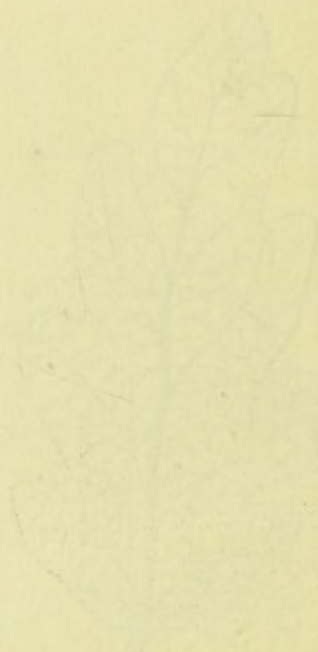
Leaflet



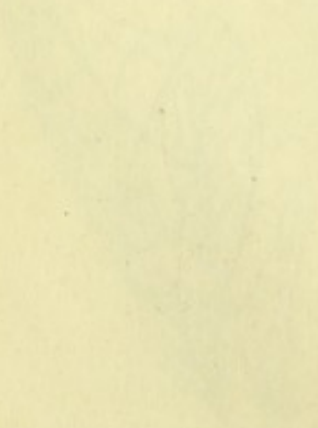
Leaflet



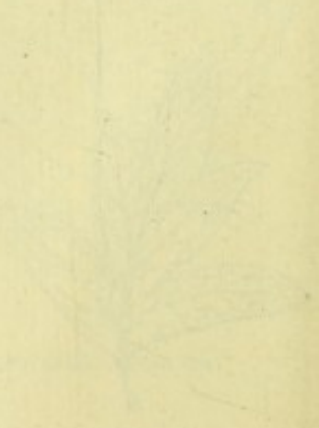
Leaflet



Leaflet



Leaflet



Leaflet

Contrasting the analysis of the exhausted and adulterated tea-leaves with that of genuine tea, it is seen that the amount of tannin, in the former, is very much less, and the quantity of lignine and also of gum considerably greater.

Adulteration of black tea with catechu or Japan earth.—Test: Determine the amount of tannin (p. 79) in the infusion; if it is much increased, the fraud has been practised.

La Veno Beno.—This substance consists of a coarse powder of a reddish-brown colour, intermixed with small fragments of a leaf, stated to be that of Sumach; to the taste, the powder is astringent and bitter, and on analysis it is found to be composed in great part of coarsely powdered catechu. (The same test as for Japan earth.)

Chinese botanical powder.—This substance is formed of a coarse reddish-brown powder, astringent to the taste, and made up of a mixture of catechu and wheat flour (p. 15).

Gum and starch.—These materials are employed in the manufacture of spurious tea; the leaves are steeped in a strong solution of gum which, in drying, occasions their contraction and causes them to assume more or less of their original appearance, giving them at the same time a polished appearance. In this case, a practised eye may readily detect the fraud, from the tea-leaves being much broken up, and from the peculiarly artificial character of their lustre (see also p. 80). The Chinese sometimes make use of a solution of rice starch (p. 15) to impart a peculiar form to the leaves.

Sulphate of iron.—A solution of sulphate of iron gives a deep colour to an infusion of tea, and, in factories of spurious tea, sulphate of iron is frequently added to the gum water to be used in making up exhausted tea-leaves.

Test: burn the leaves, and dissolve the ashes in water; add to the solution chloride of barium for the detection of sulphuric acid (p. 93), and ammonia for determining the presence of iron (p. 52).

Rose-pink.—Rose-pink consists of the colouring matter of logwood in combination with carbonate of lime (see p. 17). It is occasionally used by adulterators, to give a colour and bloom to the surface of black tea fabricated from exhausted tea-leaves.

Logwood.—Black tea is sometimes mixed with the pounded extract of logwood; this adulteration may be readily detected by moistening with water a small portion of the tea-leaves, and rubbing it gently upon a sheet of white paper, which will be stained bluish-black; moreover, if a sample of tea immersed in cold water imparts immediately to the liquid a pinkish or purplish colour, becoming red upon the addition of a few drops of sulphuric acid, it is a sign of the presence of logwood. The adulteration is employed with the view of simulating strength by the high colour of the infusion. Dr. Normandy has detected the colouring matter of logwood in teas represented as Souchong and Pekoe.

Graphite, plumbago, or black lead.—Graphite consists of a mixture of carbon and iron, in the proportion of about 95 per cent. of the former to about 5 of the latter. It gives to the surface of tea-leaves a black, shining, and metallic appearance. This adulteration may be detected by the eye alone; but the following methods are also recommended for the purpose: A thin slice of the faced leaf, placed under the microscope, will be seen thickly studded with numerous minute black particles. Moreover, the infusion of such tea will after a time, if this facing be considerable, acquire a blackish hue, and, on evaporation, the bottom of

the vessel containing black lead will be found to exhibit the dark shining characteristic coating of this substance.

Talc, China clay, or soap stone.—The adulteration with powdered talc or mica, (silicate of alumina, and tersilicate of potash,) though practised by the Chinese, has not yet been detected in any sample of our teas; *soap stone* and *mica* are, however, employed by them, for the purpose of imparting a bloom or lustre to the surface of the leaves. In this case, the leaves will exhibit, by close examination, minute shining fragments, which under the achromatic microscope appear more or less iridescent, an effect better seen with the polariscope. A simple lens will suffice to detect the larger particles of these substances. *China clay*, or *kaolin*, is prepared from decaying granite, being the result of the decomposition of the felspath, (silicate of potash and alumina), and mica of that mineral. *Steatit* or *soap stone* (silicate of magnesia and alumina), like mica, is laminated and iridescent, the laminæ exhibiting a crystallized structure.

Indigo.—Indigo is a blue colouring matter obtained from the *Tinctoria indigofera*; it does not exist ready formed in the plant, but is deposited during its fermentation. Under the microscope, it appears as minute granules and irregular fragments, reflecting a blue or greenish colour, this peculiar appearance enabling the observer to distinguish it from Prussian blue (see also p. 42). The adulteration in question is extensively practised in the manufacture of green tea, and the facing of certain descriptions of black tea, by the Chinese. From the peculiar medicinal action of indigo upon the body, the presence of this substance in tea is very objectionable.

Turmeric powder (p. 58).

According to the report of the Commission of the 'Lancet,' it appeared:

1. That not one of thirty-five samples of black tea, as imported into this country, contained any other leaf than that of the tea plant.

2. That out of the above number of samples, twenty-three were genuine and twelve adulterated. The genuine teas were the Congous and Souchongs, &c.; and the adulterated teas, samples of the scented Pekoe and scented Caper, Chulan or black gunpowder, as well as imitations of these made from tea dust.

3. That the adulterations detected consisted, in facing, so as to improve the appearance of the teas, the surfaces of the leaves with black lead, and in the manufacture of imitation tea out of tea dust, sand, &c.

4. That the fabrication of spurious black tea is extensively carried on at this time in the metropolis, and in other parts of the kingdom.

5. That two processes of fabrication are adopted: In the first, the exhausted tea-leaves are made up with gum, and redried; black lead and the mica-like powder, rose-pink and carbonate of lime, being sometimes added, to bloom or face the leaves, as well as sulphate of iron to darken the colour of the leaves and give astringency. In the second method, leaves other than those of tea are used. These, after being redried, are broken down, mixed with gum catechu, and made into a paste; the leaves are then redried, further broken down, and sometimes coated with gum. The spurious tea made from exhausted leaves is seldom sold alone, but is used either for mixing with genuine black, or is converted into green tea; while that made from British leaves and catechu is either mixed with black tea in the form of dust, or else is faced and bloomed until made to resemble green tea.¹

¹ 'Food and its Adulterations,' by Dr. Hassall, p. 290.

6. That out of twenty-four samples of black tea purchased of tea-dealers and grocers resident in the metropolis, twenty were genuine and four adulterated, the former being Congous and Souchongs, and the latter samples of scented Pekoe and scented Caper; the blame in this case not falling upon the dealers, they being in all probability wholly unaware of the fact of these peculiar descriptions of tea being adulterated in the manner described.

It thus appears that the Congou and Souchong teas are genuine, and the scented Pekoe and scented Caper all adulterated.

2. *Adulterations of green tea.*—The substances employed to adulterate green tea consist especially of those which are best calculated to improve its colour and general appearance; they may be the same as those used in the adulteration of black tea, and, besides these, it has been ascertained that many other substances are introduced.

Prussian blue.—This substance, prepared by the action of ferrocyanide of potassium on a per-salt of iron, is that which is most frequently employed in the facing of green tea. It may be detected by the action of liquor potassæ, which dissolves it instantly, and changes it into a dirty yellow or brown colour. Moreover, it is not bleached by chlorine, whilst indigo becomes white when acted upon by this substance. Under the microscope, it may be also recognised by the above reagents. Sulphuric acid, when added to the solution obtained by mixing potash with Prussian blue, causes the blue colour to reappear. When introduced into the body, even in minute quantities, Prussian blue is capable of producing an injurious action.

Mineral green, or hydrated subcarbonate of copper, is

prepared by precipitating a salt of copper by an alkaline carbonate, and treating the precipitate with boiling water. This substance is used, for the adulteration of green tea, in the form of a pigment, known as mineral green. Test: Carbonate of copper dissolves in hydrochloric acid with the evolution of carbonic acid, and ammonia added to the solution produces a blue colour. It precipitates in the infusion of tea.

Verdigris, or acetate of copper.—A highly poisonous salt. Test: When boiled with sulphuric acid it gives out the smell of vinegar, and becomes blue if treated with ammonia. Acetate of copper dissolves in the infusion of tea.

Arsenite of copper.—A highly poisonous salt. Test: Project a sample of the leaves in a fused mixture of carbonate and nitrate of potash or soda; dissolve the fused mass in water, and test for arsenic with Marsh's apparatus (see also pp. 26 and 43), and for copper with ammonia, which gives a blue colour.

Dutch pink.—Dutch pink is a bright yellow colour, consisting of a vegetable dye in combination with chalk; it is most frequently used in this country for the facing of spurious green tea. Test: *Liquor potassæ*, which converts the bright yellow into a dark brown, and acetic acid, which occasions effervescence (see also p. 17).

Chromate of potash.—This substance has a bright yellow colour; it is a poison.

Bichromate of potash.—An orange-red substance; several fatal cases of poisoning by it have occurred.

Chromate of lead.—A yellow salt, also poisonous. Test: *Chromium*, whatever be the form in which it exists, may be easily detected by means of the blowpipe. In the case of a *chromate or bichromate of potash*, let the infusion of tea be evaporated to dryness, and the residue burnt. The ashes are

now fused with the blowpipe, on a platina wire, previously mixed with borax or microcosmic salt, when a glass bead of a green colour will be obtained if any chromium is present. Should this metal occur in the form of *chromate of lead*, which is insoluble in water, the salt is to be collected on a filter, and tested with borax or microcosmic salt, as above mentioned. It may happen that, besides chromate or bichromate of potash, a soluble salt of copper has been used to adulterate the tea in question, in which case the test will not be altogether satisfactory, as copper produces the same action as chromium on borax or microcosmic salt, in the blowpipe flame. If the presence of copper has been detected by ammonia, or any other test (a solution of a salt of copper produces a blue colour with ammonia), it will be advisable to precipitate the chromic acid with acetate of lead for the purpose of obtaining an insoluble chromate of lead, which, being collected on a filter, may now be tested with the blowpipe. Moreover, when fused in the inner blowpipe flame, the green bead obtained with a copper compound becomes red and opaque, which is not the case with chromium; this is another useful means of distinguishing between the two metals.

Chalk, or carbonate of lime.—Test: Infuse the tea in water, pour off the infusion, and allow it to stand for an hour; then decant the fluid and add hydrochloric acid to the insoluble residue remaining at the bottom of the vessel, when it is dissolved with the evolution of carbonic acid; ammonia and oxalate of ammonia precipitate oxalate of lime in the acid solution (p. 17).

Gypsum, or sulphate of lime.—This substance is commonly used by the Chinese in blooming the leaves. Test: Proceed, first, as for the detection of chalk; then fuse the insoluble residue in nitrate of potash, dissolve the fused

mass in water, test for lime as in the case of chalk, and for sulphuric acid with chloride of barium, producing a precipitate insoluble in nitric acid (see also p. 19).

Carbonate of magnesia.—It has occasionally been used in this country for the same purpose as soap stone, China clay, mica, &c., to give a bloom to the leaves. Test: Hydrochloric acid dissolves the substance with evolution of carbonic acid; ammonia and phosphate of soda being added to this solution, produce a crystalline precipitate of triple phosphate (see also p. 17).

Chinese tea dyes.—1. A yellow dye composed of nearly equal proportions of turmeric (p. 58) and mica (p. 88). 2. A blue dye consisting of indigo (pp. 42 and 89) and carbonate of lime (p. 17). 3. A white powder having the properties of China clay or kaolin (p. 20).

On spurious green tea of British fabrication.—The conversion of black tea into the green variety has extensively prevailed in this country for many years past. In some cases spurious green tea has been manufactured from exhausted tea-leaves, both green and black; and, in others, an imitation green tea has been prepared from other leaves than those of the tea plant.

An interesting case, extracted from 'Accum,' is related in Dr. Hassall's book, where a party was convicted of manufacturing imitation tea from sloe and white thorn leaves. The leaves were first boiled, then baked upon an iron plate, and when dry, rubbed with the hand, to produce that curl peculiar to genuine tea; they were finally coloured with logwood. For the manufacture of green tea, the leaves were first boiled in water containing a little verdigris, then pressed and dried; they were next placed over a slow fire upon sheets of copper, and rubbed with the hand to curl them; the leaves being now dried,

were sifted, to separate the thorns and stalks ; more verdigris and some Dutch pink being now added, the verdigris gave the leaves that green bloom observable on genuine green tea.

The following analyses of samples of spurious green tea seized by the Excise during the last few years are well calculated to inform the reader of the substances employed in this fraudulent manufacture.

Seized 12th of May, 1843 :

GREEN TEA.		A.	B.
Lignine		84.9	85.5
Gum		6.8	4.8
Tannin and colouring matter		1.1	0.6
Carbonate of lime		4.0	3.6
Carbonate of copper		3.2	3.5
		<hr/> 100.0	<hr/> 100.0

In this case exhausted black tea-leaves had been dried, and dyed to imitate green tea.

Seized June 1st, 1843 :

GREEN TEA.		A.	B.
Lignine		86.5	86.6
Gum		5.4	5.6
Tannin and colouring matter		0.9	0.8
Carbonate of lime, Prussian blue, and a vegetable yellow dye		7.2	7.0
		<hr/> 100.0	<hr/> 100.0

Seized in Manchester, June 19th, 1845 :

This seizure comprised three samples of tea that were grossly adulterated with Prussian blue, bichromate of potash, carbonate of lime, carbonate of magnesia, and French chalk.

With the view of determining whether tea be artificially coloured or not, Dr. Hassall recommends the following methods :

If the leaves be considerably coated, a microscopical examination with a glass of one inch focus will suffice, to detect the foreign colouring matter which appears as minute specks, each reflecting its appropriate tint. Another method is to scrape the surface of two or three leaves with a penknife, when the spurious colouring matter may be detected in the powder thus separated. A third method is to place five or six leaves on a slip of glass, moistening them with a few drops of water, and, after the leaves have become softened, firmly squeezing the water out between the finger and thumb; the fluid will contain more or less of the ingredient forming the facing, if any has been employed. To obtain the result in question on a large scale, let half an ounce of the leaves be shaken in water for a few minutes, after a time the sediment will be detached, and collect at the bottom of the vessel. Lastly, the tea dust present in the sample of adulterated tea is usually found to contain a considerable quantity of the ingredients used for facing the leaves.¹

The Chinese employ annually a considerable quantity of leaves differing from the true tea-leaves, and known under the name of lie tea, for the adulteration of this important article of diet; they also introduce in this manufacture entirely foreign leaves. In a sample of Twankay, the Commission of the 'Lancet' detected the leaves of three other species of plant, two of which were identified as the *Camellia Sasanqua*, the other as a kind of plum.

To conclude with the adulterations of green tea, it appears according to the Commission of the 'Lancet,'

1. That the green teas, with very few exceptions, are

¹ By removing a few tea-leaves from the infusion in the tea-pot, and examining the shape, variation, colour, and other characters of the leaves, many of the above-mentioned adulterations may be detected.

adulterated, that is to say, are glazed with colouring matters of different kinds.

2. That the colouring matters used are, in general, Prussian blue, turmeric powder, and China clay, other ingredients being sometimes, but not frequently employed.

3. That, of these colouring matters, Prussian blue possesses properties calculated to affect health injuriously.

4. That, in this country there is really no such thing as green tea, or tea which possesses a natural green hue.

5. That green teas, more especially the gunpowder, in addition to being faced, are subject to adulteration with other leaves than those of genuine tea.

6. That lie tea is prepared so as to resemble green tea, and is extensively used by the Chinese themselves to adulterate gunpowder tea.

Besides the above adulterations, it is evident that tea undergoes further deterioration in our own country, and, from the investigations of the Commission, it appears—

1. That exhausted tea-leaves are frequently made up with gum, &c., artificially coloured and glazed, and are resold to the public as green tea.

2. That the substances employed in the colouring of tea are often highly poisonous.

3. That green tea is not uncommonly fabricated with leaves quite different from those of tea.

4. That black lie tea is often coloured and extensively employed by our own dealers and grocers for the adulteration of green tea.

COFFEE.

The coffee brought into commerce is the seed of the *Coffea Arabica*, a shrub belonging to the family of the

Bubiaceæ; it attains thirty feet in height when allowed to grow, but is usually cut down to the ordinary height of a man, to increase the crop of fruit. The fruit is a two-seeded berry, similar in appearance and colour to a small cherry; each berry contains two coffee beans in a fleshy or parchment-like integument. As the fruit does not all ripen at the same time, one crop requires several gatherings; the fleshy part of the berry, which contains a considerable quantity of saccharine juice, is removed partly by mechanical agency, and partly by fermentation. The fresh, ripe berries are pressed between rollers, and their thick juice allowed to run through sieves; they are afterwards cleaned by washing with water, and are subsequently dried. All that remains to be done is to remove the skin from the seeds, by submitting them to the action of a heavy wooden wheel, and winnowing the chaff by a fan, as in the case of ordinary grain. In Venezuela, however, the plan followed is different; the berries are there spread out upon hurdles in the sun, where they undergo the vinous fermentation for fourteen or twenty days, and then dry. The beans are freed from the skins by a mill, and by subsequent winnowing.

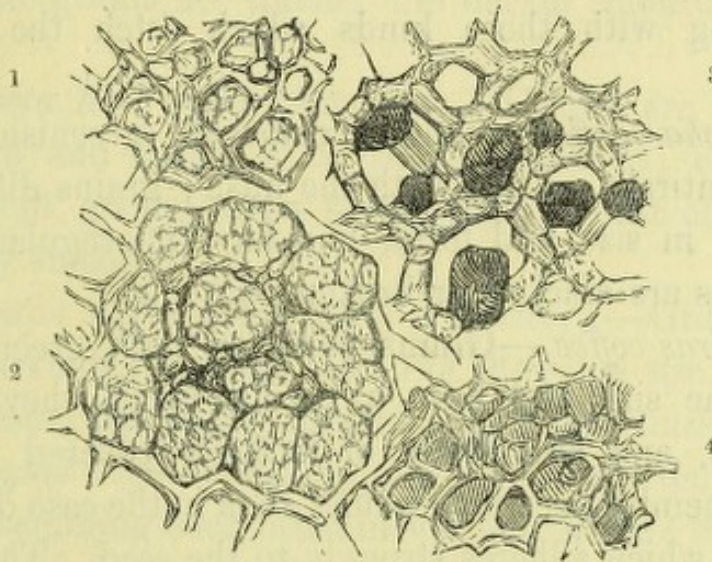
The use of coffee dates in Arabia from the end of the fifteenth century; it was introduced into Paris in the year 1669, and the first coffee-house was opened by Arminier, at St. Germain, in 1672.

Structure of the coffee seed.—The coffee seed is composed of two parts, the *substance of the seed*, and the *testa*, or membrane by which it is surrounded.

The *seed* consists of an assemblage of vesicles or cells, of an angular form, and adhering firmly together. The cavities of the cells include a considerable quantity of aromatic volatile oil, on which the fragrance of the coffee mainly depends.

The *investing membrane* is made up principally of elongated cells, forming a single layer, and having oblique mark-

Coffee.



1, 2. Section of unroasted coffee.

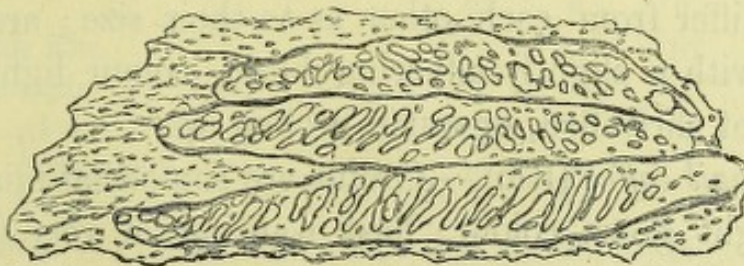
3, 4. Section of roasted coffee.

(Mag. 290 diam.)

ings upon their surface; these cells rest upon another thin membrane, which presents an indistinct fibrous structure.

The roasting of the berry does not alter materially its structure; the essential oil, however, is no longer visible in

Coffee.



Investing membrane.

(Mag. 290 diam.)

the cells in the form of minute drops or spherules, and has become more generally diffused throughout the cavities of the cells.

The following are the characters of the most important kinds of coffee, samples of which were kindly forwarded to me by a friend, one of our City brokers. The alphabetical order shows the relative value of the various coffees, commencing with those kinds which fetch the highest price.

A. *Mocha coffee*.—Light coloured, greenish-brown; partly or entirely covered with the husk; grains differ from each other in size and form, and have no regular shape; some grains are cracked or broken up.

E. *Madras coffee*.—Grains, coloured light green, are all of the same size, and have a regular form; they are not broken up, and are partly or entirely covered with an investing membrane, which is finer than in the case of Mocha coffee, and which adheres strongly to the seed. The grains have a shrivelled appearance.

G. *Ceylon coffee* (native).—Grains are larger than the preceding, and of a light yellowish-green colour, some grains being cracked or broken up; the husk is occasionally wanting, and does not adhere strongly to the seed; some grains are studded with dark green spots; the seeds differ from each other in size.

F. *Mysore coffee* (Bombay).—Grains have an elliptic shape; differ from each other as to their size; are partly covered with a slightly adhering husk; colour light green. Grains not shrivelled, or much broken up.

H. *Brazil coffee* (Rio).—Grains are somewhat misshapen, have a light green colour; husk wanting, or very fine, and strongly adhering to the grains; they are nearly all of the same size; some of them elliptic, others flattened, a few being small and shrivelled up.

I. *Brazil coffee* (Bahia).—Grains irregularly formed; colour light yellowish-green, studded with dark green

spots; husks wanting in many grains, in others it does not adhere strongly, and has a coarse structure. Grains cracked or broken up; some are elliptic, others flattened; the elliptic grains are smaller and darker coloured than the flat ones.

D. *Costa Rica coffee* (America).—Grains are all of the same size and shape, *i. e.*, rather flattened; colour uniformly light green; seeds nearly quite devoid of husk, are peculiarly smooth.

B. *Ceylon coffee* (Plantation Peaberry).—Grains small, and remarkably elliptical, are all of the same size, of a dark green colour, and partly covered with a thin husk.

C. *Ceylon coffee* (Plantation). — Colour dark green; grains resembling each other in size and shape; their under surface is concave; every grain is partly covered with husk; size rather above the average.

Chemical composition and analysis of coffee.—Professor Rochleder, who has devoted great attention to the analysis of coffee, gives the following enumeration of the substances found in raw coffee-beans, with the formula of their elementary composition :

	C.	H.	O.	N.
Woody fibre	12	10	10	0
Cane sugar	12	11	11	0
Fats { Palmitic acid	32	32	4	0
{ Oleic acid	36	34	4	0
{ Glycerine	6	8	6	0
Legumin	48	36	14	6
Caffeic acid	16	7	6	0
Caffein	16	10	4	4

Payen enumerates the proportional quantities of the different substances which he finds in raw coffee, as follows :

Cellular tissue	34·000
Hygroscopic water	12·000
Fats	10· to 13·000
Starch, sugar, dextrine, and vegetable acids	15·500
Legumin	1·000
Chlorogenate of potash and caffein	3·500
Nitrogenous portion	3·000
Free caffein	0·800
Thick insoluble ethereal oil	0·001
Aromatic oil	0·002
Mineral constituents: Potash, lime, magnesia, phosphorus, sulphur, silica, and traces of chlorine	6·697

1. *Cellular tissue* is the insoluble residue obtained by exhausting ground coffee with water and alcohol.

2. *Hygroscopic water* is detected, and its quantity determined by weighing the ground substance, drying it in the water bath, and ascertaining the loss.

3. *Fats* are obtained and determined by treating the ground coffee with ether, and evaporating the solution to dryness: or by treating the crushed coffee beans with alcohol, and mixing the extract with water, when the fatty matters are precipitated.

4. *Starch, sugar, and dextrine*.—For starch, proceed as in the case of grains (p. 14). (For sugar and dextrine, employ the method described at pp. 8 and 9.)

5. *Chlorogenate of potash and caffein*.—It is doubtful whether this combination exists. To detect the presence of caffein or thein, let the analyst adopt the same means as recommended in the case of the extraction of thein from tea (p. 80).

Chlorogenic acid is the same as the caffeic or tannocaffeic acid of Rochleder and Pfaff. To obtain this acid, dried and crushed coffee beans are treated with alcohol, and the extract is mixed with water, and filtered, in order to

separate the fatty matter. The filtered liquid mixed with acetate of lead, yields a precipitate, which is to be washed and decomposed by hydrosulphuric acid. The light yellow solution of tanno-caffeic acid thus obtained is deprived, by boiling, of an excess of hydrosulphuric acid. This solution, distilled with peroxide of manganese and sulphuric acid, yields the beautiful substance known as kinone; it is easily discernible by its volatility and peculiarly acrid odour, which greatly resembles that of chlorine. The solution of kinone gives, with ammonia, a sepia-black colour, and becomes reddish-brown with hydrosulphuric acid. It is decolorized by sulphurous acid. The beautiful green hydrokinone is obtained by exactly neutralizing the solution of the yellow kinone with sulphurous acid, great care being taken not to introduce the latter in excess.

The tests for kinone can be applied in a few minutes, and they are sufficient to indicate the presence of 10 or 12 per cent. of coffee in a mixture.¹

6. The *inorganic salts* are easily obtained by incinerating a known quantity of coffee, and submitting the ashes to chemical analysis.

Adulterations of coffee.—Coffee is usually and most extensively adulterated, especially when the berries are roasted and pounded to be sold in the form of ground coffee. The adulteration is principally Chicory, the roasted root of the chicory plant (*Cichorium intytus*), or wild endive. The importance and extent of this adulteration is such as to require the introduction of a special account of chicory and of the adulteration to which it is itself liable.

¹ Messrs. Graham, Stenhouse, and Campbell's Chemical Report on the Mode of Detecting Vegetable Substances mixed with Coffee for the purpose of Adulteration ('Quarterly Journal of the Chemical Society,' April, 1856).

Chicory and its adulterations.—This plant belongs to the natural family of the dandelion, and is indigenous, or in other words grows in various parts of this country: it may be observed on the roadside, or in the hedges, and recognised by the compound character of its flowers and their beautiful pale blue appearance. It blossoms in the months of August and September, and any one wishing to obtain a sight of this notorious vegetable, may gratify his or her curiosity by a walk along the banks of the Thames from Kew in the direction of Richmond. It has, moreover, been artificially raised in large quantities in this country. In Germany, and some parts of the Netherlands and France, Chicory is extensively cultivated for the sake of its root, which is occasionally used as a substitute for coffee.

When prepared on a large scale, the roots are partially dried, washed, cut, again dried, roasted by a process similar to that employed in the case of coffee, and finally reduced, between grooved rollers, to a powder. The powder very much resembles dark ground coffee, and has a strong smell of liquorice. The per centage composition of Chicory root in its various conditions is represented by the following analysis.

	Raw root.	Kiln dried.
Hygroscopic moisture	77.0	15.0
Gummy matter	7.5	20.8
Glucose, or grape sugar	1.1	10.5
Bitter extractive	4.0	19.3
Fatty matter	0.6	1.9
Cellulose, inuline, and woody matter	9.0	29.5
Ash	0.8	3.0
	<hr/> 100.0	<hr/> 100.0

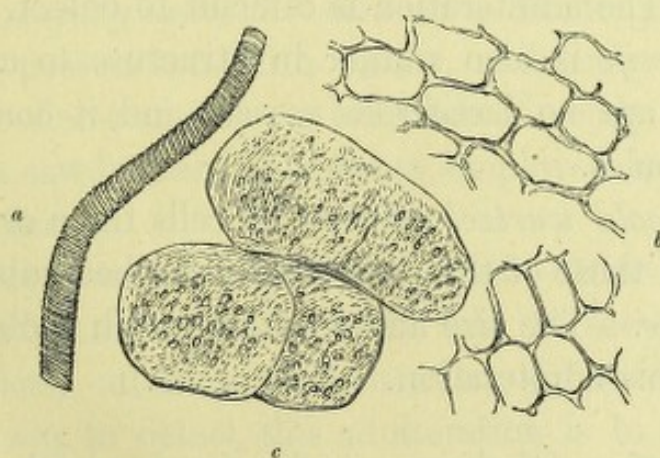
The composition of the roasted root is as follows:

	1st Specimen.	2d Specimen.
Hygroscopic moisture	14.5	12.8
Gummy matter	9.5	14.9
Glucose or grape sugar	12.2	10.4
Matter like burnt sugar	29.1	24.4
Fatty matter	2.0	2.2
Brown or burnt woody matter	28.4	28.5
Ash	4.3	6.8
	<hr/> 100.0	<hr/> 100.0

From a glance at the composition of coffee (see page 102) the reader will observe that there is no analogy between it and chicory, so that the latter cannot be made a substitute for the former. Coffee contains two principles, at least, which are possessed of undoubted value and activity: essential oil and caffein, acting as powerful stimulants on the body, whilst no such substances are found in chicory; add to this, that while the infusion made from coffee is light, transparent, and aromatic, that from the other is thick, viscid, heavy, and almost inodorous. (Hassall, p. 113.) Chicory is also highly objectionable from its medicinal properties.

Structure of chicory root.—Three structures may be distinguished; *i. e.*, 1, *cells*; 2, *dotted vessels*; and 3,

Chicory.



a, b. Section of the root, unroasted.

c. Scales seen in a section of the roasted root.
(Mag. 220 diam.)

vessels of the latex, or milky vessels. In the roasted and charred chicory root the microscopical appearance somewhat resembles that which is detected in the raw or unroasted article.¹

1. *Cells*, constituting the chief part of the root, generally of a rounded form, but sometimes narrow and elongated.

2. *Dotted vessels*, particularly abundant in the central and harder parts of the root; they are cylindrical unbranched tubes, tapering to a point at either extremity, and marked on the surface with short fibres.

3. *Vessels of the latex*, containing a milky juice, they form branched and frequently anastomosing tubes with smooth membranous parietes.

Adulterations of chicory.—Improbable as the fact may appear to the reader, chicory is nevertheless adulterated. The substances employed for this purpose are *carrot, parsnip, mangold wurtzel, beans, coffina, roasted corn, biscuit powder, burnt sugar, red earth, ground acorns, oak-bark tan, tan known as croats, mahogany and other sawdust, baked horses' and bullocks' livers, Hamburg powder, and Venetian red.*

1. *Carrot.*—This vegetable does not contain any vessels of latex. The adulteration is difficult to detect.

2. *Parsnip* is also similar in structure to chicory root, but there are no lactiferous vessels, and it contains small starch globules.

3. *Mangold wurtzel* consists of cells three or four times larger than those of the previously described substances.

4. *Beans.*—The size and form of starch globules suffice to detect this adulteration. (See p. 15.)

¹ A section of roasted chicory root, when viewed under the microscope, is found to consist mainly of broken up cells, and large yellow scales.

5. *Coffina*, a Turkish plant, having the appearance of coffee in colour, and a bitter taste ; it appears (from Dr. Hassall's woodcut) to consist of large egg-shaped dotted cells, of superposed elongated vessels, and of smaller angular cells, closely packed together.

6. *Roasted corn*.—The most frequent adulteration ; the microscope will detect at once this fraud. (See p. 15.)

7. *Biscuit powder*.—The Commission of the 'Lancet' has been informed that there exists in London a factory for the express purpose of preparing, on a large scale, from an inferior description of flour, a biscuit to be burnt, ground, and exclusively employed in the adulteration of chicory and coffee.

8. *Burnt sugar* is usually met with in black lumps about the size of a bean, they exhibit a shining fracture, and have a bitter and well-known peculiar taste.

9. *Oak-bark tan* is seen, with the microscope, to consist of three structures : 1, radiated cells ; 2, woody fibres ; 3, cells of a rounded form. Oak bark charred and ground very fine is stated to be employed in the adulteration of coffee and chicory.

10. *Tan, known as croats*, consisting of fragments of cellular tissue and bundles of dotted fibres.

11. *Mahogany and other sawdust*.—The fragments of this substance possess a reddish colour, and their woody fibres have a peculiar structure ; other kinds of woody fibre besides mahogany sawdust are sometimes employed in the adulteration of chicory.

12. *Baked horses' and bullocks' liver*.—After baking, they are ground into a powder and sold to low-price coffee-shop dealers, at from fourpence to sixpence per pound. The best way to detect this adulteration is to set aside an infusion of the suspected chicory or coffee, and if any

animal matter be present, in a few days the liquid will emit an offensive smell.

13. *Hamburg powder*, consisting of roasted and ground peas coloured with Venetian red. (See pp. 15 and 52.)

14. *Red earth*.—When placed between the teeth, chicory powder, thus adulterated, feels gritty; in some cases this grit may occur from the sand contained in the roots, derived from their having been very imperfectly cleansed.

15. *Venetian red or sesquioxide of iron*.—It is believed by the Commission of the 'Lancet' to be the principal substance, used at present for the colouring of chicory. (See p. 52.)

From the analysis of various samples of chicory, performed by the Commission, and reported in Dr. Hassall's book, it appears:

1. That eleven, or one half, of the samples examined were adulterated.

2. That four of the chicory powders were adulterated with roasted wheat.

3. That ground acorns were present in an equal number of cases.¹

4. That two of the samples contained sawdust, and one mahogany sawdust.

5. That mangold wurtzel was detected in one of the chicories.

6. That in one instance roasted carrot was present.

In a previous report on chicory, the Commission had given an account of the analysis of thirty-four samples of chicory, where it was stated:

¹ For the detection of ground acorn in coffee, see the abstract from Messrs. Graham, Stenhouse, and Campbell's report.

TABLE showing the Result of the Investigations of MESSRS. GRAHAM, STENHOUSE, and CAMPBELL, respecting the Methods of Detecting the Adulterations of Coffee.

	Coffee.	Cherry.	Washed Coffee.	Malt.	Asch.	Peas.	Beans.	Wheat.	Barley—Dry—Roast.	Barley—Wet—Roast.	Peas.	Current.	Peas.	Red Beet.	Doubleton Root.	Onion.	Carrot Root.	Turnip Root.	Carrot.	Beet.	Spent Tea.	Black Pepper.	Spice Root.
Specific gravity of solution at 60° (one part of substance to ten of water)	From 1008 to 1009.5	English, 1019.1 Foreign, 1029.6	1019.5	Brown, 1010.9 Black, 1011.2	1007.3	1007.3	1008.4	1005.3	1011.6	1021.4	1027.1	1014.3	1009.1	1001.9	Belah, 1007.9, Amber, 1008.6	1009.9	1010.9	—	1019.5	—	1005.3	1003.7	
Weight of substance (rounded), dissolved in 1000 parts of water, necessary to produce an equal depth of colour	Over-ripened, 5.46 Highly, 5.72 Medium, 6.95	Darkest Yorkshire, 2.22	1.66	Brown, 40.0 Black, 1.42	5.00	13.55	13.53	2.85	2.86	2.6	2.9	5.6	3.33	3.03	—	—	—	1	1.46	33.0	3.64	29.00	
Spice in 100 parts of substance (wet)	From 1.79 to 7.78	From 23.75 to 33.43	23.63	Brown, 9.48	3.44	—	—	—	—	30.48	Ordinary, 31.98	21.70	24.96	21.96	—	—	—	—	—	—	—	—	
Dirt (rounded)	From 0.00 to 1.14	From 9.46 to 17.98	9.91	Black, 1.60	0.70	Grey, 1.08	Brown, 1.62	0.42	Rye seed, 1.96	0.65	11.53	6.98	17.44	9.08	—	—	—	—	1.52	—	1.78	0.74	
Soluble substance obtained by agitating four times successively each article in ten times its weight of ether, (per cent.)	Mocha, 15.93	Yorkshire, 6.83	—	—	—	—	1.81	5.15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Spice in 100 parts of each substance	Roasted, from 0.0 to 0.45	Roasted, from 10.00 to 25.45	—	—	1.01	—	—	1.78	Rye, 9.22; Oat, from 38.48 to 60.05; Barley, from 21.6 to 29.77; Wheat, from 2.05 to 5.46	From 0.94 to 2.75	From 0.76 to 1.92	—	From 1.10 to 1.4	11.25	—	—	—	—	—	—	—	—	
Detective characters (from the analysis of ashes)	Carbonic acid, 14.92 to 19.11; Sulphuric, 0.98 to 0.98; Chlorine, 0.86 to 1.11	Carbonic acid, 17.5 to 23.9; Sulphuric, 0.98 to 2.53; Chlorine, 2.28 to 3.93	—	—	Carbonic acid, 13.00; Sulphuric, 0.98 to 1.14; Chlorine, 2.13	—	—	Sulphuric, 0.98 to 0.98; Chlorine, 0.50	—	—	—	Carbonic acid, 11.44; Sulphuric, 0.98 to 0.98; Chlorine, 2.09	—	Carbonic acid, 6.21; Sulphuric, 0.98 to 1.97; Chlorine, 3.44	—	—	—	—	—	—	—	Carbonic acid, 0.56; Chlorine, 1.11	

Action of chemical Reagents upon Infusions of Coffee and Chicory.

	No.	Infused Coffee	Raw Chicory	Roasted Chicory
Potash.	A. brightish-yellow precipitate, and effervesces.	Brownish-yellow liquid, and no precipitate.	Not altered.	Not altered.
Lead Water.	Pale yellow, as if no reaction at the 47th part.	Reddish-brown, with shade of purple, and no precipitate.	Not altered.	Not altered.
Sulphate of Copper.	Dirty greenish precipitate.	Brownish-green precipitate.	Pale green precipitate.	Gelatinous precipitate of a red-brown colour.
Potassium of Iron.	Deep rich-black liquid.	Very thick greenish-black precipitate.	Blackish-brown colored liquid.	No effect.
Nitric Acid.	Bright-colored liquid.	Clear port-wine-colored liquid.	No effect.	No effect or faint, on stirring, a port-wine colour.
Sulphuric Acid.	Dirty blackish-brown liquid.	Dark blackish-brown colored liquid.	Deep blackish-brown colored liquid.	Brownish-black liquid.
Hydrochloric Acid.	Pale rich-yellow liquid.	Port wine colored liquid.	No effect.	Slightly darkens the liquid.

No.	Name	Date	Remarks
1082	Sulphuric acid	From 100 to 1000	Specific gravity of solution at 80° (one part of substance to ten of water)
1083	Sulphuric acid	Over-boiled 2.45 5.17 5.22	Weight of substance (corrected), dissolved in 1000 parts of water, necessary to produce an equal depth of colour
1084	Sulphuric acid	From 570 to 15	Sugar in 100 parts of substance (100)
1085	Sulphuric acid	From 0.50 to 1.50	Lime (corrected)
1086	Sulphuric acid	Mixture 15.28	Soluble substance obtained by exhausting four times success- ively with water in the flask the weight of which (corrected)
1087	Sulphuric acid	Mixture 15.28	Sugar in 100 parts of each sub- stance
1088	Sulphuric acid	Mixture 15.28	Insoluble substance obtained from the analysis of ash

1. That fourteen of the samples submitted to examination were adulterated.

2. That in nine, the adulteration consisted of roasted corn.

3. That scorched beans were present in four of the samples.

4. That in one case ground acorn was detected.

It is needless to observe, that all the above ingredients employed to adulterate chicory may consequently be found in coffee; I have, therefore, classed them among the adulterations of coffee, and described them in this part of this little treatise.

Messrs. Graham, Stenhouse, and Campbell have just published, in the 'Quarterly Journal of the Chemical Society,' a very interesting and useful report of their investigations on the mode of detecting vegetable substances mixed with coffee for the purpose of adulteration.¹

I have thought it advisable to condense the results obtained by these gentlemen in the form of the accompanying table.

ON SAUCES AND THEIR ADULTERATIONS.

The chief substances entering into the composition of sauces are *Tomato*, *Garlic*, *Shallot*, *Sorrel*, *Mushroom* and *Walnut catsup*, *Raisins*, *Tamarinds*, the seeds of *Fœnugreck* and *Cumin*, the leaves of a number of herbs, a variety of spices and condiments, salt, treacle and burnt sugar as colouring agents, and flour as a thickening ingredient. Moreover, *Shrimps*, *Lobster*, and *Anchovy* enter into the composition of a few.

Tomato is the seed-vessel or fruit of a species of *Lyco-*

¹ See 'Journal of the Chemical Society' for April, 1856, p. 33.

persicum; it is said to contain much oxalic acid. The cells of its epidermis are rather small, flat, angular, and well defined; those of the pulp are several times larger, more or less round, and enclose the colouring matter, with a few globules also coloured and resembling oil; the cells of the ripe fruit do not contain starch. Garlic (*Allium sativum*) and shallots (*Allium Ascalonicum*) belong to the same genus of plant as the onion; they may be also recognised with the microscope.

The structures of the spices have been already described, and illustrated by the woodcuts in Chapter II.

Poisonous anchovy sauce.—Several samples of this fish sauce examined by the Commission of the 'Lancet' have been found contaminated with lead (for the test, see pp. 41 and 42).

The mode of preparation of this fish sauce consists in rubbing down the broken anchovy in a mortar, and this triturerated mass, being of a dark brown colour, receives a certain quantity of Venetian red (an iron compound) (p. 52,) for the purpose of colouring it; but instances have occurred of the pigment having been adulterated with orange lead, or red oxide of lead.

OLIVE OIL.

The olive tree grows naturally on most parts of the Mediterranean coast. It is extensively cultivated in the South of France, and especially in Spain, Italy, and Sicily. The plant is the *Olea Europa*, a small ever-green, presenting two well-defined varieties. One is a shrub, or low tree, and the other a taller tree between twenty and thirty feet in height. The fruit, when dry, is about the size of the damson, and consists of a fleshy,

greenish-white covering, a thick, strong shell, and a small kernel or seed. The fruit, gathered when not yet quite ripe, steeped for some time in lime water or alkaline ley, and then pickled in brine, is sold as the olive of the grocer's shop.

The finest, or virgin oil, is obtained by crushing the ripe olives. The ordinary oil of commerce is prepared by covering the olives with hot water and expressing; and the oil of lower quality separates spontaneously from the water used for separating the ordinary oil. Lastly, the impure oil (fermented oil), always musty tasted, is expressed from olives which have been allowed to ferment. The finest oil comes from Provence and Florence, sometimes also from Genoa and Lucca. The common sort, imported into this country under the name of Gallipoli oil, is brought from Naples; and that from Sicily and Spain, which is generally fermented oil, is the worst of all.

Fine olive oil has a pale, greenish-yellow tint, and keeps long without becoming rancid; it is fresh and without odour. Density 911 at 77° Fahr., at the temperature of 38°, a considerable part of it solidifies in white crystalline grains. It slowly absorbs oxygen from the air, and becomes thick and rancid.

Adulterations of Olive oil.—This fluid is much subject to be adulterated with poppy-seed oil, rape-seed oil, and other cheap oils. The density of the fluid is thus considerably increased, so that the adulteration may be detected, and its amount estimated by ascertaining the specific gravity of the mixture. But the best method to effect this purpose is that of Mr. Paulet. When pure olive oil is mixed with a solution of mercury in pure boiling nitric acid, the whole becomes in a few hours a firm fatty mass,

from the action of the hyponitrous acid in the solution. But if even so little as 5 per cent. of any other oil be present, the consolidation is much less complete, and slower; and if the proportion amount to 12 per cent., the foreign oil floats on the surface of a pulpy mass, for several days, before showing any tendency to consolidate.¹

¹ Dr. Christison's 'Dispensatory,' second edition, p. 660.

CHAPTER IV.

ON FERMENTED BEVERAGES AND THEIR ADULTERATIONS.

WINE, BEER, SPIRITS, VINEGAR.

WHEN a solution of sugar, in water, is mixed with a ferment (yeast, &c.), and exposed to a temperature of from 70° to 80° Fahr., it will very soon begin giving off *carbonic acid* gas, and acquiring a certain proportion of *alcohol*, both substances resulting from the decomposition of the sugar pre-existing in the liquid. This phenomenon is called the *alcoholic fermentation*. Wine, beer, and spirits are obtained by the process just mentioned; but spirits differ from the other beverages, in as much as they are the products of the distillation of alcoholic fluids. If a liquid which has undergone alcoholic fermentation, is allowed to remain still longer, freely exposed to the atmosphere in a warm place, a further process of decomposition will be induced, called the *acetous fermentation*, and the liquid will be found to contain vinegar.

I propose in this chapter—

1. To offer a few remarks on the chemical composition and distinctive characters of wines, beer, and spirits.
2. To give the reader such practical directions as are best calculated to enable him to make a satisfactory chemi-

cal analysis of alcoholic liquors, both in reference to the nature and quantity of their constituents.

3. To show how alcoholic liquors may be adulterated, and what methods should be adopted for the detection of the fraud.

4. To offer a short account of the preparation of vinegar, its chemical composition and analysis, and to show the adulterations to which this article of diet is exposed, together with the methods for their detection.

WINE.

Wine is prepared from the alcoholic fermentation of juice of grape. All genuine wines have an acid reaction, are more or less alcoholic, and contain some sugar. Their flavour depends on the presence of certain volatile ethers. In the 'Philosophical Transactions' for 1811 and 1813, Mr. Brand has given tables of the strength of wine, beer, and spirits; and more recently, in 1854, Dr. Bence Jones has devoted much attention to this subject; besides ascertaining the amount of alcohol in a great number of different wines, beer, and spirits, he has determined the quantity of sugar and acid they contained.¹

According to the general results obtained from Dr. Bence Jones's investigations respecting the acidity of wines, the quantity of alkali required to neutralize a measure equal to 1000 grains of water was—

			Grains.
In Port wine	. (8 different qualities were examined) ²	. .	2·10 to 2·55
In Sherry	. . (18 „ „)	. .	1·95 „ 2·85

¹ Lecture on the Acidity, Sweetness, and Strength of different Wines, delivered at the Royal Institution of Great Britain. By Henry Bence Jones, M.A., M.D., F.R.S., etc., February 1854.

² The same different qualities were submitted to analysis for the purpose of determining the amount of sugar and alcohol they contained.

			Grains.
In Champagne . . .	(4 different qualities were examined)		2·40 to 3·15
In Claret . . .	(8 " ")		2·55 „ 3·45
In Madeira, &c. . .	(14 " ")		2·70 „ 3·60
In Rhine wine . . .	(4 " ")		3·15 „ 3·60
In Burgundy . . .	(3 " ")		2·55 „ 4·05
In Moselle . . .	(2 " ")		2·85 „ 4·50
In Cider . . .	(1 " ")		2·85 „ 3·90

Hence, proceeding from the least acid wine to the most acid, we have: Sherry, Port, Champagne, Claret, Madeira, Burgundy, Rhine wine, Moselle.

In regard to the amount of sugar in different wines, the same distinguished physician concluded from his investigations that—

			Amount of Sugar in an ounce of fluid.
In Sherry the sugar varied from 2 to 9 degrees . . .			4 to 18 grains.
In Port " 8 „ 17 " . . .			16 „ 34 „
In Madeira " 3 „ 10 " . . .			6 „ 20 „
In Malmsey Madeira " 28 „ 33 " . . .			56 „ 66 „
In Tokay " 37 " . . .			74 „
In Samos " 44 " . . .			88 „
In Paxarete " 47 " . . .			94 „
In Cyprus " 51 " . . .			102 „
In Champagne „ " 3 „ 14 " . . .			6 „ 28 „
In Sweet Cider ¹ " 9 „ 22 " . . .			18 „ 44 „

The degrees in the above table are those of the saccharometer of Mr. Soleil, an instrument which will be described in the course of this chapter.

Dr. Bence Jones ascertained the strength of a great number of alcoholic fluids, by means of the alcoholometer of Geisler, which acts by the tension of the vapour of the fluid to be examined, forcing up a column of mercury. It may be stated generally that in these experiments the alcohol varied—

¹ Claret and Hock contained no sugar.

In Port from	.	.	20.7 to 23.2 per cent. per measure.		
In Sherry	.	.	15.4 „ 24.7	„	„
In Madeira	.	.	19.0 „ 19.7	„	„
In Marsala	.	.	19.9 „ 21.1	„	„
In Claret	.	.	9.1 „ 11.1	„	„
In Burgundy	.	.	10.1 „ 13.2	„	„
In Rhine wine	.	.	9.5 „ 13.0	„	„
In Moselle	.	.	8.7 „ 9.4	„	„
In Champagne	.	.	14.1 „ 14.8	„	„
In Cider ¹	.	.	5.4 „ 7.5	„	„

As to the salts contained in wine, they must be very different in different kinds of wine, and even in grapes cultivated on different soils. The nature of the ashes of wine may be conjectured from the composition of the ashes of the juice of grape.

In 100 parts of must of juice of grape, there have been found—

	Purple Grapes.	
	Ripened on porphyry.	Ripened on other soils.
Potash	0.2122	0.2939
Soda	0.0014	0.0049
Lime	0.0114	0.0139
Magnesia	0.0161	0.0163
Oxide of iron	0.0015	0.0003
Oxide of manganese	0.0025	0.0004
Phosphoric acid	0.0564	0.0575
Sulphuric acid	0.0189	0.0149
Chlorine	0.0035	0.0020
Silica	0.0071	0.0049
	<hr/> 0.3310	<hr/> 0.4090

BEER

Is a most agreeable and healthy beverage; it contains sugar and alcohol derived from fermented malt, the alcohol being formed at the expense of the sugar, as in the case of wine. The flavour of beer is produced by means

¹ Cider is obtained from the fermentation of the juice of various fruits, as apples, pears, &c.

of hops, and does not arise spontaneously during the fermentation. Beer also contains more or less free acid.

The amount of alcohol, sugar, and acid present in beer varies according to its quality.

The following table shows the results of Dr. Bence Jones's experiments on the quantity of alcohol, sugar, and acid contained in beer :

	Alcohol.	Sugar.	Acid.
Bitter Ale varies from	6.6 to 12.3	12 to 130	0.90 to 1.65
Porter ,,	6.5 7.0	23 40	1.35 2.25
Stout ,,	6.5 7.9	45 64	1.80 2.10

Grains in one ounce of fluid.

(The amount of acid is represented by the quantity of caustic soda necessary to neutralize a measure of each fluid equal to 1000 grains of water.)

Along with the above-mentioned constituents of beer, I might enumerate certain inorganic substances which constitute their ashes. Mitscherlich obtained 0.307 of inorganic matters in 100 parts of beer. In 100 parts of its ashes he found—

Phosphoric acid	20.0
Potash	40.8
Soda	0.5
Phosphate of magnesia	20.0
Phosphate of lime	2.6
Silica	16.6

DISTILLED ALCOHOLIC BEVERAGES, OR SPIRITS.

1. *Brandy* is an ardent spirit obtained by the distillation of wine. Its constituents are water, alcohol, volatile oil, a little acetic acid, ænanthic ether, colouring matter, and tannin, the latter being derived from the cask in which the spirit has been kept. The dark brandy usually found in the shops of this country is artificially coloured.

British brandy is extensively manufactured, and sold as foreign brandy.

2. *Gin*.—In Holland, this spirit is prepared from unmalted rye and barley malt, fermented and then distilled with juniper berries. In Britain, gin is usually obtained from a mixture of malt and barley, molasses and corn being sometimes employed, and it is in general flavoured not only with juniper berries, but with certain other aromatic substances, as coriander, cardamom, and caraway seeds, grains of paradise, angelica root, calamus root, crushed almond cake, liquorice powder, and orange peel; these ingredients, variously mixed, form what are known in the trade as “gin flavouring.”¹

3. *Whiskey* differs from gin in its peculiar smoky flavour and odour, derived from its being prepared with malt dried on turf fires; according to Dr. Ure, bad raw-grain whiskey is often impregnated with peat smoke. The other flavour of this spirit is owing to a volatile oil derived from the barley employed for preparing the liquor. The greater reputation of the Highland over Lowland whiskey, has been ascribed to the use of porter yeast by the Lowland distillers, which is said to deteriorate the flavour.

4. *Rum* is obtained in the East and West Indies, from the juice of the sugar cane, which is highly impregnated with its essential oil. This spirit is also prepared from the fermented skimmings of the sugar-boiler, molasses, the washings of the boilers, and the lees of spent wash of former distillation, called *dunder*. It is imported into this country in puncheons. In some parts of the West India Islands, it is customary to put slices of pine apple in the puncheons of rum, hence the designation of pine-apple rum.

¹ Dr. Hassall on ‘Food and its Adulterations,’ p. 634.

5. *Arrack*, or *Rack* is prepared in Batavia by the distillation of fermented infusions of rice; in Ceylon it is obtained by distillation from fermented cocoa-nut toddy. Pine apples steeped in it, impart a most exquisite flavour to the spirit; it is sometimes used in this country to give an agreeable flavour to punch. A mock arrack is made by dissolving twenty grains of benzoic acid in two pints of rum.¹

Liqueurs and *Compounds* consist of spirits sweetened and otherwise flavoured. A great variety of liqueurs are imported, as *Kirchwasser*, obtained by distillation from the fermented juice of a black cherry, cultivated in Switzerland, and in some parts of France; *Maraschino*, procured in Dalmatia from a peculiar variety of cherry; *Curaçoa*, prepared by digesting bitter orange peel, cloves, and cinnamon, in old brandy, to which sugar dissolved in water is subsequently added; &c., &c.

Qualitative analysis of alcoholic liquors.—It is necessary that the reader should now be advised, as to the best methods to be employed for the analysis of alcoholic liquors. The most important constituents of such beverages are *water*, *alcohol*, *sugar*, *gum*, certain acids, and *inorganic salts*, or *ashes*. As no alcoholic liquors are free from water, it will be superfluous to inform the reader how to detect its presence in these fluids; and from the circumstance that alcoholic drinks, after combustion, leave a considerable liquid residue, it is to be inferred that water constitutes the greatest proportion of the substances entering into the composition of alcoholic beverages. The smell and taste allow the detection of *alcohol* in any liquid; as a further proof, let a sample of the fluid be distilled, when the first

¹ Pereira on 'Food and Diet,' p. 165.

portion of the distillate will yield a more decided taste and smell of alcohol, and burn when a lighted taper is applied to it, if any alcohol be present. To find the existence of *sugar* in an alcoholic fluid, various methods may be adopted. Perhaps the most satisfactory process is to evaporate the liquid to dryness, dissolve the residue in a little water, and add to it some yeast; the mixture being introduced into a tube partly filled with mercury, is subsequently inverted into the mercury-trough, in such a manner that no air should be left in the tube; fermentation will soon commence, yielding carbonic acid, which collects in the upper part of the tube; if the temperature is not high enough, let the tube and its contents be slightly warmed with a lamp placed at a short distance from them. Unfortunately, the method just described is seldom practicable, unless it be in a laboratory of chemistry. The second process to effect the purpose in question, is one previously described for showing the presence of sugar in an aqueous solution—I mean the tartrate of copper and potash test (see pages 9 and 121); by heating the saccharine fluid with this blue compound, a red precipitate of suboxide of copper will appear just as the mixture begins to boil. With strongly alcoholic fluids, it is necessary to concentrate before applying the test, in order to expel the greatest part of the alcohol; this test is a good one, and can be relied upon in the majority of cases. Finally, the *saccharometer of M. Soleil* is an instrument extremely useful for detecting the existence of sugar in a fluid; it is, however, more especially adapted for obtaining quantitative determinations of this substance, and will be described in a subsequent part of this chapter. (See p. 123.) Very minute quantities of sugar may escape detection by this means, so that the other methods are preferable. *Gum*, more especially contained in beer, is extracted by eva-

porating the fluid to dryness, and treating the residue with alcohol; the gum remains undissolved (see also p. 80). The presence of *free acids* in alcoholic liquors is ascertained easily with blue litmus paper, which, when dipped in the fluid, will turn red. By evaporating to dryness a sample of an alcoholic liquor, and incinerating the residue, an *ash* is obtained; for its chemical examination, I beg to refer the reader to Fresenius's work on 'Chemical Analysis.'

Quantitative analysis of alcoholic fluids.—1. *Sugar.*—The amount of sugar present in an alcoholic fluid may be determined by different processes: *i.e.*, 1st, by volumetric measurement with a normal solution of tartrate of copper and potash; 2d, by means of the saccharometer; and 3d, by fermentation. Of these various methods, the first and the second are perhaps the most useful and practical; the third process, depending on the amount of carbonic acid generated by the fermentation of the liquor, is more particularly adapted to the determination of sugar in aqueous solutions.

For the volumetric determination of sugar, it is necessary to begin by preparing a normal solution of tartrate of copper and potash, and the following formula shows the proportions of the substances entering into the formation of this fluid:

	Grammes.	Grains.)
Bitartrate of potash (cream of tartar)	150	or 2315
Crystallized carbonate of soda	150	„ 2315
Potash	100	„ 1543
Sulphate of copper	50	„ 771
A sufficient quantity of water to dilute the solution to 1638 cubic centimetres, ² or 93 cubic inches.		

¹ One gramme is equal to 15.438 grains, and one English cubic inch to 16.386 cubic centimetres.

² This solution was employed by Cl. Bernard in his physiological researches.

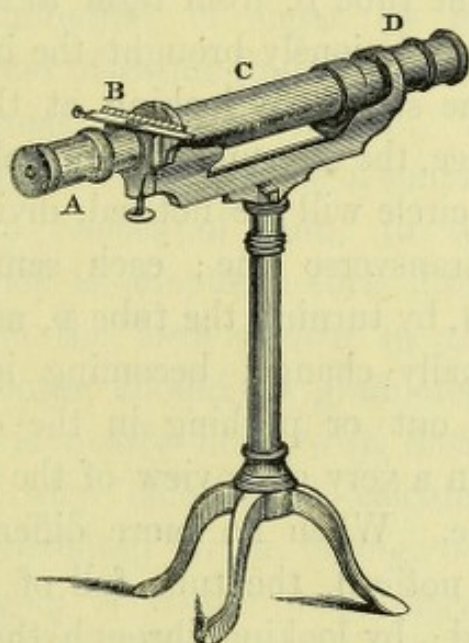
The normal solution thus prepared will have a very deep blue colour, and yield a precipitate of suboxide of copper, with a trace of grape sugar, just as the solution is about to boil.

The next operation is to determine exactly how much of this solution corresponds to a given quantity of sugar. For this purpose, weigh 0.05 grammes of pure, dry grape sugar, and dissolve it in a small quantity of water contained in a capsule. A graduated burette being filled with the blue solution, the saccharine fluid is next heated, and, when boiling, the blue solution is carefully added to it drop by drop, until no further precipitate be induced, when the mixture will immediately assume a slightly bluish tint; the quantity of solution employed will correspond to the known amount of sugar, and it will be found that about 10 cubic centimetres of the blue fluid will be discoloured by 0.05 grammes of grape sugar. In order to avoid errors, it will be necessary to repeat the operation. With the view of determining the quantity of sugar contained in an alcoholic or aqueous liquor, place in a capsule the quantity of the blue fluid which was discoloured by the known weight of sugar in the previous experiment; fill a burette with the fluid to be analysed, and pour it carefully drop by drop into the boiling blue compound; as soon as the precipitate has ceased to appear, and the fluid become discoloured, examine how much of the saccharine liquid has been used, and that quantity will contain exactly as much sugar as was employed in the first experiment; by a simple calculation the per centage of sugar may be determined.

The saccharometer is an instrument which affords a ready means of determining how much sugar is contained in a solution; the only condition required for its application, is that the fluid should be sufficiently colourless and clear

to allow the free passage of light through it. For a minute description of this interesting instrument, I must beg to refer the reader to the 'Rapport sur le Saccharimètre de M. Soleil.'¹

The saccharometer is constructed on the principle that the polarizing power of a column of saccharine fluid is proportional to the quantity of sugar it contains. The



instrument consists of two distinct parts. 1. A tube (C), closed at both extremities with glass discs, which may be screwed on the tube or removed at pleasure. 2. A stand, supplied at each extremity with two cylindrical tubes (A and D), one acting as an eye-piece, and the other intended to receive the direct rays of a strong gas or oil light. In front of the eye-piece (A), is an index and scale (B), both moveable horizontally by means of a screw. Before using the instrument, it is necessary to discolour the fluid; for this

¹ Comptes rendus des Séances de l'Académie des Sciences, tome xxvi.

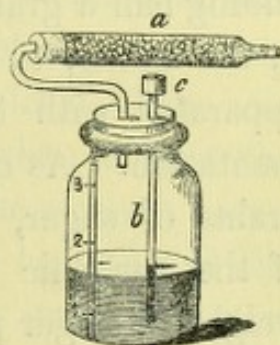
purpose, add a small quantity of acetate of lead (solid) to the coloured liquid, and filter; if it is not yet clear enough, filter again through animal charcoal. Let the liquor be now introduced into the moveable tube, closed at one end with the glass disc which is screwed on it. When quite full, stop the open extremity of the tube with the other disc, care being taken to prevent the formation of air bubbles therein.

Before placing the moveable cylinder on the stand, let the observer turn the tube D, from right to left, and from left to right, having previously brought the index in a line with the zero of the scale; by looking at the same time through the eye-piece, the instrument being placed opposite a strong light, a circle will be noticed, divided into two semicircles by a transverse line; each semicircle has a different colour, but, by turning the tube D, as directed, the colours will gradually change, becoming identically the same; by pulling out or pushing in the eye-piece, the observer may obtain a very clear view of the coloured disc and transverse line. When no more difference between the colours can be noticed, the tube full of fluid is to be placed on the stand; by looking through the eye-piece in the direction of the light, it will now be perceived that the colours of the semicircles are altered; let the index be moved from left to right, or from right to left, according to the kind of sugar in the solution,¹ and the two half-discs will again assume the same colour; when there is no more perceptible difference between them, notice the number of divisions included between the zero of the scale and the

¹ For cane sugar and grape sugar, move the short index from right to left, these sugars rotating polarized light to the right. Uncrystallizable sugar, which exists in wines, is determined by moving the index from left to right, as it rotates polarized light to the left. Cane sugar boiled with an acid is converted into this uncrystallizable sugar.

index, each division on the left-hand side, corresponding as near as possible to one grain of sugar in one ounce of solution, and each division on the left-hand side corresponding to two grains of sugar in one ounce of liquid. After a little practice, the saccharometer may be used with a sufficiently tolerable amount of accuracy for all practical purposes; it takes less than ten minutes to make an observation.

The determination of sugar by fermentation, is an accurate method of estimating the amount of sugar, in an aqueous or weak alcoholic solution. For this purpose, a small glass flask is used, capable of containing an ounce and a half or two ounces of fluid, to the mouth of which is adapted a cork fitted with tubes in the form shown in the figure; the bottle should be graduated. The tube *a* is nearly filled with small fragments of dry chloride of calcium, which are prevented from falling out by a loose plug of cotton wool placed at each end. The tube *b*, which reaches nearly to the bottom, is made open at both ends; the top, however, being accurately closed by means of a small piece of wax or cork during the process of fermentation. Fill the bottle to about one half with the saccharine fluid and weigh the instrument, its weight when empty having been previously ascertained; thus the amount of fluid used for the experiment is determined; then mix a little German yeast with the fluid in the bottle, and weigh the apparatus again. After standing for a day or two at a temperature of about 70° or 80° Fahr., if the fermentation appears to have entirely ceased, remove the small plug of cork or wax from the tube *b*, and blow air gently through



it for the purpose of expelling the carbonic acid contained in the bottle, and replacing it with common air. The small plug is now attached to the tube *b* as before, and the whole apparatus weighed. The loss will indicate the weight of carbonic acid, which has escaped through the tube *a*; but as this gas is soluble at ordinary temperatures in about its own bulk of water, the portion of acid held in solution by the fluid must be added to that which has escaped; this amount is readily known by the bottle being graduated; one cubic inch of carbonic acid weighs 0.47 of a grain. The whole amount of carbonic acid formed during fermentation is therefore determined by adding half a grain, for every cubic inch of liquid contained in the bottle, to the difference between the weight of the apparatus with the fluid and yeast before and after fermentation. As one grain of carbonic acid represents 2.25 grains of sugar, it follows that by multiplying the weight of the carbonic acid obtained by 2.25, we obtain the weight of sugar present in the quantity of fluid submitted to analysis.¹

2. *Gum*.—The determination of the amount of gum contained in a given weight of an alcoholic liquid, is effected by evaporating to dryness the weighed fluid, and treating the residue with alcohol; the gum remains undissolved, it is to be well washed with hot alcohol, and finally dried and weighed.

3. *Alcohol*.—To find out how much alcohol there exists in a known quantity of an alcoholic liquor, several methods may be employed. From the circumstance that alcohol is a much lighter fluid than water, it follows that mixtures of alcohol and water are lighter than water, or have a lower specific gravity: there are tables showing exactly how

¹ T. E. Bowman, 'Practical Handbook of Med. Chemistry.'

much alcohol and water in an alcoholic fluid correspond to different specific gravities at certain temperatures ; so that nothing more is required for the determination of the quantity of absolute alcohol in an aqueous solution, than to reduce or increase the temperature of the fluid to that indicated by the tables, and then take its specific gravity with a common hydrometer. In order to obtain correct results by this method, it is necessary that the liquid should consist of no more than alcohol and water. In consequence of the presence of sugar, gum, colouring matter, &c., in wine, and of other extractive substances in beer, the direct quantitative determination of alcohol in these fluids, by means of the hydrometer, cannot be effected with a sufficient degree of accuracy ; it will therefore be necessary to distil them, having previously neutralized their acid reaction with a little carbonate of soda ;¹ when at least the two thirds of the fluid have distilled into the receiver, ascertain the temperature of the distillate, and heat or cool the liquid to 60° or 68° Fahr. Let its specific gravity be now ascertained with the hydrometer (water being 1000), or with the specific gravity beads,² or with a bottle of a known weight and a balance ; and, finally, read in the accompanying table how much alcohol corresponds to the specific gravity just determined. Spirits, or distilled alcoholic liquors, containing much less extractive matters than wine or beer, may be examined at once without previous distillation ; where much accuracy is required, it will be advisable, however, to distil them also, and ascertain the specific gravity of the distillate.

¹ This operation is in most cases unnecessary.

² Small glass beads are prepared, having their weight engraved upon them ; when they are immersed in a fluid, the bead which has the slightest tendency to rise or fall indicates by its weight the specific gravity of the liquid. This method is very convenient.

The following is a table showing the quantity of absolute alcohol (sp. gravity 0.791), in spirits or mixtures of alcohol and water of different densities.¹

100 parts.		Specific gravity.		100 parts.		Specific gravity.		100 parts.		Specific gravity.	
Alcohol.	Water.	At 68°	At 60°	Alcohol.	Water.	At 68°	At 60°	Alcohol.	Water.	At 68°	At 60°
100	0	0.791	0.796	66	34	0.877	0.881	32	68	0.952	0.955
99	1	0.794	0.798	65	35	0.880	0.883	31	69	0.954	0.957
98	2	0.797	0.801	64	36	0.882	0.886	30	70	0.956	0.958
97	3	0.800	0.804	63	37	0.885	0.889	29	71	0.957	0.960
96	4	0.803	0.807	62	38	0.887	0.891	28	72	0.959	0.962
95	5	0.805	0.809	61	39	0.889	0.893	27	73	0.961	0.963
94	6	0.808	0.812	60	40	0.892	0.896	26	74	0.963	0.965
93	7	0.811	0.815	59	41	0.894	0.898	25	75	0.965	0.967
92	8	0.813	0.817	58	42	0.896	0.900	24	76	0.966	0.968
91	9	0.816	0.820	57	43	0.899	0.902	23	77	0.968	0.970
90	10	0.818	0.822	56	44	0.901	0.904	22	78	0.970	0.972
89	11	0.821	0.825	55	45	0.903	0.906	21	79	0.971	0.973
88	12	0.823	0.827	54	46	0.905	0.908	20	80	0.973	0.974
87	13	0.826	0.830	53	47	0.907	0.910	19	81	0.974	0.975
86	14	0.828	0.832	52	48	0.909	0.912	18	82	0.976	0.977
85	15	0.831	0.835	51	49	0.912	0.915	17	83	0.977	0.978
84	16	0.834	0.838	50	50	0.914	0.917	16	84	0.978	0.979
83	17	0.836	0.840	49	51	0.917	0.920	15	85	0.980	0.981
82	18	0.839	0.843	48	52	0.919	0.922	14	86	0.981	0.982
81	19	0.842	0.846	47	53	0.921	0.924	13	87	0.983	0.984
80	20	0.844	0.848	46	54	0.923	0.926	12	88	0.985	0.986
79	21	0.847	0.851	45	55	0.925	0.928	11	89	0.986	0.987
78	22	0.849	0.853	44	56	0.927	0.930	10	90	0.987	0.988
77	23	0.851	0.855	43	57	0.930	0.933	9	91	0.988	0.989
76	24	0.853	0.857	42	58	0.932	0.935	8	92	0.989	0.990
75	25	0.856	0.860	41	59	0.934	0.937	7	93	0.991	0.991
74	26	0.859	0.863	40	60	0.936	0.939	6	94	0.992	0.992
73	27	0.861	0.865	39	61	0.938	0.941	5	95	0.994	
72	28	0.863	0.867	38	62	0.940	0.943	4	96	0.995	
71	29	0.866	0.870	37	63	0.942	0.945	3	97	0.997	
70	30	0.868	0.872	36	64	0.944	0.947	2	98	0.998	
69	31	0.870	0.874	35	65	0.946	0.949	1	99	0.999	
68	32	0.872	0.878	34	66	0.948	0.951	0	100	0.1000	
67	33	0.875	0.879	33	67	0.950	0.953				

(For this Table we are indebted to Lowitz.)

Acids.—To determine the amount of acid contained in wine, beer, or spirits, the method adopted by Dr. Bence Jones

¹ Ure's 'Dictionary of Chemistry and Mineralogy,' p. 129.

will be found practical and accurate. A standard solution of caustic potash must be prepared, so that each division of a graduated tube should contain 0.15 grains of caustic soda; a thousand-grain bottle is filled with the fluid to be examined; it is then weighed, and the quantity of test alkali necessary for neutralization determined with Clarke's test paper.¹

Adulterations of wine.—In all times, wine has been more or less subject to adulterations; thus the Greeks used to add sea water to their wine to the extent of three pints in every six gallons; they perfumed it with pitch, rosin, cassia, myrrh, cypress leaves, saffron, &c.

The adulterations of wines may depend on the presence of impurities, owing to a defect in their manufacture, or to their being mixed with foreign substances.

Lees and acid in wines.—The principal impurities found in wine are deposits, or lees, and acid substances, resulting mainly from the acetous fermentation of the grape sugar. The lees, consisting principally of bitartrate of potash, vary in different kinds of wines, and are owing in the majority of cases to a secondary fermentation, induced by the wood of the cask; in order to prevent this process of decomposition, it is customary in some countries to burn sulphur in the empty casks, previous to the admission of the wine into them; it is also believed that the fumes of burning sulphur (sulphurous acid) prevent wine from turning sour, an action which is explained by the sulphurous acid being slowly oxidized, and converted into sulphuric acid, so that the injurious action of the air on the wine is entirely prevented, as long as there is any sulphurous acid to be converted into

¹ Dr. Bence Jones on the Acidity, Sweetness, and Strength of different Wines.

sulphuric acid. We may therefore expect, assuming this view to be correct, to find traces of sulphuric acid (for test, see pp. 94 and 139) in every case where the wine has been exposed to the fumes of burning sulphur. The formation of lees and acid in the cask are, in all probability, closely connected. Lees act, moreover, as a ferment, and may induce a further process of fermentation in the wine, which becomes very sour, and unfit to drink. To arrest acetification in wines, various methods are employed, as the addition of evaporated must, honey (for the methods of testing the presence of sugar, see p. 120), and sulphuring. In old wines, however, the acidity will often disappear spontaneously. Another decomposition which may occur in wine, is the formation of carbonate of potash from the tartar contained in the liquor; wine, under these circumstances, acquires a bad taste, loses its red colour, and assumes a dark violet hue; to restore the natural colour nothing more is required than to add a small quantity of tartaric acid to the wine. The impurity is also recognised by an effervescence taking place when the liquor is tested with a mineral acid. (To determine the degree of acidity of wine, proceed as directed at p. 129.)

Colouring matters.—In many cases, wines are artificially coloured; and this constitutes one of the most frequent forms of adulteration. In the case of Port wine, its bright red colour is often due to the elderberry, whortleberry, beet-root, Tournesol, logwood, Brazil-wood, &c., which substances deteriorate considerably the flavour and durability of wine; in these cases the colour of wine, unless brightened by alum, approaches to violet, and the liquor acquires a flat and herbaceous taste. According to Cadet, the adulteration in question is detected by pouring a solution of alum in the wine, and then adding potash; if the wine is pure

the precipitate thus induced will possess a bottle-green colour, more or less dark, according to the natural hue of the wine; if colour has been artificially obtained, the results will be as follows: Tournesol will give a precipitate of a bright violet colour, Brazil-wood will occasion a brownish-red precipitate, elderberries or privet a brownish-violet precipitate, whortleberries a precipitate of the colour of dirty wine lees, with logwood the precipitate will be coloured lake-red. Vogel recommends, for the same purpose, the use of acetate of lead; in genuine wines, it produces a greenish-gray precipitate, which is not the case with coloured wines. Prout gives ammonia, as a test for the determination of artificial colours in wines; this reagent occasions in genuine wines an olive-green colour, and a precipitate containing phosphate of ammonia and magnesia or triple phosphate; in those artificially coloured, the precipitate forms more gradually, in less quantity, and is free from admixture with triple phosphate.¹

Alcohol.—This fluid is added in large proportion more especially to Port and Sherry, but also to most of the wines sold in the London market, for the purpose of making them stronger to the taste, and preventing their decomposition. The wine reserved for exportation at Oporto is mixed with a considerable quantity of brandy, and when it arrives in this country possesses a dark, purple, or inky colour, with an astringent, bitter-sweet taste, and a strong flavour and odour of brandy; and it is only after being kept for ten or fifteen years in bottle, that the odour of the brandy is completely subdued, and the genuine aroma of the wine developed. During the process of melioration, a considerable portion of the extractive and colouring matter

¹ Henderson's 'History of Wines.'

is deposited on the sides of the bottles, in the form of crust, and when this takes place to a great extent, the wine has been found to have lost its flavour and aroma. In those wines which have been manufactured from white grapes, and coloured with elderberries or other foreign materials, this change occurs much earlier than in others; these colouring matters are often added by wine-makers, together with a large quantity of brandy, when there is a deficiency of black grapes. It was stated before the Committee of the Wine Duties, in 1852, by Mr. Forrester, an extensive vine-grower of Portugal, that no Port is brought to England with less brandy in it than three gallons to a pipe of one hundred and fifteen gallons, and that if it contained less, the English would not purchase it. (To determine the amount of alcohol in wines, see p. 126.)

Artificial wines.—Not much is known on the methods employed in this country for making artificial wines. There are many recipes for preparing Port wine; thus Mr. Redding stated, in his evidence before the Wine Duties Committee, that the following is a mode of making surreptitious Port in London:

230	gallons of Beni Carlos,
230	„ Figueiras,
137	„ Cape,
165	„ good Port,
115	„ common Port,
20	„ Mountain,
26	„ brandy-casks washings, colouring liquid, &c.

Another recipe recorded is—12 gallons of strong Port, 6 of rectified spirits, 3 of brandy, and 42 of rough cider, making 63 gallons of imitative Port.¹ There is little doubt, but that French and other foreign wines are also imitated, and artificially made in this country.

¹ 'The Food of London,' by Dodd.

Adulterations of beer.—This healthy and agreeable beverage used to be prepared about twenty-five years ago from a mixture containing many violent poisons, as Indian hemp (*Cocculus Indicus*), opium, sulphuric acid, sulphate of iron, &c.; the addition of strychnine even to beer has more recently been suspected.

At the present time, the principal adulterations of beer (more especially porter), consist of water, to increase the bulk of the fluid, and burnt sugar and salt, to restore in a measure its colour and flavour.

Water.—From the circumstance that the amount of alcohol in beer is not subject to considerable variations, it is evident that, when water is added to beer, the proportion of alcohol it contains will be diminished. In order, therefore, to detect the adulteration in question, determine the quantity of spirit existing in the fluid (p. 126). The samples of stout examined by the Commission of the 'Lancet,' yielded from 7.15 to 4.53 per cent. of alcohol, sp. gr. 0.796, obtained from brewers, or purchased at their taps, and from 4.87 to 3.25 per cent. of alcohol when procured from publicans. Analogous results were derived from the examination of various samples of porter; the amount of alcohol in porter obtained from the tap varying from 4.51 to 2.42 per cent., whilst in that purchased from publicans it ranged from 3.97 to 1.81 per cent. A more accurate method of determining the amount of water in alcoholic liquors, is to estimate the proportion of alcohol in a sample of the fluid, and evaporate another weighed quantity to dryness; the weight of the residue, subtracted from that of the fluid, shows how much water and alcohol it contained; and this last result, minus the quantity of alcohol previously determined, is equal to the amount of water present.

Sugar.—The use of this substance is allowed in breweries; still, its admixture with beer is probably not frequent, since sugar is considered to prevent it from keeping well. Moreover, the high price of sugar forms an obstacle to its use in breweries.

Burnt sugar or *treacle* was extensively employed some years ago, with the view of increasing the dark colour of porter and stout; the ingredient known as *Essentia bina*, formerly used in the manufacture of beer, consisted of moist sugar boiled in an iron vessel until it had become syrupy, perfectly black, and extremely bitter. (For the detection and quantitative determination of sugar in alcoholic beverages, see pp. 120 and 121.)

Salt.—According to Dr. Hassall, it appears that salt is almost constantly present in porter, the addition being made first by the brewers themselves, and subsequently by the publicans, in order to assist in restoring the flavour of beer which has been reduced in strength from the addition of water. Salt is used by the brewers in the following manner: "It is first mixed up in a tub with some kind of flour, usually wheat flour, and the mixture is cast by handfuls over the surface of the wort in the cooling vat."¹ To estimate the quantity of salt, or chloride of sodium, contained in an alcoholic beverage, evaporate a sample of the fluid to dryness, or dry the residue left in the retort after the determination of the alcohol; burn the solid substance; and dissolve the ashes in distilled water; finally, add nitrate of silver to the solution, and proceed as directed at p. 25.

Acid in beer.—The acidity in beer is very considerable; it depends, probably, on the presence of malic and lactic acids. In many cases, however, acetic acid or vinegar is formed in beer from a decomposition or excessive fermen-

¹ Dr. Hassall on Food, &c., p. 631.

tation of its sugar; the beverage is then very sour, and unfit for use. (For the detection and estimation of the acidity of beer, see p. 129.) There is some reason to believe that sulphuric acid is occasionally used to give astringency to beer, in which case the addition of chloride of barium to the liquor will cause the formation of a bulky precipitate insoluble in nitric acid.

Sulphate of iron.—This substance was employed formerly in the manufacture of beer, and is possibly used for the purpose in question at the present time. Should this substance be present in an alcoholic beverage, by adding ammonia and sulphide of ammonium to the fluid, a black precipitate will be produced.¹ For sulphuric acid, test as directed in the preceding paragraph.

Adulterations of spirits.—Spirits may be adulterated with water, sugar, capsicum, cinnamon or cassia, various sulphates and free sulphuric acid, and lead.

Water and sugar.—For the methods employed to detect the presence of an excess of water, and to estimate the amount of alcohol and sugar in alcoholic liquors, I beg to refer the reader to pp. 133, 126, and 121.

Capsicum or cayenne pepper.—A ready means is offered for discovering the presence of this spice in spirits, from the taste of the residue obtained by evaporating the fluid nearly to dryness. If it should contain cayenne pepper, the taste of the residue will be hot and fiery.

Cinnamon or cassia.—The oils of these substances are sometimes used for flavouring gin. In order to detect them, the spirit should be concentrated at a low temperature, and finally tested as in the case of capsicum.

Compounds containing sulphuric acid.—The presence of

¹ Examine also the ashes of beer for iron, see p. 52.

sulphates was found in gin by the Commission of the 'Lancet.' This adulteration is detected by means of chloride of barium, or nitrate of baryta, which occasion in the liquor a precipitate of sulphate of baryta, insoluble in nitric acid. If the acid is combined with zinc, ammonia and sulphuretted hydrogen will produce a precipitate of white sulphuret of zinc; if it is combined with alumina, in the form of alum, evaporate to dryness, dissolve the residue in water, and proceed as directed at p. 20. Free sulphuric acid is also occasionally added to spirits.

Lead.—Should acetate of lead have been used to adulterate spirits, concentrate the liquor, and test as directed at p. 41 for lead, and p. 43 for acetic acid.

The samples of spirits examined by the Commission of the 'Lancet' yielded from 22.35 to 48.80 per cent. of alcohol; this great variation in their strength being, doubtless, principally attributable to dilution with water. They found from 3 oz. 4 dr. 23 gr. to 13 oz. 4 dr. 13 gr. of sugar per gallon of gin; two of the analysed samples contained oil of cinnamon, or, more probably, of cassia; seven of the samples yielded cayenne pepper, some of them in very large quantity. They failed to detect free sulphuric acid in gin, the spirits being neutral to test paper; but most of the samples were found to contain sulphates, mostly derived from the water and alum used in the adulteration and clarification of the spirit.

VINEGAR.

Vinegar being the result of a peculiar fermentation, I shall conclude the present chapter with a short account of this article of diet, and its adulterations.

Vinegar is the product of the phenomenon known as the

acetous fermentation. When a solution of sugar is mixed with a ferment, and allowed to stand undisturbed, freely exposed to the atmosphere, it is converted into alcohol; but if the fermentation be allowed to continue longer, the alcohol rapidly disappears, and, in its place, vinegar is found.

In France, vinegar is usually prepared from wine. At Paris, the wine destined for this purpose is mixed with wine-lees, transferred into cloth sacks, and strained by pressure. The fluid is next exposed to the heat of the sun in summer, or to that of a stove in winter. Fermentation supervenes in a few days; in summer, the process is usually completed in a fortnight; in winter, double the time is requisite. The vinegar is then run off into barrels, which contain chips of birch wood. In about a fortnight, it is found to be clarified, and is then fit for the market. In this country vinegar is usually made from an infusion of malt mixed with the barm of beer; the fluid is collected in casks placed upright, and supplied with a false cover pierced with holes, which is fixed at about a foot from their bottom. The liquor is poured into another barrel every twenty-four hours; and, towards the end of the fermentation, rape or refuse from the maker of British wine, or a quantity of low-priced raisins, are added to communicate flavour.

Finally, vinegar has been long prepared by the distillation of wood; oak, ash, birch, and beech being used for this purpose. The crude products of distillation are rectified by a second distillation in a copper still; and then, by mixing the fluid with lime, evaporating it to dryness, roasting gently the residue, decomposing the calcarious salt with sulphuric acid, and distilling the mixture; a perfectly colourless and grateful vinegar distils over. French vinegar is distinguished from all those varieties made in

Britain, by the action of ammonia, which occasions a purplish muddiness and precipitate in the former. The latter, or British vinegars, are either unaltered by ammonia, or produce with it a dirty brownish precipitate.

Chemical analysis of vinegar. — Vinegar owes its active properties to an organic acid called *acetic acid*, it is important that we should possess satisfactory and practical means of estimating the proportion of this acid in a given quantity of vinegar. The most convenient method is to use a normal solution of carbonate of soda, and to add the fluid, drop by drop, until the mixture, when tested with blue litmus paper, has ceased to turn it red. 97 grains of the pure hydrated acid (sp. gr. 1063) are neutralized by nearly 242 grains of crystallized carbonate of soda. As in the analysis in question, the colour of the test paper might be affected by the carbonic acid evolved from the carbonate of soda, it will be advisable to dry the test paper after each immersion; if the red colour is owing to free carbonic acid, the paper, when dry, will reassume its blue appearance. Should free sulphuric acid have been found present in the vinegar under examination, it will be necessary to distil the liquid nearly to dryness, and then determine the amount of anhydrous acetic acid contained in the distillate. French wine vinegar yields from 3.46 to 5.10 per cent. of pure acetic acid (Dr. Hassall).

Adulterations of vinegar. — According to Dr. Christison, vinegar may be adulterated with water, sulphuric acid, copper, lead, and acrid vegetable substances; to these, Dr. Hassall adds pyroligneous acid and burnt sugar.

Water. — To determine how much water there exists in a given quantity of vinegar, ascertain first the amount

of pure hydrated acid which it contains (see page 138); then evaporate to dryness another weighed sample of the fluid, and weigh the residue, thereby obtaining the total amount of fluid in the vinegar; by subtracting the weight of the pure acetic acid from the total amount of fluid lost by evaporation in the second operation, the weight of the water will be obtained.

Sulphuric acid.—The addition of one part of sulphuric acid to a thousand of British vinegar is permitted by law; so that, unless the quantity should exceed this, it is not to be considered as an illegal adulteration. In some cases, however, the Commission of the 'Lancet' have found samples of vinegar to consist of little else than sulphuric acid, coloured with burnt sugar. This adulteration is not uncommonly met with in low coffee-houses and oyster-stalls. Test (see page 94): The quantitative determination of sulphuric acid may be obtained with a normal solution of chloride of barium, prepared in such a way that 1.2 grain of chloride of barium be dissolved in 100 grains of distilled water, a quantity which represents half a grain of commercial sulphuric acid. Five hundred grains of vinegar should be poured into a beaker, and the solution gradually added so long as any precipitate forms. A more exact method is to add an excess of chloride of barium to a weighed sample of the vinegar, to collect the precipitate of sulphate of baryta on a filter, burn the filter, and determine the weight of the ashes. If sulphuric acid should be present in vinegar in the form of a sulphate, by evaporating some of the vinegar to dryness and igniting the residue, the ashes dissolved in distilled water will yield, with chloride of barium, a precipitate insoluble in nitric acid.

Burnt sugar.—For the detection of this adulteration, evaporate the vinegar to dryness, treat the residue with

water, and test the aqueous solution as directed at p. 9. Burnt sugar is sometimes used for colouring vinegar.

Copper and lead.—These substances may find their way into vinegar. Test: The adulteration is detected by sulphuretted hydrogen, which occasions a black precipitate in the vinegar. If copper be present, ammonia will produce a blue colour in the fluid; iodide of potassium will occasion a yellow precipitate of iodide of lead, in vinegar containing a comparatively large quantity of this metal.

CHAPTER V.

ON ANIMAL FOOD—MEAT, FISH, MILK, ETC.—AND ITS ADULTERATIONS.

MEAT, or flesh, may be viewed as consisting of two distinct parts: 1. An organized tissue, composed especially of fibres. 2. A fluid, moistening every part of this tissue, and containing a number of substances in the dissolved state. If a sample of raw meat be cut into fine pieces, mixed with cold water, and strained through a cloth, the operation being repeated until the strained liquid be colourless or nearly so, an insoluble fibrinous mass is obtained, which has completely lost the colour, taste, and smell of flesh. Animals fed with meat thus deprived of its soluble constituents cannot live, and die from starvation, showing that the organic fibres of meat are entirely devoid of nutritive power; if, on the other hand, animals be fed with the juice or fluid extract of meat, they will live and thrive. It is therefore of the greatest importance that the meat which is to constitute our food, should possess the whole of its soluble principles; and I shall have an opportunity of showing how far people appear unaware of this fact, when we consider the

usual mode of cooking, and more especially of preserving meat.

Chemical composition of flesh.—The fibrinous network of meat, when thoroughly washed with water, contains much *nitrogen*, the most essential chemical element of food; still, by itself, as I have already observed, it is incapable of sustaining life. Notwithstanding the received views that this network of fibres is dissolved by digestion and converted into blood, it is not improbable that the whole, or a part of these fibres, though greatly lacerated by digestion, find their way through the intestinal canal. The fluid extract of meat, or soup, has a complex composition, and every one of the substances it contains acts an important part in the formation of blood, and finally of new flesh. The investigations of Baron Liebig have shown that the juice of flesh contains the following substances: *Albumen*, *Creatine*, *Creatinine*, *Lactic acid*, and *Inosimic acid*, besides *Inorganic salts*. Every one of these principles undergoes changes or metamorphoses in the intestinal canal, and is partly or entirely absorbed into the blood.

The most important of the soluble principles of meat is *albumen*; it occurs in large quantity in soups prepared with cold water, and assumes the solid form, or coagulates, on boiling the fluid. The coagulation commences shortly before the liquid begins to boil, the albumen assuming the form of colourless flakes; presently, the flakes seize upon the colouring matter of the soup, and, when the boiling has commenced, they acquire a deep brown or nearly black colour. The mother-liquor in which the coagulated albumen is suspended, has now lost its red and muddy appearance, and becomes perfectly transparent, colourless, and as limpid as pure water. If the coagulated albumen be

removed with a skimmer from the boiled extract of meat, and the clear fluid employed to cook vegetables or for other culinary processes, it is evident that the soup thus prepared will possess but very little of the nutritive properties of the entire fluid extract of meat. The reader will therefore understand, that in order to make the most nutritive soup, it should not be skimmed.

Since the nutritive qualities of soup depend upon its containing those principles of meat which are dissolved within its fibrinous network, it follows that to obtain the most useful soup from a given quantity of meat, the whole of its juice must be withdrawn from it, and this is best effected by allowing the meat to soak in cold water for some hours, and then heating the fluid gradually for a certain time, without, however, allowing it to boil. If water be poured upon meat, and then made to boil rapidly and briskly, a coating of coagulated albumen will be produced on the outer surface of the meat, which, becoming hard and tough, will prevent it from giving out its juice; so that the soup will be deficient in albumen and other constituents. On the other hand, to prepare boiled meat, it will be advisable to increase the temperature rapidly to the boiling point, and keep on the boiling until the whole of the albumen be coagulated within the meat. Roasted meat yields still more food than boiled meat or soup, for in the process of roasting nothing is removed from the meat but the gravy, which finally becomes also an article of food.

The other constituents of meat are only important in a physiological point of view, and I shall abstain from dwelling upon them.

Fish has the same chemical composition as meat; it contains also albumen and other extractive matters fit to be

converted into blood and flesh, when taken into the body. Salt fish is objectionable on the same ground as salt meat (see the article on "Salt Meat," &c.). I believe dried fish to be a wholesome article of food when properly cooked, and if dried before putrefaction has commenced.

Putrid meat.— In warm weather, meat is very apt to undergo decomposition. The chemical change thus induced might be divided into two stages: the first, which is attended with a peculiar well-known taste and smell, though the eye fails to detect it; and the second stage, at once determined by the sight, when small insects are seen making their way inside the meat, and converting it into a disgusting mass of rotten flesh. In both stages of decomposition, meat has become unwholesome and decidedly objectionable as an article of food. It is a well-known fact, that meat preserved in the form of sausages by exposure to smoke becomes a violent poison if allowed to undergo the first stage of decomposition, previous to its being smoked. M. E. Van der Corput ('The Chemist,' May, 1855, No. 20) states that, by official return, in Wurtemberg alone, during fifty years, more than 400 cases of poisoning with such meat have occurred, and 150 deaths.

This poisonous effect of bad sausages was observed so far back as 1735. Dr. Kerner collected 135 cases from 1793 to 1822, of which 84 were fatal. Dr. Weiss, of Wurtemberg, collected 19 cases in eight months, of which 6 died. In regard to the symptoms attending this kind of poisoning, they occur in general twelve or fourteen hours after having taken the food; there is much oppression, sharp pains in the stomach, nausea, vomiting, and great thirst, with irregularity of pulse, coldness of extremities, and

finally syncope. Other symptoms of a nervous character accompany the latter, as paralysis of the muscles of the pharynx and eyelids, a croupy cough and peculiar dryness of the mucous membrane. The treatment must depend on the most prominent symptoms.

Not only are sausages in a state of decomposition liable to produce disease and death, but also cases of poisoning have occurred from pork-butcher's meat under similar circumstances; thus, in 1832, M. Chevalier, of Paris, had to make a report upon serious cases of poisoning from pork-butcher's meat; no metallic poison was found in the meat, but it was noticed to be covered with a peculiar mouldiness. Many other cases of poisoning in France with moulded meat are recorded. Rancid fats and decayed cheese have also given rise to symptoms of poisoning.

It is singular and important to observe, that though putrid meat be decidedly unhealthy, still, meat from diseased animals appears quite innocuous, which is shown to be the case from experiments made at the Veterinary School of Alfort, by Hussard, Renault, and others;¹ but as diseased meat is very apt to undergo putrid decomposition, immediately or very rapidly after death, it may at all events be considered objectionable.

I do not propose to enter upon a discussion as to the wholesome and nutritive characters of different kinds of meat. The market is undoubtedly provided with horse and dog's flesh, which is more particularly employed for making soup and sausages; but beyond the tough nature of the flesh and its disagreeable taste, it can hardly be called unwholesome.

¹ M. Flourens relates, that during the fatal period of 1789, the poor of St. Germain and of Alfort ate 700 or 800 horses which were afflicted with glanders or farcy, without suffering any inconvenience.

MILK.

Milk is composed of casein, fatty matters, sugar of milk, salts, and water, and when a drop is examined with the microscope, it is seen to contain a great number of small round globules.

Milk is usually a white fluid, but on certain occasions it has been observed to possess a blue colour, which is caused, according to some, by microscopic vegetation, according to others by an infusion of animalculi (*Vibrio cyanogenus*). The smell, taste, and even colour, of different kinds of fodder, more particularly of turnips, are well known to be communicated to the milk.

Not only is milk an article of food fit for keeping up life, but also, by mechanical and chemical decomposition, it yields other kinds of nutritive substances. When milk is allowed to remain undisturbed for some hours in a shallow and wide basin, it divides into two parts; the superior layer, or cream, being more abundant in fatty matters, and the inferior layer containing a greater proportion of casein, and known as skimmed milk. When milk or cream are violently agitated, as by the process of churning, the globules run together, and a more solid substance is formed, known as *butter*, which differs but very slightly from cream. *Curds* are merely casein transformed into a solid substance by the action of rennet, or an acid; the mother-liquor is the *whey*, or serum, and consists only of water, sugar, and salts. *Cheese* is made either from pure milk, or from milk free from cream (skimmed milk), and consists of casein precipitated by the influence of rennet, and then subjected to great pressure in moulds. Its flavour increases by keeping, from the progressive decomposition which it gradually undergoes. Some kinds of cheese are

full of what are called eyes, that is, hollows formed by bubbles of gas; and in these apertures a liquid is sometimes found containing free ammonia, a product of decomposition which greatly heightens the flavour. Little is known of the chemical differences in the processes employed for making the various kinds of cheese. The richest consist almost entirely of cream, as *Stilton* and *Parmesan*; others, as *Gruyère*, *Gloucester*, *Cheshire*, and *Dutch* cheese, are made with fresh uncreamed milk, or mixtures of this with cream. More or less salt is mixed with cheese, or powdered over it, and various methods of coagulating the casein are used in different places. (Prof. Gregory.)

The following analysis of cheese was made by Mr. Jones in Professor Johnston's laboratory:¹

	Skim-milk Cheese. Made June 1845, analysed June 1846.	Double Gloucester Cheese. Made June 1845, analysed July 1846.	Dunlop Cheese. Made at Wellwood 1845, analysed 1846.
Water . .	43.82	35.81	38.46
Casein . .	45.04	37.96	25.87
Fat . .	5.98	21.97	31.86
Ash . .	5.18	4.25	3.81

The relative proportion of the different constituents of cows' milk depends on the age of the animal, the time after calving, food, temperature, weather, and the time and frequency of milking, &c.

Analysis of milk.—Haidlen found 100 parts of milk to contain—

Butter	3.0
Sugar of milk and salts soluble in alcohol	4.6
Casein and insoluble salts	5.1
Water	87.3
	<hr/>
	100.0

¹ Knapp's 'Chemical Technology,' vol. iii, p. 62.

With the view of determining approximately the quantity of the constituents of milk, it will be advisable to adopt the following methods:¹

1. *Determination of the specific gravity.*—This may be done conveniently with the hydrometer. Still, if it be expected that the richness of the milk will be proportional to its specific gravity, very erroneous results may be obtained by this test, as it very frequently happens that the quality of milk is in an inverse ratio to its density, so that milk may be of high specific gravity, and yield but little cream.

2. *Determination of the cream.*—This is effected by the *lactometer*, invented by the late Sir Joseph Banks, and consisting of a tube of about eleven inches in height; its inferior end is closed, and the other left open; the upper part is graduated; sometimes the graduations are extended to the whole length of the tube. The tube is filled with milk, and after some hours the number of divisions, included by the layer of cream, are read off. According to Dr. Normandy, the thickness of the stratum of cream on pure milk is generally from 8 to $8\frac{1}{2}$ per cent. From the observations of the Commission, the average does not exceed $9\frac{1}{2}$ per cent. If an hydrometer and lactometer were at hand, it would be advisable to ascertain, first, the amount of cream with the lactometer, and then take the specific gravity of the inferior layer, previously decanted with a pipette. It might be still better to have the lactometer open at the bottom, and connected with a small tube, provided with a stop-cock; by shutting the stop-cock, to determine the cream, and then opening it to let out the skimmed milk, the operation might be considerably simplified.

The addition of a small quantity of warm water to milk

¹ Dr. Hassall on Food, &c., p. 326.

does not increase the quantity of the cream, but facilitates and hastens its formation and separation in a most remarkable manner.

Determination of the fatty matters.—For this purpose, the casein and fats may be precipitated together, by means of acetic acid; the precipitate being collected on a cloth, dried, and treated with ether, will yield the fat to this fluid; and by evaporating the ethereal extract to dryness, and weighing the residue, the amount of fatty matters may be ascertained.

There is another method to effect the same purpose, which is, perhaps, more practical, though less correct than the above; that is, by means of the instrument called the *lactoscope*, invented by M. Donné, of Paris. It is constructed in such a way that the milk may be examined in it in layers of every thickness; from the thinnest, through which all objects are visible, up to that which allows of nothing to be perceived, it gives at once the richness of the milk, by indicating the degree of opacity, to which the proportion of cream stands in relation.

Determination of the cheese, sugar, and saline matters.—This can be effected by weighing the residue left, when the precipitate obtained in milk with acetic acid is treated with ether to ascertain the amount of fatty matters. To determine the sugar, the whey or mother-liquor left after the separation of the casein and fats is evaporated to dryness; the residue weighed, and treated with hot alcohol, will lose an amount of weight equal to that of the sugar it contained. Dr. Hassall proposes to determine the sugar in whey by volumetric measurement with the sulphate of copper and tartrate of potash solution. For the manipulations necessary to perform this experiment, see page 121. The saline or inorganic salts are easily determined by

burning the residue, from a known quantity of milk, and ascertaining the weight of the ashes.

Adulterations of milk.—Milk may be adulterated with water, flour or starch, milk of almonds, gum, gum tragacanth, chalk, turmeric, sugar, and cerebral matter; it is occasionally mixed with a little carbonate of soda. Finally, it has been found to contain zinc when stored in zinc pans.

1. *Water*, though a very frequent adulteration, is difficult to detect, the results obtained with the hydrometer (see page 148) being not altogether satisfactory. The general density of pure milk is about 1038; a mixture of 75 parts milk and 25 parts water has a density of 1021; 66 parts of milk mixed with 33 of water has a density of 1020. In some cases, not only is water added, but cream abstracted. The best method of proceeding to detect this adulteration would be to determine first the amount of cream, and then take the specific gravity of the skimmed milk with the apparatus described above (see page 148). A collection of specific gravity beads would be extremely convenient for this purpose.

2. *Flour* and *starch* occur in milk as small diaphanous clots. The iodine test (see page 8) will suffice to indicate at once this adulteration; but the milk must be boiled previous to the addition of the tincture of iodine or iodide of potassium.

3. *Milk of almonds.*—In this case, the addition of a few grains of amygdaline will suffice to develop after a few minutes the odour of bitter almonds.

4. *Gum* is seldom employed. To detect it, coagulate the milk with a little acetic acid, filter off the whey, and pour into it a small quantity of alcohol; a dull, opaque, and

abundant white precipitate will appear, which will be found to possess the properties of gum; when boiled with a little dilute sulphuric acid, this substance will be converted into grape sugar, which may be readily recognised by the sulphate of copper test (pp. 9 and 121).

5. *Gum tragacanth* is sometimes employed in the form of a mucilage, to increase the volume of the cream, or to simulate its presence in skimmed milk. It may be detected by boiling the milk, and leaving it at rest for some hours; a gelatinous translucent deposit is then formed, which, being washed with a small quantity of water, and tested with a few drops of solution of iodine, produces a blue colour, because gum tragacanth contains starch.

6. *Chalk* is seldom if ever employed to adulterate milk. From its separating readily and falling to the bottom of the vessel containing the fluid, its presence would be recognized by the formation of a white deposit in the milk, after its standing undisturbed for a few hours; the deposit will dissolve with the evolution of carbonic acid, when treated with dilute hydrochloric acid; this solution yielding, with ammonia and oxalate of ammonia, a precipitate, insoluble in acetic acid.

7. *Turmeric* is detected by mixing a solution of potash with a sample of the milk previously concentrated; if the milk apparently possesses a yellow colour, which is rendered brownish with the above reagent, turmeric has been added.

8. *Sugar*.—To determine the existence of this adulteration, a quantitative determination of sugar must be undertaken by means of the saccharometer (see page 122), the fermentation method (see page 125), or Bernard and Barreswill's normal solution (see page 121). According to Dr. Hassall's experiments, 1000 parts of milk contain 52·7

of sugar ; so that if the proportion of sugar obtained be much above this number, the analyst may conclude that some has been added to the milk examined.

9. *Cerebral matter*.—It is very probable that the adulteration in question is not practised ; at all events it would be easily found out with the microscope, cerebral matter consisting of large rounded vesicles or cells, and long narrow tubes or fibres.

10. *Carbonate of soda* is occasionally added to milk in order to prevent its becoming acid ; if used in large quantity it must prove injurious to health, but a small amount may be harmless. To detect its presence a little acetic acid is to be added, which causes the evolution of carbonic acid gas, and, moreover, coagulates the casein ; the fluid is next to be filtered, and evaporated nearly to dryness ; by mixing it now with alcohol, and setting fire to the mixture, a flame will be noticed possessing a marked yellow colour, and thus showing the presence of soda.

11. *Zinc*.—It is hardly credible that zinc should occur in milk ; still, milk is sometimes kept in zinc pans for the purpose of increasing the yield of cream ; and a small quantity of the metal might be dissolved. Its presence is easily detected by evaporating a sample of the milk to dryness, incinerating the residue, and dissolving the ashes in dilute hydrochloric acid ; to this, ammonia is added in excess, and, in the filtered fluid, sulphide of ammonium will produce a white precipitate of sulphuret of zinc if the metal be present.

The analysis of twenty-six samples of milk, by the Commission of the 'Lancet,' yielded the following results :

1. Twelve samples were genuine.
2. Of these, two showed a deficiency of cream.
3. Eleven were adulterated.

4. The adulteration consisted in all cases of water, which varied from 10 to 50 per cent., or one half of the article.

5. In no case was chalk, size, gum, or sheep's brains detected, or any other substance said to be occasionally used for the adulteration of milk.

CHAPTER VI.

ON MINERAL OR INORGANIC FOOD AND ITS ADULTERATIONS : SALT AND WATER.

FROM the circumstance that common salt is a very cheap article of food, it is seldom adulterated; I shall consequently allude but shortly to this substance.

I propose also in the accompanying chapter—

1. To show what qualities water ought to possess in order to prove a wholesome article of food.

2. To give an account of the methods to be employed for the chemical and microscopical examination of pure and impure waters, and show how waters may be purified.

3. To inform the reader of the principal sources of impurities liable to pollute drink-water.

4. To add a few words on the water with which our metropolis is supplied.

SALT.

Salt, or *chloride of sodium*,¹ is an important article of diet, as it forms a large proportion of the inorganic matters

¹ For the chemical composition of salt, see page 25.

contained in the blood, and it is evident that salt must be supplied to the body in order to maintain health. Chloride of sodium occurs abundantly in nature, as the principal solid constituent of sea water, in the form of rock salt, or in the so-called brine springs. The salt-districts in this country are Northwich, Middlewich, and Nantwich, in Cheshire; Shirleywich in Staffordshire, and Droitwich in Worcestershire. Salt is also procured in Durham, at Lymington in Hampshire, and in some parts of Scotland; it is, moreover, obtained by the evaporation of sea-water.

Common salt, as found in commerce, is not absolutely pure, being contaminated with from 12 to 64 per thousand of foreign substances; they consist especially of sulphate and carbonate of lime, sulphate of magnesia, and chloride of magnesium. Sea-salt prepared by rapid evaporation, is not always entirely soluble in water, the insoluble residue being a mixture of carbonate of lime and carbonate of magnesia, with a fine siliceous sand. The salt prepared from Cheshire brine yields an insoluble residue consisting almost entirely of carbonate of lime. The insoluble part of the less pure pieces of rock-salt is chiefly a marly earth with some sulphate of lime, the quantity of this impurity in Dr. Henry's¹ analysis varied from 10 to 45 parts in a thousand.

Extraction of salt.—Rock-salt or stone-salt is dug from the earth in salt-mines, and sold in the crude state; it forms compact masses of various sizes, translucent, colourless, or but slightly coloured, and somewhat deliquescent in moist air. For domestic use, it is purified by solution and crystallization. From mineral or brine springs, salt is obtained either by concentrating their water with

¹ We are indebted to Dr. Henry for a very elaborate investigation into the different varieties of common salt.

the application of heat, or by spontaneous evaporation ; for this purpose the water is conducted in pipes to the top of hurdles of great extent, composed chiefly of buckthorn branches, and exposed freely on both sides to the atmosphere, but covered above ; as the water trickles over the hurdles, it evaporates with rapidity, and the remaining liquor, which is a strong solution of chloride of sodium, is then concentrated with heat, and allowed to crystallize. Salt is prepared abundantly in Germany by this process, and I have seen the same methods extensively used in Switzerland.

The extraction of salt from sea-water, which contains about $2\frac{1}{4}$ per cent. of this substance, is effected either by spontaneous evaporation, or concentration with the aid of heat. The former method is chiefly employed in the warmer countries of Europe, and yields the bay-salt of commerce, known by its occurring under the form of large grain crystals. Sea-salt is obtained by concentrating artificially sea-water ; the impurities are partly deposited during the first stage of the evaporation, and the mother-liquor, left after the crystallization of the salt, contains a large proportion of magnesian compounds ; sea-salt is white, with irregular grains. Both this kind of salt and rock-salt are often purified by a subsequent crystallization, and thus is prepared the so-called basket-salt, from its being sold in conical baskets. The best qualities of commercial salt are bay-salt and basket-salt.

Adulterations.—According to Dr. Christison, salt is subject to adulteration in this country with sulphate, nitrate, and muriate of lime¹ (see pp. 19 and 44). To find out the presence of nitric acid in a solution of salt, add to the fluid

¹ Sulphate of lime would be deposited in a solution of the adulterated salt.

a crystal of sulphate of iron, and pour a few drops of sulphuric acid along the side of the vessel; if any nitric acid be present, a brown cloudiness will appear at the spot where the sulphuric acid comes in contact with the sulphate of iron. Dr. Christison adds, that on the Continent salt is sometimes adulterated with arsenious acid (see page 43), and sometimes with an alkaline iodide; in this last case the solution will become blue by the addition of starch and nitric acid. (See page 8.)

WATER.

Of all fluid food, water is the most important; it is, therefore, of the greatest moment that its quality should be such as to prove in no way injurious to health; it happens, unfortunately, that in large towns the supply of water is often unwholesome from its impurities and chemical composition, or deficient in quantity; and it is much to be regretted that in London, where a vast population is in want of a daily allowance of water to drink, its quality is far from what it ought to be. The purest water is certainly not that which affords the most agreeable and healthy beverage; thus, rain water, snow, or ice water, even lake water, being tasteless, are disagreeable and insipid, and fail to supply the body with certain inorganic salts, which it obtains but insufficiently from other sources; such waters are more especially adapted for washing. On the other hand, water containing too many salts is not only incapable of affording food, but may become possessed of medicinal properties, and act injuriously on health.

The purest water for drinking must, therefore, contain

a certain quantity of earthy and other saline substances, to be finally absorbed into the blood and tissues. The following are the characteristic properties of the best water to be used as a beverage; they are so easily ascertained, that in most cases the reader will find no difficulty in testing the water at once on the breakfast or dinner table:

1. The water must be perfectly colourless and transparent, leaving no deposit when allowed to stand undisturbed.

2. It must be quite devoid of smell.

3. When litmus paper is immersed into the water, the colour of the paper must remain unaltered.

4. The water when boiled must not become turbid.

5. About half a table-spoonful of the fluid being evaporated to dryness on the spirit lamp, there must be a slight residue left at the bottom of the spoon, not turning black, from organic matters.

6. The residue obtained by evaporating to dryness a sample of the water in a porcelain cup, upon the tea-urn, must not become black on the addition of a solution of sulphuretted hydrogen.

Examination of water in order to detect its impurities.—For the purpose of detecting the impurities of water, it will be advisable to begin by examining the physical characters of the fluid: its smell, taste, and transparency. If the smell is fetid, somewhat resembling that of putrid eggs, the water contains sulphuretted hydrogen, resulting from the decomposition of organic substances. If the smell is ammoniacal, ammonia is present in it, owing to the putrefaction of animal matters. The taste of the water is to be carefully ascertained; a metallic or chalybeate taste indicates that it contains some iron; a rankish or insipid taste shows

the absence of the due quantity of inorganic salts; a salt taste indicates an excess of chloride of sodium or common salt.¹

The transparency of drink-water is a most important character of its purity; water may be dirty and opaque from its containing both inorganic and organic matters in suspension, as happens in that of the Thames, more particularly between Westminster and London Bridge. In this case, it will usually have a disagreeable odour; and if left in a warm place for some days, will putrefy and evolve very fetid smells. The nature of the deposit may be ascertained by chemical and microscopical examination. We are indebted to our distinguished countryman, Professor Faraday, for a rapid and satisfactory method of determining the degree of muddiness of water, without having recourse to chemical analysis. His experiments were performed in the Thames, and consisted in the immersion of small pieces of white cards into the river, when he observed the fluid to be so dirty in many places, that the cards disappeared as soon as they had sunk under water.² This experiment is perfectly conclusive, and, by determining the depth at which a card disappears when immersed in water, every degree of opacity might be ascertained, between that of the Thames as one extreme, and that of the Lake of Geneva as the other, where the bottom is seen at a depth of at least fifteen or twenty feet.

Chemical examination of waters.—If the water is perfectly transparent, examine it at once for the gases it may

¹ Waters containing a deficiency of salts, more especially of earthy substances, are often called soft waters; when an excess of these salts is present, water is known as being hard.

² See the 'Times,' July 9th, 1855.

contain, and its solid constituents ; filter muddy water previous to this operation. These gases may be carbonic acid, sulphuretted hydrogen, oxygen, or nitrogen. If free ammonia be present, it is also given off in the form of a gas, by application of heat.

Carbonic acid gas, in water, has the property of dissolving carbonate of lime and magnesia. When water is boiled, its free carbonic acid is evolved, and the earthy carbonates are precipitated ; carbonate of lime is soluble in 8834 times its weight of boiling water, and in 10,601 of cold water ; so that if a precipitate or turbidity should occur by boiling a sample of water, it is a sign that it contains more than 11.32 parts of carbonate of lime in 100,000 parts of water, supposing the muddiness to result entirely from this salt. Sulphuretted hydrogen gas is known at once by its smell of putrid eggs ; a piece of paper moistened with a solution of acetate of lead will immediately turn brown or black when immersed in water containing this gas. Oxygen and nitrogen are taken up by water from the atmosphere, but a greater proportion of oxygen is absorbed than exists in air ; these gases are entirely evolved from the fluid by boiling, and it is principally for this reason that boiled water is not so good and so healthy as water which has not been boiled. The presence of free ammonia in water is easily detected by the smell of the liquid when boiled ; traces of ammonia may be found out by means of a slip of paper dipped in a solution of sulphate of copper, and held before the opening of the test tube in which the water is boiled ; if ammonia be evolved, the paper will turn deep blue. The occurrence of this substance in water results from the decomposition of organic, and more especially animal, matters.

It will now be advisable to proceed to the examination of

the clear water, or that filtered from the deposit; for this purpose, evaporate a sample of the fluid to dryness, upon the water bath, and ignite the residue; if it turns black and porous, organic matters were present. To determine whether the organic impurities are vegetable or animal, evaporate to dryness a sample of fluid, in a test tube, add lime, and test for ammonia as directed at page 38; the presence of ammonia shows that the residue contained, in all probability, animal matters.

It often happens that water intended to be drunk is muddy, or contains a cloudiness; in some cases, these impurities consist of no more than sand, the filtered water being perfectly pure; thus, the River Arve, at Geneva, is of a deep brown colour, the water filtered from this deposit being exceedingly pure; the water of the Arve contains from 12·8 to 24·3 parts in 100,000, of solid matters, including 0·35 parts of organic matters; the deposit consists mostly of sand, with a small quantity of vegetable matters. Insoluble substances suspended in water may be *carbonate of lime, phosphate of lime, sulphate of lime, carbonate and phosphate of magnesia, silica, and vegetable and animal matters*. The following is the most practical method for the detection of these substances: Add dilute hydrochloric acid to the liquid; if the deposit be entirely dissolved, it contains no silica and no organic matters; if it dissolves with evolution of carbonic acid, the deposit consists partly or entirely of carbonate of lime or carbonate of magnesia. Filter a sample of the original water from the insoluble residue suspended in it, and wash the filter with boiling dilute hydrochloric acid, nothing but silica and organic matters can remain on the filter; then add a solution of potash in excess to the clear acid fluid in order to precipitate the lime and magnesia; boil the mixture, and

filter; divide the filtrate into two portions, and test one for *phosphoric acid* with molybdate of ammonia and nitric acid, which throws down a yellow precipitate, or with ammonia and sulphate of magnesia, in order to precipitate the triple phosphate. To the other portion, add chloride of barium, which produces a precipitate, insoluble in nitric acid, if any *sulphuric acid* be present. The precipitate which was induced by boiling the acid fluid with potash, and collected upon a filter, as directed above, is now washed with distilled water, and dissolved in dilute hydrochloric acid. Add to this fluid a solution of ammonia and of carbonate of ammonia; the occurrence of a precipitate shows the presence of *lime*; as a confirmatory proof, test the original acid solution with ammonia and oxalate of ammonia, when a precipitate insoluble in acetic acid will appear. Filter the fluid from the precipitate obtained with carbonate of ammonia, and if carbonate of ammonia does not produce any more precipitate in the filtrate, add to it a solution of phosphate of soda; a crystalline precipitate, occurring after the lapse of some minutes, shows the presence of magnesia.

Microscopical examination of the deposit.—With the view of determining the nature of the substances which remain insoluble in water acidulated with hydrochloric acid, it will be necessary to subject this residue to microscopical examination; if it consists entirely or partly of silica, a sample of the deposit will exhibit, with a low magnifying power, a number of small angular bodies. For the detection of organized structures, living infusoriæ, algæ, &c., it will be advisable to examine with the microscope a drop of water containing the original deposit; if, for instance, the composition of the water of the Thames be investigated, let the fluid stand for half

an hour in a tumbler, pour off the clear supernatant fluid, and proceed to the microscopical examination of a sample of the deposit. Living animalculi of every description will then be noticed shooting about the liquid in every direction, and making their way among amorphous masses, pieces of muscular tissue, vegetable hairs, and other organic substances.

Methods employed to purify water.—There are several methods employed to purify bad water; they act by separating the impurities mechanically or chemically; the principal means used to purify water mechanically, is by filtration, which, when carefully applied, yields very satisfactory results. The filters employed for this purpose consist of finely divided and perfectly insoluble materials, as sand, broken-up shells, charcoal, &c.; and for the filtration of water on a large scale, gravel and small pebbles are used. A charcoal filter will be found admirably suited to purify water containing organic and inorganic matters dissolved and in suspension; for not only does charcoal arrest mechanically the passage of substances insoluble in water, but it also possesses to a remarkable degree the property of seizing upon the products of decomposition of organic matters, thus in many cases removing the taste and nauseous smell of water. Moreover, charcoal has the power of absorbing more or less of certain soluble inorganic salts, and separating them, therefore, from the water where they are contained in solution. I believe that a filter consisting, first of a layer of sand, and then of a layer of charcoal, will be found very useful as a means of removing foreign matters from dirty water. Water is also purified by allowing the impurities to subside and decanting the clear fluid, but the results of this operation are unsatisfactory. Chemical methods are occasionally employed for the same

purpose; thus, the addition of lime to water, by neutralizing its free carbonic acid, causes the precipitation of the whole of the lime in the form of a carbonate; the proportion of lime water to be added to the Thames and other river waters coming to London may be stated at about a twelfth. The effects of boiling the water have previously been described (see page 160); boiled water is evidently made softer, but it is not so agreeable to the taste. Finally, the Commission of the 'Lancet' recommends the addition of a little acetic acid to waters which are alkaline and contain organic matters.

Having described the most convenient and practical means we possess for detecting the various impurities which water may contain, and given a short account of the methods employed to remove these impurities, it is necessary that I should add a few words on the sources from which water derives its solid constituents, and becomes polluted with organic matters. Spring water, and well water, passing through calcareous strata, become gradually saturated with carbonate of lime, and probably a small quantity of this substance, very minutely divided, is carried away, and finally dissolved by carbonic acid absorbed from the atmosphere; this accounts for spring and well water frequently containing much calcareous salts, and being thereby very hard. Rivers owe their formation to various sources; in most cases they arise from springs, but are shortly joined by other streams, consisting mainly of rain water; lakes are formed by rivers, they do not differ much as to their chemical composition. Lakes contain usually, however, more solid substances in solution than rivers. In rainy seasons, river water yields but a very small proportion of dissolved solid substances; in dry weather the reverse happens. Heavy rains produce, moreover, an increase of

organic matters in river water, by washing into it a quantity of vegetable substances, as grasses, leaves, branches, &c., and by stirring up the bottom of the river-bed, and thus mixing with the water vegetable matters and mud. When warm and dry weather has succeeded to rains, the organic matters are partly deposited with mud at the bottom of the stream, and partly remain suspended in the water, where they putrefy and give rise to nauseous and morbid sulphuretted and ammoniacal products; the water is thus rendered unfit for an article of diet. This is the case more especially with large rivers moving on slowly in a comparatively flat country; a rapid stream is not so liable to be polluted with putrefying organic matters.

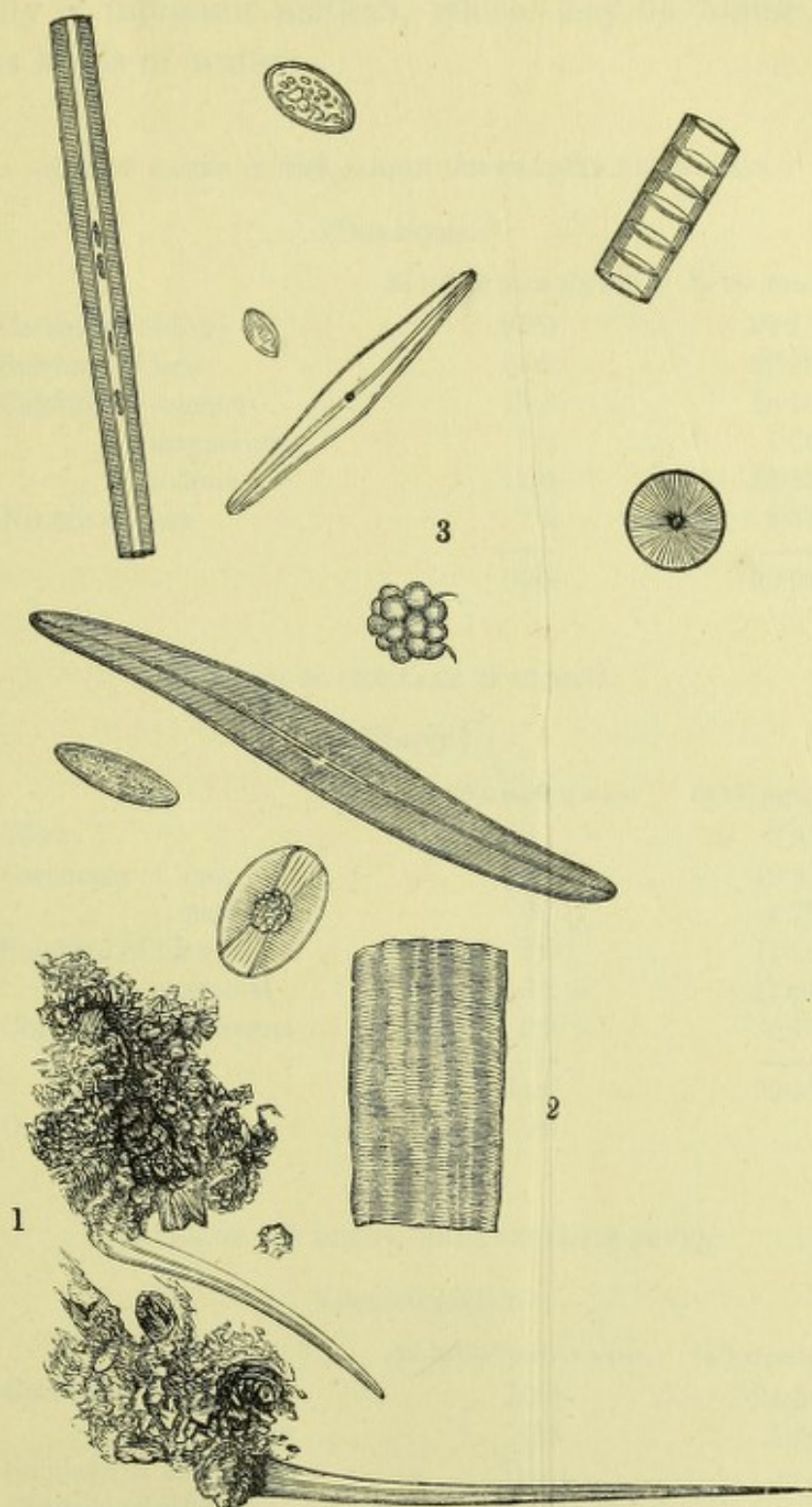
Rivers passing over a chalky bed dissolve a certain amount of carbonate of lime, and the free action of the atmosphere on the water induces, in some cases, the solution of large quantities of this salt; thus the formation of hard river water. Rivers are, I regret to say, supplied with impurities and decomposing organic substances, not only from the above sources, but also from the refuse and sewers of large towns; as it is the easiest and cheapest way to get rid of these disgusting materials, advantage is often taken of this circumstance, without calculating its fearful effects upon the population, especially when that same water is to become of daily use as an article of diet. Such is the case in our metropolis; and such is the state of the Thames water, that a drop of this muddy liquid will reveal, under the microscope, the presence of hundreds of infusoriæ, shooting in every direction, and mixed with amorphous masses known to come directly from the contents of sewers (p. 167, fig. 1), with fragments of muscular tissue (p. 167, fig. 2) formerly belonging to the body of a cat or a dog, with sand and mud, and calcareous

salts. Thames water contains, moreover, a considerable proportion of lime compounds dissolved in it ; so much so that the average supply of water to a single family would yield in eight months a hundred pounds of chalk.¹ Is it to be expected that epidemics will spare a dense population crowded in dark and ill-ventilated houses on both sides of our river, and labouring from morning till night to obtain such scanty means as will procure insufficient, and, in most cases, unhealthy food? If England be the first country in the world for manufactures, what will happen if the manufacturing districts in England, and more especially in London, cannot even provide good air and good water for its industrious inhabitants?

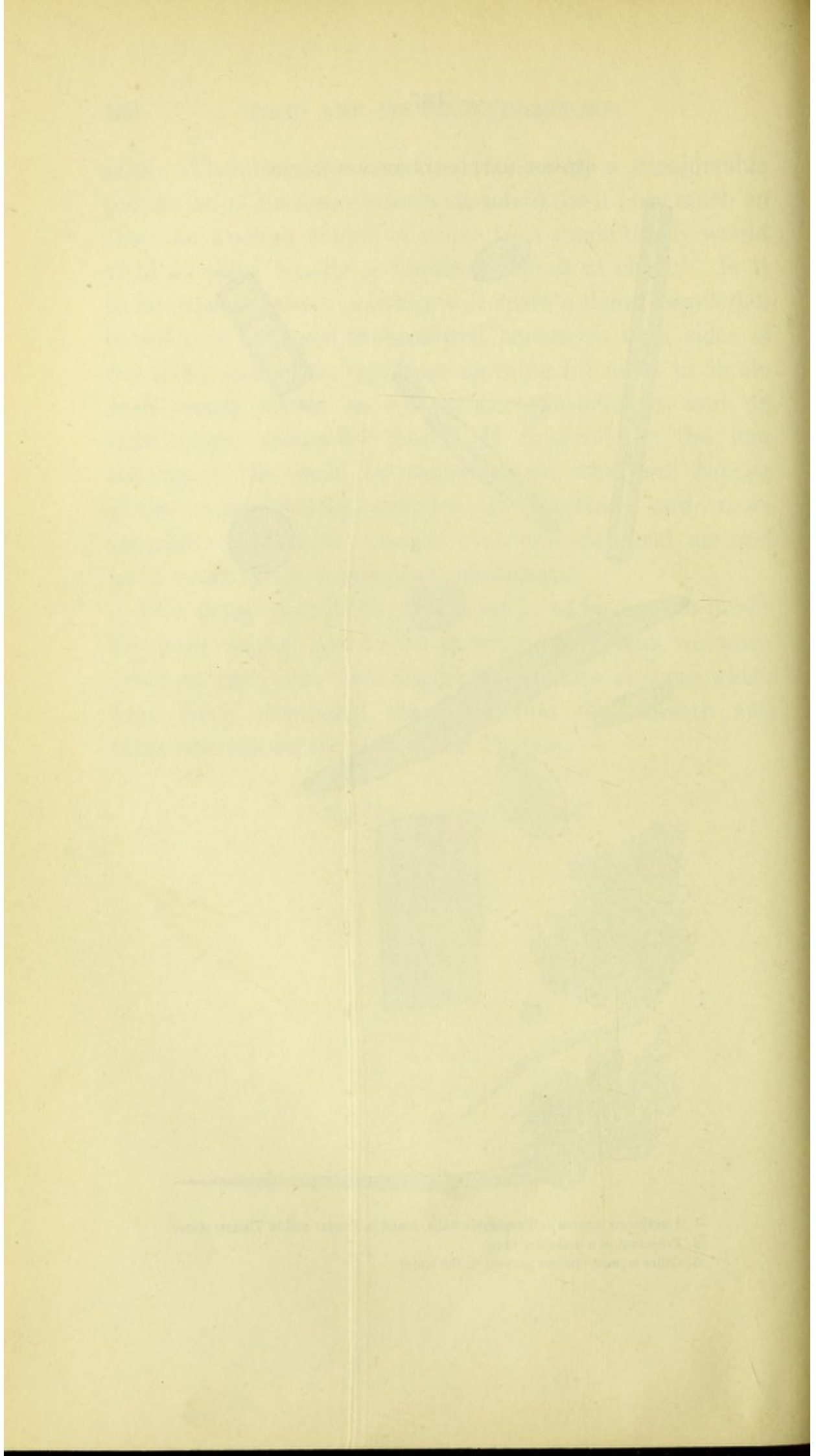
One thing is evident—that what is to be done to purify the river ought not to be delayed ; and that we must avoid, at any price, such frightful epidemics as those which have lately decimated the population of Lambeth and other districts on the side of the Thames.

¹ The 'Chemist,' for July, 1856.

ORGANIC MATTERS IN THAMES WATER.



1. Amorphous masses and vegetable hairs, found in Sewers and in Thames water.
2. Fragment of a muscular fibre.
3. Other organic matters present in the water.



The following table shows the nature and proportional quantity of inorganic matters, which may be found in the various kinds of water :

SPRING WATER IN THE JARDIN DES PLANTES NEAR LYONS.

(Dupasquier.)

	In 100,000 parts of water.	In 100 parts of ashes.
Carbonate of lime . . .	27.0	29.73
Sulphate of lime . . .	25.2	27.75
Chloride of calcium . . .	16.8	18.50
„ magnesium . . .	1.6	1.76
„ sodium . . .	12.6	13.87
Nitrate of lime . . .	7.6	8.37
	<hr/> 90.8	<hr/> 99.98

WATER OF THE LAKE OF GENEVA.

(Tingry.)

	In 100,000 parts of water.	In 100 parts of ashes.
Silica . . .	0.1	0.68
Carbonate of lime . . .	7.2	49.31
„ magnesia . . .	0.7	4.79
Sulphate of lime . . .	2.6	17.80
„ magnesia . . .	3.1	21.23
Chloride of magnesium . . .	0.9	6.16
	<hr/> 14.6	<hr/> 99.97
Organic matters . . .	0.6	

WATER OF THE RHONE, NEAR LYONS (IN JUNE).

(Boussingault.)

	In 100,000 parts of water.	In 100 parts of ashes.
Carbonate of lime . . .	10.0	94.34
„ magnesia . . .	0.6	5.66
Sulphate of magnesia . . .	Trace.	—
Chloride of calcium . . .	„	—
„ sodium . . .	„	—
	<hr/> 10.6	<hr/> 100.00

WATER OF THE THAMES, AT LONDON BRIDGE.

	In 100,000 parts of water.	In 100 parts of ashes.
Carbonate of lime . . .	11.58	38.58
Sulphate of potash . . .	0.37	1.24
„ soda . . .	4.43	14.76
Chloride of magnesium . . .	0.12	0.40
„ sodium . . .	3.39	11.26
„ calcium . . .	9.96	33.18
Silica . . .	0.17	0.57
	<hr/>	<hr/>
	30.02	99.99
Soluble organic matters . . .	3.34	
Insoluble „ „ . . .	6.65	
	<hr/>	
	9.99	

CHAPTER VII.

ON PRESERVED FOOD.

I PROPOSE in this chapter to allude shortly to the various methods employed for preserving food, and to show the relative value of these articles of diet.

The spontaneous decomposition of food, known as fermentation and putrefaction, is owing to the action of *heat*, *air*, and *moisture*; and in order to prevent this phenomenon, it will be necessary to remove one or more of the causes on which it depends. There are, moreover, substances called antiseptic agents, endowed with the property of preventing the decomposition of organic matters; which, when perfectly harmless to health, may be employed with advantage to preserve certain articles of food.

1. *Preservation of food by cold.*—It is probably a fact well known to the reader, that frozen organic matters do not undergo decomposition. Meat and fish are thus transmitted for sale from Archangel to St. Petersburg;¹ provisions are also sent, packed in ice from remote parts of Britain to London, &c.; the application of a lesser degree

¹ Lecture delivered at the Royal Institution, March the 30th, 1855, by the Rev. J. Barlow.

of cold is also extensively used to prevent too rapid a decomposition of food in hot weather, as in the case of fish, butter, &c. I have nothing to add on the state of food thus preserved; if it has not undergone the slightest decomposition, it is exactly in the same condition as when quite fresh, and consequently, as healthy and nutritive.

2. *Preservation by exclusion of air.*—There is no doubt that if an article of food be so prepared, the atmosphere can have no access whatever to it, this food will preserve for a very considerable length of time; the practical objection attending this method is the difficulty of preventing completely the contact of the atmosphere with organic substances. Articles of food intended for preservation, by exclusion of air, may be fluid or solid; if fluid, they are first to be thoroughly boiled, in order to expel the air they may contain dissolved within them, and next to be introduced through a small opening into metallic or earthenware vessels; when the vessel is overflowing, the opening must be soldered or stopped up; it is difficult, however, to prevent a very small quantity of air from being enclosed in the vessel. Such liquids, when kept in metal jars, may dissolve small quantities of the metal of which the vessel consists, and thereby acquire a very objectionable character.

Food is preserved on a very large scale by the exclusion of air and destruction of the small amount of oxygen contained in the jar; this is known as Appert's method. For this purpose, the jars, or boxes of tin plate, containing the article for preservation, are thoroughly corked or soldered, care being taken that the vessel be quite full, they are afterwards immersed in boiling water for a certain length of time; the air left in the jar is thereby de-

stroyed, its oxygen being made to combine with some of the carbon of the substance, and, consequently, the contents of the vessel lose the power of decomposing. Ships of the English navy, on the coast of Africa, East Indies, West Indies, and China, where meat is not procurable, are thus provided with fresh provisions. Other methods are adopted for preserving articles of food by exclusion of air; thus an attempt has been made to preserve meat by surrounding it with a thick coating of gelatine; eggs are also prevented from decomposing by greasing and dipping them in milk of lime; Warrington has proposed a plan founded upon similar principles to preserve the flesh of buffaloes.¹

There appears no objection to this method, beyond the difficulty of preventing the access of air to the article, and the necessity of inducing certain chemical changes by boiling the food; there is also a possibility that the metal of the cases might be dissolved to a slight extent by the preserved articles, the more so that juice of meat has an acid reaction. The method in question is objectionable especially from its expense. I am not aware that vegetable and animal food preserved by Appert's method is liable to adulteration.

3. *Preservation by drying*.—Articles of food are preserved by direct drying, with or without the application of artificial heat. Organic substances dried without being previously cooked are not likely to remain sound beyond a short period, and in moist and damp weather run the risk of decomposing; but if the articles have been cooked, or rather steamed at a high temperature, the albumen of the food is rapidly coagulated, enclosing in a hard covering, and thereby excluding from air, the other constituents of the substance. Vegetable and animal food

¹ Potted meats are preserved on the same principle, air being carefully excluded by a tolerably thick layer of suet or lard.

thus preserved is found to keep very well for many years, and this method, both in a sanitary and practical point of view, has been found unobjectionable; we are indebted to Dr. F. Verdeil for this ingenious plan of preventing food from decomposing; and the English and French army, during the Crimean campaign, has been extensively supplied with vegetables preserved by his process.

My friend, Dr. Verdeil, having kindly showed me every stage of the operation in the extensive factory belonging to his company, at Paris, where he is the chief superintendent of the chemical and mechanical department, I shall enter into some details as to the various operations I witnessed.

The vegetables intended for preservation in the Paris factory are first cut into small pieces, mostly by machinery, and then transferred to a number of shallow wirework trays. When a set of these trays is full, they are placed on a stand, which moves on a little railway, and can be pushed into an iron chest; a contrivance not unlike that employed in washhouses to convey wet linen into the drying chambers. These iron chests may be filled with steam, under a pressure of four or five atmospheres; and as soon as the stand is rolled in, the door is shut, hermetically fastened by means of a screw, and then steam freely admitted; by this means a temperature is rapidly obtained, sufficient to coagulate completely all the albumen of the vegetable, none of the constituents of the food being lost; five minutes suffice for this operation. The next step is the drying. The steamed vegetable is rapidly conveyed on the trays into a series of wooden chambers, where a strong draught is obtained by means of ventilators revolving very rapidly with steam power; the air

admitted into the drying chambers is made to pass first through iron pipes, maintained at a very high temperature, by a furnace, so that the desiccation is effected by hot air; the whole process takes so short a time, that from five to eight hours suffice to dry a large quantity of vegetables; they are afterwards set aside, ready for the market.

Food thus preserved, whether it be animal or vegetable, has the advantage—

1. Of preserving in a fresh condition, though freely exposed to the atmosphere, for a great number of years.

2. Of being reduced to about one fifth of its original bulk, from its having lost all its water.

It is very remarkable how completely the prepared vegetables resume their shape and bulk when boiled in water; the soup possesses all the aroma of the food, to such an extent, that it is often difficult to notice the difference between these soups, and those prepared from recently gathered vegetables.

Food is, moreover, preserved by the peculiar action of certain substances, called antiseptic agents, which, when mixed with articles of diet, enable them to resist the decomposition induced by heat, air, and moisture. The principal of these methods are *salting*, *smoking*, and *immersing in vinegar*.

4. *Preservation by salting*.—This process is used more especially for preserving meat. The meat is cut into large pieces, and left in a tub for a certain number of days, covered with a thick layer of salt; the result of this operation is the extraction from the meat of a considerable amount of its juice, in which the salt becomes dissolved: this same brine is then removed from the tub and employed to salt another sample of meat, and so on until it has become so

saturated with juice of flesh that it has no longer the power of permeating the meat, when it is (I believe) usually emptied into a sink. In this way an enormous quantity of excellent and useful food is lost, and it would be consequently of the greatest importance to find a means of separating the salt from the juice of meat, in brine, or of preserving meat, by a method which would not entail the loss of any of its constituents.

Having given some attention to this subject, and attempted by various chemical and mechanical means, the separation of the organic substances in brine, from the salt, I have come to the conclusion that with the present state of science there is very little chance of this important problem being solved; but I am happy to say that, with Dr. Verdeil's method, we now possess such perfect means of preserving meat with all its constituents, that I hope the day will soon come when salt meat, as a food both unhealthy¹ and deficient in nutritive materials, will be altogether given up.

5. *Preservation with smoke.*—The *smoke* of burning organic matters, as wood, &c., appears to be peculiarly possessed of the properties of an antiseptic agent, for it is well known that meat suspended in smoke loses its susceptibility to decay; it acquires at the same time the taste of smoke, a dark colour, and a certain hard consistence. Smoking has an advantage over salting, as none of the nutritive constituents of smoked food are lost. The substance from which smoke derives its antiseptic properties is called *creosote*, and was discovered by Reichenbach among the products of distillation of tar; when pure, creosote

¹ I regret that the limited extent of this work, should prevent me from giving an account of the injurious effects of salt meat upon health.

assumes the form of a clear colourless liquid. If meat be dipped for a short time in a dilute aqueous solution of this substance, it will be entirely prevented from decomposing. Meat exposed even to the vapours of creosote (upon an ingenious plan proposed by Stenhouse) acquires the same property.

6. *Preservation with sugar.*—It is a very curious circumstance that, notwithstanding the tendency of a weak solution of sugar in water, to undergo the alcoholic and acetous fermentation, still a concentrated solution of sugar has the power of preventing the spontaneous decomposition of organic matters boiled in the syrup. Sugar is chiefly used in preserving fruit, and is so applied that it becomes dissolved in the juice of the fruit. This method is evidently attended with much expense, and can only be applied in a few cases.

7. *Preservation by means of vinegar.*—Vinegar is employed more particularly for the preservation of cabbages, girkins, beans, &c., in the form of pickles. It is much to be regretted that the vinegar used for this purpose is frequently impure or adulterated, and artificial means are moreover employed for heightening the colour of the pickles. Dr. Hassall's book contains much useful information on this subject; he states, referring to Accum's work, that fatal consequences have ensued from boiling pickles with halfpence, or suffering them to stand for a considerable period in brazen vessels. Boiling in a copper pot, or the use of verdigris, are recommended in modern cookery books for greening pickles. To detect the presence of copper in the vinegar used for pickling, add to it a little ammonia, and if it turns blue, the fluid contains this metal; test the pickles for copper by mincing them, and pouring some dilute ammonia upon them. For the adulterations of vinegar, see page 138.

In closing this little work, an apology is due for the incomplete account given of so important a subject as our Food and its Adulterations ; the limited extent, however, of the book that I contemplated, has prevented me from entering into certain details which would have been undoubtedly of great interest to the reader, though not in direct relation with the form I proposed to adopt.

THE END.