Adulterations of food : with short processes for their detection / by Rowland J. Atcherley.

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Atcherley, Rowland J.

Publication/Creation

London : W. Isbister, 1874 (London : Virtue and Co..)

Persistent URL

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STUDIO · ET · VIGILANTIA ·

ADULTERATIONS OF FOOD

ADULTERATIONS OF FOOD

With Short Processes for their Detection

BY

ROWLAND J. ATCHERLEY, Ph.D., F.C.S.

W. ISBISTER & CO.
56, LUDGATE HILL, LONDON
1874

574

LONDON:
PRINTED BY VIRTUE AND CO.,
CITY ROAD.

Cayenne Pepper	23
Cheese	24
Chicory	25
Cocoa	27
Coffee	30
Confectionery or Sweetmeats	33
Flour	43
Gin	47
Honey	48
Isinglass	50
Jams, Jellies, &c.	51
Lard	53
Lentil-Flour	56
Lemon-Juice, Lime-Juice	57
Liqueurs	59

TABLE OF CONTENTS.

PAGE

Preface vi

Adulterations and their detection in—

- Aerated Waters 1
- Anchovy Sauce, Bloater Paste, &c. 6
- Arrowroot 7
- Beer, Ale, Porter, &c. 9
- Brandy 14
- Bread 15
- Butter 18
- Catsup 21
- Cayenne Pepper 23
- Cheese 24
- Chicory 25
- Cocoa 27
- Coffee 30
- Confectionery or Sweetmeats 33
- Flour 43
- Gin 47
- Honey 48
- Isinglass 50
- Jams, Jellies, &c. 51
- Lard 53
- Lentil-Flour 56
- Lemon-Juice, Lime-Juice 57
- Liqueurs 59

PAGE

Adulterations and their detection in—

Maize (Corn-flour) 59
Milk 60
Mustard 63
Oatmeal 66
Olive Oil 67
Pea-Flour 71
Pepper 71
Pickles 73
Rice-Flour 74
Rum 74
Sago 74
Spirits 75
Sugar 80
Tapioca 83
Tea 83
Vinegar 87
Whisky 89
Wine 89
Volumetric Solutions and their Application . . . 101

PREFACE.

THE writer of the following pages has endeavoured to supply a want which he believes to be much felt at the present day. Adulteration is practised to an incredible extent, and it is highly desirable that every one should have at hand a ready means of distinguishing between a genuine and a sophisticated article. This little work is addressed, therefore, to three classes of readers — the consumer, the dealer, and the professional analyst.

Easy and practical tests as to the purity of an article of food are given for the benefit of the two former, while processes of great accuracy, and requiring considerable experience in their manipulation, are supplied for the latter. Hence the consumer or dealer may apply his comparatively rough tests to articles suspected, and then, if further information be required on the matter, he may cause the same to be submitted to the more elaborate processes of examination by a trained analyst.

The scientific processes here given are chosen as being the best in use at the present time. Some few of them are new; such, for instance, as the detection of picric acid in beer, by means of distillation with chloroxide of calcium. They have all been found by the author to be trustworthy, and have worked exceedingly well in his hands.

A carefully-compiled description of Volumetric Solutions and their applications, specially bearing on the subject, has been added for the benefit of the professional chemist, and will be found in the concluding pages.

PRESTON: *September*, 1873.

ADULTERATIONS OF FOOD.

AERATED WATERS.

PROBABLE IMPURITIES of Soda Water.—*Lead*, *copper*.

PROBABLE ADULTERATIONS of Lemonade—*Sulphuric acid*, *tartaric acid*; of Ginger Beer—*Cream of tartar*, *tincture of capsicums*.

In samples where impure water has been used, or where the organic matter present is in a state of putrefaction, particles of fungoid growth, vibriones, and other organic germs are visible under the microscope.

ANALYSIS.—Evaporate a known quantity, say half a litre, in a porcelain basin to a small bulk over an argand, gas, or spirit lamp, and suspend in it a bright steel needle, the point of which dips about one centimètre into the liquid, and allow it to repose overnight. If, on examination, the needle immersed be found covered with a red brown metallic coating, the liquid contains *copper*.

Search may be made for lead by adding to the concentrated liquid a few drops of dilute sulphuric acid ; when, if that metal be present, a milkiness of the liquid will become more or less apparent according to the amount of metal it contains.

Sulphuric acid may be detected and estimated by means of a solution of chloride of barium in excess, care having been first taken to expel carbonic acid by boiling with the addition of a few drops of nitric acid. A white precipitate will indicate sulphuric acid. In order to collect this in a filter, it is necessary first to boil the solution well, and after having allowed the precipitate to settle, pour the clear portion of the liquid through the filter, taking care not to disturb more than necessary the sulphate of barium, then flush the precipitate out with fresh hot distilled water on to the filter, and finally wash with hot water, dry and incinerate to whiteness in a weighed porcelain crucible. One part of sulphate of barium is equivalent to 0·5958 parts of sulphuric acid, $H_2 SO_4$.

Tartaric acid and cream of tartar (acid tartrate of potassium) will crystallize out of the liquid on concentration, should they be present, and may be recognised by their acid reaction to blue litmus paper, their effervescence with carbonated alkalies, their emitting, when incinerated, a peculiar smell resembling that of burning bread, and leaving in the case of cream of tartar a black residue consisting of charcoal and carbonate of potassium.

The tincture of capsicums is frequently added to ginger beer for the purpose of giving to the beverage a piquancy which in the case of a genuine article is due to ginger or the extract thereof only. The fraud may easily be detected on evaporating the previously neutralised liquid to incipient dryness, and applying a portion of the residue to the tongue. The hot, blistering taste of capsicums is thus distinguished with great facility from the milder aroma of ginger.

Pure and wholesome aerated waters should be entirely free from the above additions and impurities; they should be clear, sparkling, and of a pleasant pungent flavour, added, in the case of lemonade and ginger beer, to such moderate sweetness, piquancy, and acidity as is agreeable to the taste.

The saline constituents of soda or potass water should consist of nothing but from 1 to 1·5 grammes per litre of carbonate of sodium or potassium, with perhaps the addition of a trace of manganese; and the pressure exerted by the carbonic acid in solution should amount at ordinary temperatures to at least sixty pounds the square inch.

So-called ginger beer is often manufactured by the same method as lemonade and soda water, that is to say, carbonic acid is forced under great pressure into a previously-prepared fluid, which is subsequently bottled by machinery. This should not be, for although a very pleasant and refreshing beverage may be made in this manner, yet the genuine ginger beer should be and is a truly fermented liquor, fermentation having in the proper process of manufacture been excited by the growth of yeast in a solution of sugar flavoured with a certain amount of ginger, and the bottling only proceeded with after the mixture has been allowed to " work " a definite period of time.

Low-priced soda waters and lemonades frequently contain atmospheric air in lieu of carbonic acid. The beverage is, however, flat and vapid, and to the taste is deficient in that agreeable sharpness peculiar to the genuine article.

ANCHOVY SAUCE and PASTE, BLOATER PASTE, &c.

PROBABLE ADULTERATION. — *Venetian red.*

ANALYSIS.—The sauce or paste is mixed with a sufficient quantity of water to make it fluid, and then, after having been well shaken up, is allowed to stand, when all heavy adulterations will sink to the bottom. The supernatant liquid is then decanted off, and the residue treated with a mixture of nitric and sulphuric acids to destroy the organic matter and dissolve the iron. When a clear solution is obtained, it is diluted with water and filtered, and a portion thereof is tested with ferrocyanide of potassium for iron, with which the test gives a dark-blue precipitate or coloration, according to the amount of iron present. Should it be necessary quantitatively to estimate the metal, the iron in a portion of the solution, having a known relation to the sauce or paste, is reduced by means of pure metallic zinc to the ferrous or protostate, and then titrated with a standard solution of permanganate of potassium, the preparation and method of application of which are given in the chapter relating to volumetric analysis.

ARROWROOT.

PROBABLE ADULTERANTS.—*Potato starch, plaster of Paris.*

ANALYSIS.—The first of these sophistications may be detected by means of the microscope. Arrowroot consists of regular ovoid particles of nearly equal size, whereas potato starch consists of particles of an irregular ovoid or truncated form, varying exceedingly in their dimensions, some being so large as $\frac{1}{300}$th of an inch and others only $\frac{1}{2000}$th. Their surfaces in arrowroot are smooth and free from the streaks and furrows to be seen in potato starch. A very convenient test is dilute nitric acid, sp. gr. 1·1, which, when triturated with the potato starch, forms immediately a transparent viscid jelly. Wheat starch acts in a similar manner; arrowroot, however, forms an opaque paste, and takes a much longer time to become viscid. Pure arrowroot is destitute of the fetid oil extractable from potato starch by means of alcohol. Search may also be made with the same means for tapioca and sago, both of which may be sometimes met with. (*See* Figs. 1, 2, 9.)

A large amount of ash will indicate the addition of a proportion of mineral matter, generally plaster of Paris. Two grammes of the suspected arrowroot should be taken in a platinum capsule and ignited over a Bunsen's burner. Should the carbon prove tedious to burn out, a piece of nitrate of ammonium—the size of a pea—may be added, and the ignition cautiously proceeded with. It is well to test the residue with an acid, as chalk might possibly have been used as the adulterant. In the event of this being the case, the addition of an acid will cause considerable effervescence.

Arrowroot is furnished by the root of

the *Maranta arundinacea*, a West Indian plant. The same root yields a poison with which the native Indians are wont to smear their arrows, and hence its name.

It is highly esteemed as the most elegant and richest of all the feculas.

BEER, including ALE and PORTER.

PROBABLE ADULTERANTS.—*Caramel, or burnt sugar, "foots," liquorice, grains of Paradise, quassia, picric acid, cocculus-Indicus, tobacco, sulphate of iron, salt, water.*

Caramel, liquorice, and "foots" are added to porter in order to give it a dark colour and body after the strength has been let down by admixture with water; picric acid and quassia for the purpose of increasing its bitter flavour; cocculus-Indicus, tobacco, and grains of Paradise evidently for the purpose of giving intoxicating properties to beer and porter, the alcoholic strength of which has been lessened by fraudulent dilution.

Sulphate of iron is said to give a "head" to malt liquors, and salt is frequently detected in considerable quantities in beer of a low quality.

ANALYSIS.—For burnt sugar, liquorice, and grains of Paradise, the beer should be evaporated to an extract, this dissolved in alcohol and again concentrated, when the adulterations will be rendered evident to the sense of taste. These substances may also be detected by means of the spectroscope. (*See* WINES.)

Tobacco may be recognised by gently heating the same extract over a lamp, when the peculiar odor of the volatile oil due to the "weed" will, if the latter be present, become perceptible.

Cocculus-Indicus is best detected by acidulating the beer with hydrochloric acid and agitating with ether. The ethereal solution is drawn off with a pipette and evaporated to incipient dryness, when picrotoxine, if present, will crystallize out. These crystals can be tested by rubbing up with nitrate of potassium, adding a drop of strong sulphuric acid, and finally a strong solution of caustic potash. Picrotoxine gives, on being thus treated, a bright reddish yellow coloration.

On distilling the extract in a tubulated retort with a solution of chloride of lime (bleaching powder), chloropicrine, a compound of an extremely penetrating odor will be found in the distillate should picric acid be present in the beer, and may be distinctly recognised by its smell.

Quassia is very difficult to detect in the presence of other organic bitter principles.

For the purpose of testing for mineral adulteration, the liquor is evaporated to dryness, and the residue incinerated at a low red heat. The ash is then dissolved in nitric acid, the solution diluted with water, and filtered. Nitrate of silver will produce in this filtrate a white curdy precipitate, should chloride of sodium be present; and ferrocyanide of potassium, a dark blue one indicative of the presence of an iron salt.

It should, however, be noted that the natural ash of genuine beer may contain both salt and iron, though in small quantity. In judging, therefore, as to whether the liquor has been purposely adulterated, it is necessary to estimate quantitatively these ingredients. The weight of the ash having been ascertained, and its relation to the bulk of the original beer, we may precipitate the salt, as before, with nitrate of silver; collect the precipitate on a filter, wash, ignite, and weigh; then calculate from the amount of chloride of silver obtained the quantity of salt in the beer. In the same manner we precipitate the iron with acetate of ammonia, go through a similar process as with the chloride of silver, and calculate from the peroxide of iron obtained the amount of proto-sulphate of iron in the original liquid; 143·5 parts of chloride of silver represent 58·5 parts of salt, and 160 parts of peroxide of iron are equivalent to 308 parts of the protosulphate.

Both the salt and iron may be estimated quickly by volumetric processes. The salt by means of a standard solution of nitrate of silver with neutral chromate of potassium, as an indicator of the end of the reaction; and the iron, by means of a similar solution of permanganate of potassium. The details of the preparation of these solutions and their application will be given in a chapter devoted to the purpose.

Beer is the fermented infusion of malted barley, flavoured with hops, which by law are the only substances permitted to be used in its manufacture. How far this law is carried out, is a matter which only the analyst can determine. The color in porter and stout is due to the fact that the malt is burnt to a certain degree, prior to its introduction to the mash-tub. Moderately enjoyed, it proves as a beverage one of a most refreshing, stimulating, and strengthening character; but there can be no doubt that many of the vile decoctions nowadays sold under the name of beer are little less than slow poison to the even moderately imbibing consumer. Good beer is known by its clear transparent color and its brightness. It should contain free carbonic acid, but not in great excess. The taste should be pleasant, not too acid; if bitter, the bitterness should not be persistent, and there should be no perceptible astringency.

The average composition of genuine beer is as follows :—

Alcohol	50 grammes	
Extractive	75 ,,	
Free acid	·35 ,,	
Salts	·19 ,,	per litre.

BRANDY. *See* SPIRITS.

BREAD.

PROBABLE ADULTERANTS.—*Bean, potato and chestnut flour, bone dust, clay, plaster of Paris, alum, and sulphate of copper.*

The first of these are generally added to the flour; for the means of their detection see the article on that substance.

Alum and sulphate of copper are introduced into bread for the purpose of enabling the baker to give to loaves made from an inferior quality of flour, the whiteness and appearance of the best bread, and to force it to retain a larger quantity of water than could otherwise be done. They may be detected by the following methods:

ANALYSIS.—Reduce 100 grammes of the crumb to ashes at a low red heat, taking care to avoid fusion; then drench with pure hydrochloric acid, and evaporate the mixture to complete dryness to separate silica; again boil with more hydrochloric acid and water, and nearly saturate with carbonate of sodium, but not quite; render strongly alkaline with alcoholic potash, boil, and filter. To the filtrate add carbonate of ammonium. Should alum be present a flocculent precipitate will be thrown down, which may be filtered off, and a small portion thereof tested on a platinum wire in the blow-pipe flame, after having been moistened with a little nitrate of cobalt. The mass will not fuse, and will assume a beautiful blue colour.

One part of alumina = 9·027 of crystallized alum.

For sulphate of copper, the crumb is likewise to be incinerated and the residue dissolved in a small quantity of nitric acid, filtered and supersaturated with ammonia. If copper be present, the solution will have a fine blue colour. If in large quantity, the copper may be precipitated with potash at a boiling heat, and the amount calculated from the oxide of copper obtained. The presence of copper may be ascertained by cutting a smooth slice of bread and drawing across its surface a rod dipped in a solution of ferrocyanide of potassium ;

when, if the metal be present, the streak will appear of a more or less brown color. This adulteration is not, however, frequently met with in bread of English manufacture.

Good bread should consist of not less than 25 p. c. of crust; the crumb should be permeated with small regular cavities, the walls of which should not be tough. It should be homogeneous, no parts should be heavy. If made from wheaten flour, it should be white and not taste acid. The ash should be neutral; when potatoes are added the ash is always alkaline. The last-named fact taken in conjunction with that of an aqueous extract of the bread being neutral, may be looked upon as a certain indication of potato admixture. The average composition of white bread is—

Water	32
Albuminous substances .	8·5
Fat	1·5
Starch, fibre, &c. . . .	57 parts in 100.

BUTTER.

PROBABLE ADULTERANTS.—*Water, salt, silicate of sodium, chloride of calcium, starch, mashed potatoes, flour, cheese stuff, rag-pulp, gelatine, beef and mutton suet, and various other fats, both animal and vegetable.*

Silicate of sodium is added to butter containing tallow for the purpose of increasing its weight and giving it an appearance of lightness. The objects of the other adulterants will be obvious. Rancid and stale butters are frequently washed with permanganate of potassium and palmed off as the fresh Dorset article. The permanganate is, however, never quite washed out, and may be easily detected.

ANALYSIS.—The amount of water may be noted by melting a known quantity of the butter in a graduated tube, when the water will sink to the bottom, where its volume may be read off; or a known weight of the butter may be heated in the water-bath until the weight remains constant; the loss will indicate the amount of water volatilised, the amount of which should not exceed 10 p. c.

For salt, the butter should be boiled for some hours with fresh quantities of distilled water, in order to obtain it in aqueous solution. In this solution the salt may be estimated with standard nitrate of silver. (*See* chapter on VOLUMETRIC SOLUTIONS). It should not exceed more than 8 p. c. in salt butter, nor more than 0·5 p. c. in fresh.

In order to determine the presence of sodium silicate, the butter must be incinerated, the ash fused with three times its weight of carbonate of sodium at a bright red heat, then dissolved in hydrochloric acid, again evaporated to dryness and dissolved in boiling water. Any residue there may be will consist of silica, which is to be filtered off, washed, ignited, and weighed as such.

All butter contains a certain amount of casein, good butter from 3 to 5 p. c.; beside this, however, it is often introduced in the form of cheese, hence the technical name for the adulteration.

For its detection and estimation the butter should be dissolved in warm ether, in which casein is insoluble, and may be filtered off, and afterwards thoroughly freed from fat by washing with more ether, dried in the water-bath and weighed.

The addition of beef and mutton suet may be inferred when the butter under examination has a high melting point. Beef suet begins to melt at 33° C., and is fluid at 55° C.; mutton suet begins to melt at about 38° C., and is fluid at 66° C.; while butter shows signs of melting at 21° C., and is quite melted at 49° C. Butter is also completely soluble in ether at 15° C., and on standing does not deposit, while beef and mutton fat are only slightly soluble, and deposit a crystalline substance on standing.

Under the microscope, adulterations such as potatoes, flour, rag-pulp are at once visible. The filaments of the latter have been discovered even colored. The linen and cotton fibres are easily recognised.

Butter containing starch may be treated under the microscope with iodine, when the characteristic blue color will become evident. Lard may also be recognised by the microscope; it is highly crystalline.

Pure butter consists essentially of the glycerides of stearic, palmitic and oleic acids, together with a small quantity of butyrin, the glyceride of the volatile butyric acid. In rancid butter this latter fat is decomposed, and the volatile acid is set free. Minute quantities of capric, caproic, and caprylic acids are also present. The total of these fats amount in genuine fresh butter to about 85 p. c., the remainder should consist of nothing else but casein, salt, water, and a trace of earthy phosphates.

CATSUP or KETCHUP.

PROBABLE ADULTERANTS. — *The juice expressed from the livers of putrefying horses and other animals.*

Some time since, while managing an artificial-manure factory in the East End of London, the present writer was requested to purchase a peculiar, damp, cakey material, said to contain a quantity of nitrogen. Upon inquiry this turned out to be nothing less than the residue from livers, which had been pressed in order to extract their fluid constituents. Further inquiry revealed the disgusting fact that this juice, or extract, after having been allowed to ferment, was mixed with salt and vinegar, and sold under the lying name of mushroom catsup. A sample was shortly afterwards obtained at a shop, not a hundred miles from the same place, and on being submitted to analysis revealed its horrible constituent. It is to be hoped that the consumption of this mixture is confined to the district where it is manufactured.

ANALYSIS.—An ethereal extract should be made by shaking the suspected fluid with methylated ether, decanting and evaporating the ethereal solution in the steam-bath until all the ether has been distilled off; the residue is then tested by the sense of smell. The fatty matters found in the liver have a peculiar fetid odor, which when once smelt is not easily forgotten.

Good catsup, when concentrated to half its bulk and left to cool, forms no scum or skin on the surface. The alcoholic extract has no other taste but that of mushrooms.

CAYENNE PEPPER.

PROBABLE ADULTERANTS.—*Salt*, *brick-dust*, *Venetian red*, *red lead.*

All these adulterants, being of a mineral character, may easily be recognised on incineration.

ANALYSIS.—The salt may be detected and estimated by means of a solution of nitrate of silver. A portion of the ash being dissolved in hot nitric acid, gritty insoluble particles will be rendered visible should brickdust have been added. The diluted solution will give a blue colour with ferrocyanide of potassium in the case of

Venetian red, and a golden yellow precipitate with iodide of potassium in the event of lead being present. In burning the pepper to an ash it is necessary to perform the operation under a hood or chimney, as the vapors arising from the crucible are of an extremely acrid and penetrating character.

Cayenne is the Guinea pepper dried and ground; when pure, it does not feel gritty on rubbing between the thumb and finger; should it do so, such grittiness would indicate the presence of brickdust. Neither should it, when rubbed in the palm of the hand and then blown off with the breath, leave behind it a fine impalpable powder clinging to the skin.

CHEESE.

PROBABLE IMPURITY.—*Red lead.*

Cheese is frequently colored with anatto. Were this latter itself pure, it would be quite a harmless admixture, but it is often the case that red lead is added to anatto of an inferior description to bring up a greater depth of color. Dr. Normandy recites a case of several persons in the same house being grievously poisoned by eating a cheese, afterwards discovered to have been colored with this adulterated extract.

Analysis.—The cheese is incinerated in a porcelain crucible, the residue dissolved in nitric acid, and a few drops of a solution of sulphuretted hydrogen are added. Should there be a black precipitate formed, the presence of lead is indicated. The precipitate may be collected on a filter and heated in the reducing flame of the blowpipe on a piece of charcoal, when the metal will run together in the shape of minute beads, surrounded by a yellow ring of oxide.

CHICORY.

Probable Adulterations.—*Roast peas, lupines, beans, sawdust, roots, acorns, horse-chestnuts,* "*coffee flights,*" *&c.*, together with *Venetian red* and *reddle* as coloring matters.

All these substances are also found in adulterated coffee, and their detection will be treated of under that heading.

Pure chicory is allowed by law to be mixed with coffee, providing that the purchaser is informed by label or otherwise of the admixture. It is rarely sold in an unmixed state as far as coffee goes, excepting by dealers in the wholesale trade.

ANALYSIS.—Unadulterated ground chicory, when thrown into water, rapidly imbibes the liquid and sinks to the bottom, and leaves no particles floating on the surface. Its structure, visible under the microscope, is shown at Fig. 4. Iodine does not impart a bluish color to a decoction of pure chicory. When in a perfectly dry state it yields from 4 to 5 p. c. of a grey or fawn-colored ash. Should the ash obtained by incineration exceed this amount, a mineral adulteration may be suspected.

COCOA.

PROBABLE ADULTERANTS.—*Rice, potato, wheat, sago and arrowroot starches, sugar, peroxide of iron.*

Many preparations of cocoa are at the present day in the market, their name is legion.

Out of thirty-one samples from different sources, Dr. Muter found twenty-four to be more or less adulterated with arrowroot or sago, while four of them were colored with iron.

ANALYSIS.—The microscope detects the admixture of foreign starches. The starch grains of cocoa are usually embedded in the cells (*see* Fig. 3), and are very small.

Peroxide of iron may be discovered in the ash, which latter, in the case of pure cocoa, should not have the least trace of a red or brownish color. Sugar may be detected by taste in the filtered solution of the cocoa; a certain quantity of sugar is natural to all cocoas, but not in such amount as to be perceptible to the taste.

After examination with the microscope,

it will be a good plan to test the effects of different solvents upon the cocoa.

On an average good cocoa may be said to yield the following to different solvents:

To ether	48·5 per cent.
To water	11·8 ,,
To acid	18·8 ,,

Leaving a residue of 20·9 per cent., of which 16·4 consists of cellulose and 4·5 of hygrometric moisture.

For the purpose of testing with solvents, 10 grammes of the material should be taken, and after having been dried in the air-bath at 100° C. and the loss of weight noted, it should be thoroughly exhausted with several relays of methylated ether, the cocoa being well stirred about to facilitate the solution of the fat, and then thrown on to a tared filter, dried, and weighed. The difference between the first and second weighings added to the weight of the filter and multiplied by ten will be the percentage of fat.

The same material is then treated with water on the filter. The filter is filled with distilled water, and a flask of water armed with a doubly-perforated stopper through which two short tubes of different lengths pass, is fixed in an inverted position above it, in such a manner that while the end of one of the tubes dips about one half a centimètre below the level of the water in the filter, the other only just touches it. By this arrangement the operation of washing is self-acting, for, as the liquid in the filter lowers in obedience to the law of gravity, the air is admitted into the flask by the short tube, and allows a fresh quantity of water, sufficient to bring to the same level, to run from the flask into the filter. Much valuable time is thus saved, and the washing is more perfectly carried out. When exhausted the contents are again thoroughly dried and again weighed, the difference between this and the last weighing multiplied by ten giving us the percentage of matter soluble in water. Washing is then carried on with hydrochloric acid, diluted with six times its bulk of distilled water, and used at a nearly boiling temperature in order to dissolve out the starch, &c.

Nothing now should remain but insoluble woody fibre.

Cocoa owes its great value as an article of diet to the large quantity of fat and albuminous substances it contains, the latter amounting from 13 to 18 p. c. The most active ingredient, however, is theobromine, an alkaloid akin to, if not identical with, theine or caffeine in tea and coffee. This alkaloid is present in ground cocoa nibs to the amount of 1·5 p. c.

COFFEE.

PROBABLE ADULTERATIONS. — *Chicory, roast wheat, peas, beans, acorns, mangel-wurzel, baked liver, sawdust, tan, Venetian red, &c.*

As in the analysis of bread and other vegetable substances used for food, we depend likewise mainly on the microscope for the examination of coffee. The untrained eye being apt in this method of analysis to lead the experimenter into serious error, it is necessary for those not accustomed to microscopic research to be extremely careful both in their choice of instrument and their methods of manipulation. The analyst should select a microscope of as simple construction as is compatible with efficiency and utility. For general purposes an instrument manufactured by Messrs. Beck and Beck, of London, and named by them the "Popular" microscope, will be found extremely useful. Its workmanship is of the very best description, and it is unencumbered with the vast quantity of screws and incomprehensible apparatus to be found in many more expensive instruments. The observer should first accustom his eye to the appearance of the pure, unadulterated article, and should, if possible, have always by him a standard specimen of the same for comparison with other samples. The structure of the roasted coffee-berries and chicory-root is shown at Figs. 4 and 6.

Analysis.—The long cells of the testa containing and showing the spiral fibre are very marked; the cellular tissue is also very different from that of chicory. The cells in the latter are larger and more loosely put together, and the ducts traversing the tissue are very distinctly dotted.

The cells of turnip, carrot, and mangel-wurzel, are like chicory, but larger starch-granules may be seen. These are colored blue by iodine. Coffee contains no starch. The presence of chicory may also be discovered by its smell and by its sinking at once when thrown on water, while coffee floats for some time on the surface, in consequence of the gas it contains.

The addition of the baked liver of horse, or other animal, may be suspected when, after making an infusion of the coffee and allowing it to become cold, a pellicle or scum forms on the surface.

Mineral adulterations may be detected in the character and quantity of the ash.

If it be of a red color the addition of oxide of iron (Venetian red) is indicated.

Pure roast coffee yields about 7 p. c. of ash; should the sample under investigation yield less, the addition of chicory, &c., may be suspected; should it give more than that amount, a mineral is indicated as the adulterant.

To be good, coffee should yield about 12 p. c. of its weight to ether. Its aqueous infusion, when cleared, should have a specific gravity of from 1·008 to 1·010.

When slightly moistened and squeezed in the hand, pure coffee does not agglomerate, but, on the pressure being removed, it falls again to powder, whereas an adulterated article may be rolled into a ball of a more or less cohesive quality.

CONFECTIONERY or SWEETMEATS.

PROBABLE ADULTERATIONS AND IMPURITIES.—*Whitening*, *plaster of Paris*, *terra alba*, *prussic acid*.

INJURIOUS COLORING MATERIALS.—Red—*Vermilion, red lead, aniline reds containing arsenic.* Blue—*Blue verditer, cobalt.* Yellow—*Chrome yellow* (*chromate of lead*), *chromate of barium, Naples* (*sulphide of antimony*), *King's* (*sulphide of arsenic*), *massicot* (*oxide of lead*), *gamboge.* Green—*Brunswick* and *chrome, zinc* or *Rinman's green, Scheele's green* (*arsenite of copper*).

Whitening, plaster of Paris, and terra alba, form the basis of many comfits and "dragées" which should consist of flour and sugar only. Prussic acid may be found in many sweetmeats and flavorings, where impure oil of bitter almonds or nitrobenzol has been used to convey the taste of noyeau, bitter almonds, cherry and peach kernels, &c.

The coloring materials are either painted on the surface or are diffused throughout the mass of the article under consideration.

Prussian blue has been considered a

poisonous pigment, but there is no evidence that it really is to be held as such.

The daily papers of February 1st, 1871, quoting an analysis of Dr. Cameron's, made in Dublin, gave the following description of a "baby in its cradle," apparently a delicious sweetmeat:—

"The cradle was made of plaster of Paris and sugar, and the body of the baby was of sugar and starch. Its eyes were Prussian blue, its cheeks stained with cochineal, and its clothes were painted with chromate of lead."

ANALYSIS.—The material should be burnt to an ash. Mineral adulteration may be suspected if this latter is large. Should it effervesce violently on the addition of an acid, whitening or chalk has been added. Plaster of Paris is soluble in much water, and its solution gives a white precipitate with chloride of barium. Terra alba is insoluble in water and acids.

The distinction and detection of the various coloring materials present a matter of greater difficulty. We will commence with the red.

Observe whether the color can be dissolved out by alcohol; if so, it may be an aniline red and may contain arsenic. If it is not dissolved, try the effect of a drop of a solution of hypochlorite of calcium (bleaching powder) placed on the color. Should this be discharged or lose its red hue, the color is probably of vegetable origin. If neither of these reagents produce any marked effect, mercury, lead, or iron are probably present.

Dissolve the material in nitro-muriatic acid, and evaporate to dryness at 100° C. Re-dissolve in a little water, and add cautiously from a pipette two or three drops of a dilute solution of iodide of potassium, when, if mercury be present, a scarlet precipitate soluble in excess of the test will be formed; while, in the event of lead being in solution, a yellow insoluble precipitate will be thrown down, which, when the solution is boiled and allowed to cool, is deposited on the sides and bottom of the beaker in minute crystalline plates of a beautiful golden lustre.

If the color is soluble in alcohol, it is probably a compound of aniline, a substance frequently containing arsenic. For the detection of this poison, the following method, known as Marsh's test, may be applied. The apparatus necessary consists of a **U** tube about two centimètres in diameter and about fifteen centimètres high, fixed in a stand. One of the outlets is fitted with a small stopcock and gas-jet. A few pieces of pure zinc are introduced into the tube, and dilute hydrochloric acid added so as to induce a disengagement of hydrogen gas on the side of the tube at which the stopcock is fixed. Both the acid and the zinc must have been previously tested and proved free from arsenic. When the gas has been for some time disengaging, and all the atmospheric air is expelled from the vessel, a light is applied to the gas-jet, and a white porcelain crucible lid depressed on the flame. This, if zinc and acid be both pure, will not be stained. Should, however, the flame make a dark mark, the materials must be rejected and others quite pure used. But if the lid remain untarnished, a portion of the suspected substance is introduced, and the flame again depressed with the lid, when, if arsenic be present, a dark metallic spot will appear on the portion of the lid acted on by the flame. Antimony makes a similar stain, but in the case of red colors is not likely to be confounded with arsenic.

The yellow pigments claim our next attention. We have to search for chromium (lead and barium salts), antimony, arsenic, lead as oxide, and gamboge.

The sweetmeat is dissolved in water, and the clear solution decanted from the insoluble residuum. A small portion of this residue is then heated before the blow-pipe on a piece of dense charcoal, when, if chromate or oxide of lead be present, the metal will be reduced and assume the appearance of minute metallic globules. The remainder is boiled in a solution of carbonate of potassium and filtered; the filtrate is neutralized with dilute nitric acid, and a few drops of nitrate of silver are added. Should a purple or scarlet precipitate or coloration take place, it indicates the presence of chromium. If lead has also been discovered, this metal will be combined as chromate of lead, but if otherwise, it (the chromium) is probably present as chromate of barium.

Arsenic and antimony may be recognised by the residue being completely volatilized when heated on platinum foil, emitting at the time of ignition, if arsenious, a peculiar smell resembling that of garlic. A better method is to heat a portion of the residue from the aqueous solution of the sweetmeat in a reduction-tube with a little oxalate of lime mixed with carbonate of ammonia. This ignition must be so arranged that the oxalate should be quite red-hot before the vapour of the sulphide passes through it. Metallic arsenic will be deposited in the cooler part of the tube. The tail end of the tube may then be broken off, and the metallic arsenic further heated and oxidised to arsenious acid, which again is condensed further along the tube, and may be shown under the microscope to consist of white transparent octahedral crystals.

Sulphide of antimony is fusible and will run into the lower point of the tube, from which it may be extracted and dissolved in hydrochloric acid. The solution is then tested with sulphuretted hydrogen. An orange-red precipitate indicates the presence of antimony.

These results should always be confirmed by a second or third experiment.

When gamboge has been used the aqueous solution retains a yellow tint. The gum-resin is best detected by making an alcoholic solution of the sweetmeat, filtering and adding excess of distilled water. The resin will then fall as a precipitate, which, when moistened with a solution of ammonia, assumes a characteristic deep red color.

The poisonous green colors contain either copper, zinc, chromium, or arsenic. The detection of chromium and arsenic has already been described. For copper or zinc a solution should be made in acetic acid and supersaturated with aqueous ammonia. A fine blue color is a certain indication of copper.

Should there be no blue precipitate or coloration, the solution is again made acid with acetic acid and treated with a current of sulphuretted hydrogen. Zinc, if present, will be precipitated as white sulphide, which may be further identified by redissolving in hydrochloric acid, boiling to expel sulphuretted gas, adding great excess of ammonia, and then precipitating with sulphide of ammonium.

The filtrate from the previous precipitate of sulphide of zinc probably contains cobalt, as the pigment named Rinman's green combines these two elements. The solution of cobalt has a pink color, and when evaporated yields a deliquescent semi-crystalline mass of a purplish hue.

Blue colors are poisonous only when containing copper or arsenic. Cobalt in itself is not poisonous, but the compounds in which it is met with in commerce nearly always contain more or less arsenic. This may be detected by Marsh's test as given above. The ammonia test for copper may also be used, the pigment having been first dissolved out by means of hydrochloric acid.

Prussic acid may be discovered, as before stated, in custards, beverages, &c., to which an impure or artificial essence of bitter almond or laurel has been added. The following test for its detection is extremely delicate and reliable. A little of the suspected mixture rendered acid, if necessary, with dilute sulphuric acid, is put into a watch-glass, and covered with another inverted watch-glass, the concave side of which is moistened with a solution of yellow sulphide of ammonium. The glasses are allowed to remain in this position for about half an hour, after which the upper one is taken off, and thoroughly dried in the water-oven. If any prussic acid has been present in the liquid under examination, it will have become volatilized, and have combined with the sulphide of ammonium, in the inverted watch-glass, forming a sulphocyanide of ammonium. This, when moistened with a weak solution of perchloride of iron, will immediately produce a blood-red color, due to the formation of sulphocyanide of iron.

FLOUR.

PROBABLE ADULTERANTS. — *Bean and potato-flour*, *chalk*, *bone-dust*, *clay*, *&c.* (*See* BREAD.)

ANALYSIS.—A weighed quantity of flour should be dried in the air-bath, and then incinerated. If the ash amounts to more than 2 p.c. of the original weight, the flour is adulterated with a mineral. The character of the ash should then be noted. If it effervesces on the addition of hydrochloric acid, chalk has probably been added. Bone-dust is soluble in the acid without effervescence, and is precipitated from the filtered solution by aqueous ammonia in a flocculent state; clay is perfectly insoluble.

The specific gravity of the flour may be taken. Potato-flour and mineral adulterations are considerably more dense than pure wheaten flour. Nitric acid and ammonia poured successively on good flour have no marked reaction; but with flour adulterated with bean-meal, the mixture assumes a deep red color.

A determination of the gluten, calculated from the amount of nitrogen yielded on combustion of the flour with soda-lime, should also be made. This should be present in not less amount than 10 p. c.

The nitrogen determination may be thus conducted:—2 grammes of the flour are intimately mixed in a perfectly dry porcelain mortar, with as much soda-lime as is sufficient to fill one half of a 14-inch combustion tube. The mixture having been transferred to the tube, the mortar is rinsed out with more soda-lime, enough to fill the tube to about 2 inches from its mouth. The latter is then loosely stopped with a plug of asbestos, and fitted with a perforated cork, and the whole gently tapped, so as to form a channel for the passage of gas along the entire length of tube. A bulb tube containing a measured amount of standard sulphuric acid is then fitted to the cork, and the operation proceeded with in a gas-combustion furnace, gently heating that portion of the tube nearest to the bulbs, and when that is red-hot, gradually extending the heat to the whole tube, so as to keep up a moderate and continuous evolution of gas. When this ceases, and the acid in the bulbs threatens to rise through absorption into the tube, the tail is broken off, and air slowly sucked through the apparatus, so as to empty the combustion tube of any ammonia it may yet contain. If the operation has been properly conducted, all the nitrogen will now have been absorbed into the acid as ammonia, and will have neutralised a certain amount of the free acid.

The remaining free acid is now determined by titration with standard alkali (*see* chapter on VOLUMETRIC ANALYSIS), and the difference in amount of free acid before and after the operation gives us the quantity neutralised by the ammonia formed, and hence also on calculation, the amount of nitrogen in the flour. One part of nitrogen equals 6·24 of gluten. An approximately accurate estimation of gluten may also be made by kneading ten grammes of the flour with a little water, so as to make a dough, and then carefully washing it with different relays of water, pouring off the starch into another vessel. The gluten, after a time, becomes coherent, and may be worked more easily between the fingers until all the starch is removed, and the water comes away quite clear. The gluten may then be dried in the water-oven and weighed.

The microscopical examination of flour is very complicated. Indeed, it is questionable whether the admixture of other kinds of flour with that of wheat can be thus detected with certainty, even when the adulteration is considerable. Attention is best paid to the shape and size of the starch cells. (*See* Figs. 7, 12, and 14.)

Fungi may be easily detected. The most common is that known as *Puccinium* (*see* Fig. 10); the *Acari farinæ* (mites) are also distinguishable with facility. For a more fully detailed description of the microscopic characteristics of genuine and adulterated flour, the reader is referred to Dr. Parkes' comprehensive treatise entitled "Practical Hygiene." (*See* also OATMEAL, MAIZE, PEA-FLOUR.)

GIN. *See* SPIRITS.

HONEY.

PROBABLE ADULTERATIONS. — *Chalk, flour, gelatine, dextrin, glucose.*

ANALYSIS.—The suspected honey is dissolved in a sufficient quantity of cold water, when chalk or flour, if present, will sink slowly to the bottom of the vessel. The fluid should then be decanted, and the residue tested with a drop of a solution of iodine, which strikes a deep blue coloration with starch. Hydrochloric acid may be added to the same residue, when, if violent effervescence ensues, the presence of chalk is indicated.

These substances may be quantitatively estimated by taking a weighed portion of honey, treating with cold water as before, filtering and washing the filtrate on a weighed filter, drying and weighing for the starch, and subsequently incinerating and weighing for the chalk.

Dextrin is said to be indicated when the honey, after being boiled with 6 or 8 times its volume of alcohol (80 p.c.), throws down an insoluble residue, which, when dried, has the appearance of gum, and which, when in aqueous solution, does not give a precipitate with tannic acid. Should, however, tannic acid cause a precipitate, the residue consists of gelatine, which may be further recognised by its evolving ammonia, when heated with soda-lime in a test-tube.

Glucose, or starch-sugar, always exists naturally in honey, to a certain extent. It is, therefore, a difficult matter to detect its fraudulent addition. No direct process is known for its detection in honey, and its amount can only be estimated by a complicated proximate and fractional analysis, in the latter portion of which the polariscope plays an important part.

Honey spoils when kept for a considerable period—it becomes limpid and of an acid or pungent taste. It is for the purpose of disguising this deterioration that flour and chalk are often added to it.

Virgin honey, which is considered the

best, is of a pale yellow color, slightly opaque, and possesses a fragrant smell and slightly pungent taste. The common honey obtained from old hives, the bees of which have swarmed, is darker in color and less agreeable to the taste and smell. Some honeys are said to possess an intoxicating quality; this is probably due to the fact that they have been subjected to a partial fermentation.

ISINGLASS.

Probable Adulterants.—*Gelatine, the intestinal membranes of the sheep and calf.*

Analysis.—The best indication of these adulterations is the amount of ash: genuine isinglass yields only 0·9 p. c., while gelatine yields 4 p. c.; an article showing, therefore, more than 1 p. c. of ash should be looked upon as adulterated.

Isinglass is manufactured from the dried coats of the air-bladder of the sturgeon, *Accipenser huso*, and is found in the market in three different varieties or qualities.

The best is lyre-shaped, the medium quality is cut in square leaves, and the cheapest variety is of all sorts of shapes, no particular pains having been taken in its manufacture or drying.

Good isinglass should be white, inodorous and tasteless; it should be readily and completely soluble in hot water, and, on cooling, the solution should form a transparent and semi-solid jelly.

Genuine isinglass can be divided only in the direction of its fibres, while many of its spurious imitations may be rent in all directions when torn asunder. The latter are also destitute of the peculiar shining appearance noticeable when a thin piece of isinglass is held up between the eye and a bright light.

JAMS or JELLIES.

PROBABLE ADULTERANTS. — *Glucose, coloring matters, turnips, flour, gelatine, cellulose* (*straw-pulp*). *Lead* and *copper* may also be sought for.

ANALYSIS.—Injurious coloring matter, lead and copper, may be detected by the methods given under the heading CONFECTIONERY. For the general examination, the material should be brought into a fluid state with warm distilled water, and the soluble portions separated by this means from the insoluble. This latter should be first tested with iodine for starch, the presence of which would indicate an adulteration, and then well washed in a stream of water until all adhering matter is removed. The residue is then examined with a lens, and suspicious-looking objects may be picked out for further investigation, either under the microscope or otherwise. A frequent adulteration in deep-colored jams is straw-pulp. On treating as above, the small pieces of broken and torn-up straw are easily to be recognised. The addition of glucose is next to impossible to detect. (*See* HONEY.) Many so-called fruit jellies consist of colored gelatine and sugar, flavored with the artificial essence of the fruit they pretend to be made from. They may be distinguished from the genuine article by being precipitated by a solution of tannic acid; by their almost complete insolubility in strong alcohol; and by their evolving ammonia when boiled with a strong solution of caustic soda. All of which reactions are indicative of the presence of gelatine.

LARD.

PROBABLE ADULTERANTS. — *Tallow*, *water*, *alkali* and *chloride of calcium*, and *potato starch*.

ANALYSIS.—The quality of lard may be judged by the amount of its resistance to pressure and its behaviour when put to the practical test in the frying-pan. Should it feel hard and difficult to make an impression upon with the finger, tallow has in all probability been added. If, when thrown into a hot frying-pan, it should splutter and splash instead of gently melting down to a liquid and clear oil, the operator may be certain of its containing an undue amount of water.

The fusing point of lard varies in different samples, but it never reaches above 38° C. (100° F.), while tallow remains unfused at a more elevated temperature. (*See* BUTTER.) The smell of tallow may be noticed on melting the adulterated fat. Pure hog's lard is almost colorless.

The specific gravity of hog's lard at 15° C. is 0·930, while that of average tallow is 0·913. Pure lard is entirely soluble in ether, any portion, therefore, of the fat under examination remaining undissolved by this medium will consist of an adulterant.

Soluble adulterations and starch may be detected by boiling the lard with distilled water for two or three hours, allowing it to cool, and separating the solidified fat from the aqueous solution. Salt is almost sure to be present, and is indicated by forming a precipitate when treated with a solution of nitrate of silver, but it must not be looked upon as an adulterant unless it be present in undue proportion. Chloride of calcium is likewise precipitated by nitrate of silver, and might be confounded with salt; hence, to prove the presence of this compound, we must detect the calcium previously, in combination with the precipitated chlorine, by means of a solution of oxalate of ammonium, which salt gives with calcium compounds a white precipitate of oxalate of calcium, converted on ignition into carbonate. Starch may be tested for in the same solution with iodine tincture. This, if starch be present, immediately strikes a deep blue color. The solution should also be tested with a red litmus paper for an alkali. The object of the sophisticator in adding this last together with the chloride of calcium is to enable the lard partially saponified to retain an enormous quantity of water, the amount sometimes so fraudulently added reaching upwards of 50 p. c. In order to measure this water a quantity of lard is put into a graduated cylindrical glass, and the whole warmed until the lard is melted. The volume is then noted. To this a known volume of acetic acid is added, the mixture agitated and then allowed to cool undisturbed. When cool, the water will have completely separated from the lard and have mixed with the acetic acid. The total volume of aqueous acid is then read off, and the volume of acid previously added deducted therefrom. The remainder gives the proportion in bulk of the water present.

Genuine lard should be white, nearly inodorous, soft to the touch, and crystalline in its texture. It should not be salt to the taste, and when newly divided should not give evidence of the presence of much water.

LENTIL FLOUR.

PROBABLE ADULTERANTS.—*Potato starch, Venetian red.*

ANALYSIS.—Potato starch is at once recognised under the microscope (*see* Fig. 2). Venetian red may be detected in the ash.

This, in genuine lentil flour, amounts to 2·6 p. c., and is quite white. Should it be colored, or amount to more than 2·6 p. c., it must be analyzed. For this purpose it is dissolved in hydrochloric acid, diluted with water, and tested with a solution of ferrocyanide of potassium, which, if iron (Venetian red) be present, will cause a precipitate of Prussian blue. In ten samples of lentil flour, two of which were of British and eight of foreign manufacture, the writer has not, however, detected any adulteration. (Fig. 5.)

LEMON-JUICE. LIME-JUICE.

PROBABLE ADULTERANTS.—*Tartaric acid, sulphuric acid, hydrochloric acid.*

ANALYSIS.—The juice, if turbid, should be filtered, and a solution of acetate of potassium added, stirring briskly the while, and taking care not to touch the sides of the vessel with the stirrer. This should then be allowed to stand for twenty-four hours; when, if tartaric acid be present, precipitation of acid tartrate of potassium will take place. For sulphuric acid, the filtered juice is diluted, and a few drops of hydrochloric acid and a solution of chloride of barium are added; a white precipitate will consist of sulphate of barium, indicating sulphuric acid. The precipitate may be filtered off, with the same precautions as stated under the heading BEER, and the amount of acid calculated from the weight thereof.

Hydrochloric acid is best tested for with nitrate of silver, a little nitric acid having been added to the juice. Any precipitate indicates a chloride; the amount of this latter should be determined with a standard volumetric solution of nitrate of silver. (*See* chapter on VOLUMETRIC ANALYSIS.)

A spurious lemon-juice is sometimes concocted with citric acid, essence of lemon, and water. Its flavor is not, however, like the genuine juice; which, when good, has a specific gravity of 1·037, and contains about 30 grains of citric acid to the ounce.

The citric acid may be determined by means of a standard solution of caustic soda. (*See* chapter on VOLUMETRIC ANALYSIS.)

LIQUEURS. *See* SPIRITS.

MAIZE (CORN-FLOUR).

PROBABLE ADULTERANTS.—*Potato starch, plaster of Paris.*

ANALYSIS.—Potato starch is detected with great facility under the microscope.

The starch cells of Indian corn are small and irregularly shaped, their hilum is either circular or radiate, no concentric rings are perceptible. Sulphate of lime is detected by the amount of ash, which should not exceed 1·6 p. c., and by the solution thereof in water giving a precipitate when treated with nitric acid and chloride of barium.

Several samples of corn-flour and "maizena" now in the market have been examined by the present writer and found to consist of corn-flour only, in its pure and unadulterated form. (*See* Fig. 15.)

MILK.

PROBABLE ADULTERATIONS. — *Water, starch, chalk.*

ANALYSIS.—Water is the most common, if not the only adulteration the analyst will meet with. Starch is said to be sometimes added, to conceal the blue color produced by the addition of water. It is easily detected by the violet-blue color it forms with a drop of tincture of iodine.

Chalk, it is stated, is added to neutralise the acidity in sour milk, and also to give it thickness and body. When this is the case, the deposit left by the milk, after standing some time, if washed and dissolved in acetic acid, will effervesce; and the solution, after effervescence and dilution, will give a white precipitate with oxalate of ammonia.

A very common fraud consists in removing the cream. The amount of this abstraction can be roughly measured by the lactometer.

This instrument consists of a tall cylindrical glass, graduated into 100 parts; its precise capacity is a matter of no moment. When used, it is filled with the milk to be tested, and allowed to stand for twelve hours. The cream will rise to the top, and its bulk in relation to the remainder of the milk may be read in percentages. The amount of cream in genuine milk varies according to the season of the year and the breed of the cow from which it has been obtained. It should not be below 6 p. c. The average amount is about 8 p. c., while in milk from Alderney cows the cream will sometimes reach to 40 p. c. of the total milk. It is, however, not probable that the analyst will often be troubled with the examination of milk of the last description.

The specific gravity of milk ranges from 1·026 to 1·036. The average of unskimmed being 1·030 p. c., the addition of water is best detected by its specific gravity; this, in a sample of pure milk, was lowered, when mixed with its own volume of water, from 1·031 to 1·015. In order to be certain of the purity or adulteration of milk, it will be necessary, in addition to the above physical tests, to estimate the total solids —the casein, the fat, and the sugar.

TOTAL SOLIDS.—Five grammes of milk are evaporated in a weighed capsule in the steam-bath, the operation being finished in an air-bath at a temperature of 110° C., until the weight remains constant. The dry residue should not weigh less than 0·55 grammes (11 p. c.), and not more than 0·75 grammes (15 p. c.).

CASEIN.—The residue should be mixed with one-fifth of its weight of plaster of Paris, and well triturated in a mortar. The mass is then thoroughly exhausted with ether (the ethereal solution being preserved for the estimation of fat), and then with alcohol, and afterwards dried. The residue consists of casein plus plaster of

Paris, which should weigh, after the weight of the gypsum has been deducted, at least 0·15 grammes (3 p. c.). Good milk contains about 4 p. c. of casein.

FAT.—The ethereal solution from the casein is evaporated in a weighed beaker at 100° C.; the residue represents the fat, which should weigh about 0·2 grammes, or 4 p. c.

SUGAR.—Ten grammes of the milk should be taken, the casein and fat separated by adding a few drops of acetic acid and filtering. The filtrate is boiled with a little sulphuric acid to convert milk-sugar into grape-sugar, and this is then estimated by a standard compound copper solution. (*See* chapter on VOLUMETRIC ANALYSIS.) The normal amount of sugar in milk is 5·27 p. c.

MUSTARD.

PROBABLE ADULTERATIONS.—*Plaster of Paris*, *wheat flour*, *turmeric*, and *peppers*.

Wheat-flour is used to increase the

weight and bulk of the mustard; the strength thus reduced is brought up again by the addition of ground peppers, and the color by the admixture of turmeric. Plaster of Paris is probably added, for the double purpose of giving weight and facilitating the dressing of the mustard. There appear to be five qualities or brands of mustard manufactured in England, and known by the name of "genuine," "double superfine," "superfine," "fine," and "seconds." The first of these, viz. the "genuine," is the only one truly deserving of the name, the others being more or less adulterated with wheat-flour, turmeric, and plaster of Paris.

ANALYSIS.—Wheat flour is detected under the microscope. The starch granules should be looked for; pure mustard contains no starch. Turmeric may be easily detected by adding a few drops of a solution of caustic potash to the mustard, suspended in water; the bright yellow color of turmeric is instantly changed by the alkali to a deep orange hue. Turmeric may also be detected by the fluorescent appearance characteristic of its alcoholic solution. Mustard yellow does not exhibit this peculiarity. Professor Stokes gives the following directions for viewing fluorescence:—"A glass containing water, and blackened internally, is placed at a window, and the solution to be examined as to its fluorescent tint is placed in a test-tube, which is held vertically in the water, the top slightly inclined from the window, and the observer regarding the fluorescent tint from above, looking *outside* the test-tube." The minutest trace of turmeric imparts to alcohol a beautiful green fluorescence.

Ground peppers are much used to adulterate the low-priced qualities of mustard. For their detection a strong alcoholic tincture of the suspected mustard should be made, and evaporated to an extract in the water-bath. The extract from pure mustard leaves, when applied to the tongue, no burning sensation in the mouth; while that of mustard adulterated with peppers has a powerfully irritating, blistering taste.

Plaster of Paris can be detected in the ash. Should this amount to more than 5 p. c., plaster of Paris is almost certain to have been added, and may be tested for and estimated in the aqueous solution of the ash by means of nitric acid and chloride of barium. (*See* analysis of the ash of BEER.)

Indeed, the amount of ash left on incineration of the mustard may be regarded as a criterion of its purity. For should it be more than 5 p. c., a mineral adulterant is indicated; and should it amount to less than 4 p. c., wheat-flour and turmeric have probably been added.

OATMEAL.

PROBABLE ADULTERANT.—*Barley-meal.*

This is detected in the microscope; the starch grains of barley are smooth and round, while those of oat are small, many-sided, and cohere together in little lumps, which can be broken down into separate grains by pressure. (*See* Figs. 13 and 18.)

The starch granule of oat does not polarize light.

The ash of pure oatmeal does not exceed 2·36 p. c. Dr. Hassall found about half the samples of oatmeal to be adulterated. (*See* FLOUR, MAIZE, and PEA-FLOUR.)

OLIVE OIL.

PROBABLE ADULTERANTS.—*Poppy oil, rape oil, lard oil, sulphuric acid, oxide of lead.*

The various oils are added for the purpose of sophistication, while sulphuric acid is employed for the purpose of bleaching, or separating the mucus from the oil, and is not always perfectly removed. Oxide of lead is added to rancid oil, for the purpose of sweetening and decolorising it.

ANALYSIS.—Poppy oil is indicated when the oil is briskly agitated, by the production of a froth which takes some time to subside.

A very reliable test has been suggested by M. Poutet, which depends upon the peculiar action of nitrous acid. A solution of mercury is made by dissolving six parts of the metal in seven and a half parts of nitric acid, sp. gr. 1·36 in the cold. When one part of this freshly-prepared solution is added to ten parts of pure olive oil, the mixture becomes concrete in a few hours. The admixture of foreign oils prevents this solidification, and the resulting mixture is more or less fluid in proportion to the adulterating oil present.

The method is, however, inapplicable to quantitative valuation.

The peculiar odor of the various adulterating oils in olive oil is rendered far more distinct on heating a few drops over a lamp in a porcelain capsule.

The comparative purity of an oil may be indicated by its specific gravity. An instrument called the oleometer is specially graduated for the purpose. In pure rape and olive oils the stem of this instrument marks

37° or 38° at 15°; in poppy oil, 32° to 33°. The true specific gravities of these oils at 15° C. are:—

Olive	0·917
Poppy	0·924
Rape	0·913
Lard oil	0·915
Nut	0·923
Tallow oil or oleic acid	0·900

Sometimes these two latter oils are also used for adulterating olive oil.

Messrs. Tomlins and Moffatt have recently studied the peculiar reactions of the different oils known as "cohesion figures," which afford an excellent method for the valuation of olive, and indeed all oils. A perfectly clean soup plate is filled with clean cold water, a small dry pipette, drawn out to a fine point, is filled up to a fixed height with a *pure* sample of the oil in question, and a drop is allowed to fall upon the surface. A drop of the sample under examination is now allowed to fall in a similar manner upon the surface of water in another plate, and the figures or patterns produced by the oils on the surface are compared. It is absolutely necessary, however, in order to obtain satisfactory results, that everything be perfectly and scrupulously *clean*, and that the water be quite cold. In filling the soup plates, it is best to rinse them out first with oil of vitriol, and then place them under a tap, letting the water run violently into them for some time. By this means a chemically clean surface is obtained. In the operation of testing, there must be no shaking or vibration of the water; everything must be quite calm. The drop of oil must be in each case alike in size, and must be let fall from the same height, say four inches, upon the surface of the water, in the middle of the plate. If these precautions are attended to, a genuine sample of the same oil will always give the same pattern.

The sulphuric acid is indicated by the acid reaction of water that has been shaken with the oil, and the precipitate which it gives with a solution of chloride of barium in the presence of free nitric acid. Oxide of lead may be detected by a black precipitate when the oil is shaken with sulphuretted hydrogen water. Genuine olive oil has a specific gravity of 0·917 at 15° C. It is odorless, and of a pale straw color. It is neutral to test-paper, and begins to solidify when cooled to 2·5° C.

PEA-FLOUR.

Rarely adulterated.

The starch granules of peas are long and irregularly shaped, the hilum presents a longitudinal depression (*see* Fig. 17). The ash of pea-flour is deliquescent and has an alkaline reaction upon turmeric paper. (*See* FLOUR, LENTIL-FLOUR, OATMEAL, and MAIZE.)

PEPPER.

PROBABLE ADULTERANTS.—*Oilcake, linseed meal.*

Pepper in the grain is sometimes, according to Bussy and Boutron-Charlard, adulterated with artificial peppercorns, consisting of mustard and Cayenne pepper made up into a paste with mucilage and granulated in such a way as to bear considerable resemblance to the genuine article. The fraud is, however, detected on placing them in tepid water, when they soon become disintegrated and fall to pieces, while genuine pepper retains its spherical shape.

ANALYSIS.—To detect adulterations in ground pepper, both black and white, the best way is to ascertain the amount of piperine contained in them. This may be done by treating 50 grammes of the pepper with alcohol, sp. gr. ·833, until it is exhausted. The solution is then distilled to the consistence of an extract, and this latter treated with a solution of caustic potash, which separates the resin, leaving the piperine in a state of fine green powder, which should then be well washed with distilled water and dissolved in alcohol, and the solution allowed spontaneously to evaporate. Piperine crystallizes in colorless monoclinic prisms, which are tasteless and inodorous, insoluble in cold water, and only very sparingly soluble in boiling water, from which they separate out on cooling.

Good pepper yields about 1·5 p. c. of this alkaloid, any lower amount obtained will therefore be of assistance in indicating the quality of the pepper under examination, and extent of adulteration.

PICKLES.

PROBABLE IMPURITIES.—*Lead, copper, sulphuric acid.*

Lead may be detected in pickles when improper metallic vessels have been employed in their manufacture. It falls as a black precipitate when the filtered liquor is treated with sulphuretted hydrogen. (*See* CONFECTIONERY.) Copper is used for the purpose of giving to pickles a fine green color, and may be detected on immersing a bright steel blade in the vinegar. The blade, if copper be present, becoming coated with a red film of metallic copper.

Sulphuric acid in excess is found sometimes in pickles made with inferior vinegar. (*See* VINEGAR.)

Pickles may also be tested by Marsh's test for arsenic. (*See* CONFECTIONERY.)

RICE-FLOUR.

Rarely adulterated.

The microscope shows the starch grains as very small, many-sided, and angular. They have neither a visible hilum nor concentric rings. (*See* Fig. 16.) The ash should not amount to more than ·85 p. c.

RUM. *See* SPIRITS.

SAGO.

PROBABLE ADULTERANT.—*Potato starch.*

ANALYSIS.—Potato starch is at once recognised under the microscope. The granules of sago are mostly shapeless, having been altered in the peculiar method of drying they are subjected to in the process of manufacture, while those of potato starch are more regular in their shape. (*See* Figs. 2 and 11.)

So-called German sago is prepared from wheat and potato starch. It is of a pure white color and less hard and friable than real sago, which is generally more or less tinted by the method of drying above referred to.

SPIRITS.

PROBABLE ADULTERATIONS AND IMPURITIES :—

BRANDY.—*Fousel oil*, *caramel*, *acetate of lead.*

GIN.—*Tincture of capsicums*, *sulphuric acid*, *alum*, *acetate of lead.*

WHISKY.—*Fousel oil*, *methylated spirit*, and *ether.*

The basis of home-manufactured spirits is "plain spirit" produced from grain at the distillery. This is rectified and flavored by the rectifier, and becomes, under his treatment, the particular spirit or cordial he desires to manufacture. The difference of taste and appearance of the several spirits is brought about by distillation of the plain spirit with various aromatic vegetable products, viz. bitter almonds, aniseed, cardamoms, carraways, pine-apples, juniper berries, angelica root, orris root, grains of Paradise, calamus root, orange-peel, liquorice, &c.—the distillate being brought up to a certain color with caramel or burnt sugar. Cordials are flavored with a natural or artificial essence, and when pungent, as is the case with ginger brandy, are often adulterated with capsicums. Rum may be made from plain spirit in the same manner as gin, &c.; but its chief sources are the West Indian sugar plantations, where it is largely manufactured by distilling fermented molasses. French brandy is distilled from wine, but the pale and dark brandies mainly consumed in England consist of flavored "plain spirit."

ANALYSIS.—The average strength of rums, whiskies, and brandies sold to be consumed on the premises amounts to from 20 to 25 under proof, as shown by Sykes' hydrometer, while that retailed in bottles ranges from 18 to 20 under. Gin, in bottles, averages about 17, and that to be consumed on the premises about 20 under proof. These numbers refer to the London trade only. Should the hydrometer show a lower strength, an excessive quantity of water has been added. Dissolved materials, however, affect the accuracy of this method of testing. It is necessary, therefore, in order to arrive at the real amount of alcohol present, to obtain the latter free from substances in solution. This is effected by introducing a measured quantity of the spirit or cordial under investigation into a retort connected with a proper condensing and receiving apparatus, and distilling over to about one half if a weak spirit, and to incipient dryness if a strong one, making up the distillate to the original bulk and testing the same with the hydrometer. All the alcohol contained in the spirit will be found in the distillate free from any fixed organic or inorganic matter. The residue may be retained for the purpose of testing for mineral adulterations, &c.

The residue is poured out, and, if necessary, further concentrated. A drop of it should be placed on blue litmus paper, on which it should not exert any immediate reaction. Should it do so sulphuric acid is probably present. The litmus paper is dried at 100° C., when, if sulphuric acid be present, the paper will be charred and blackened on the spot acted on by the drop. The sulphuric acid may then be estimated in the original spirit by means of a solution of chloride of barium. (*See* AERATED WATERS.) Capsicums, like sulphuric acid, are frequently added to cordials and spirits for the purpose of imparting a hot and fiery taste. To detect them, a portion of the extract, if acid, is neutralised with carbonate of soda, whereby the biting taste of the pepper is rendered evident to the palate. Lead is detected by dissolving a portion of the extract in distilled water and submitting the solution to the action of sulphuretted hydrogen, a reagent which, if lead be present, will throw down a black precipitate, which may be collected on a tared filter and weighed. Alum may be detected as in bread.

Fousel oil and sulphuric ether can only be detected after repeated rectification, the ether in the most volatile portion, and the fousel oil in that portion least so. Both are often found in Irish whisky. Pure ether boils at 35° C. (95° F.); plain spirit from 78° C. (173° F.), to just below the boiling point of water, while pure fousel oil only begins to distil at 132° C. (269° ·6 F.). Thus by the process termed fractional distillation the three may be separated and recognised by their physical and chemical characteristics.

Methylated spirit is difficult to isolate, but the practical man discovers its presence with facility. He rubs a few drops of the liquid in the palms of his hands, and applying them loosely to his face, inspires the air through his fingers. By this means the aroma of the spirit is fully brought out, and the "twang" of the wood-naphtha easily recognised.

SUGAR.

PROBABLE ADULTERATIONS IN RAW SUGAR.—*Water*, *sand*, *plaster of Paris*, *chalk*, *glucose*, and, as an accidental impurity, *lead*.

White lump-sugar is rarely adulterated.

ANALYSIS.—Sand, plaster, and chalk remain undissolved when the sugar is treated with water; their weight should be noted. Chalk effervesces on the addition of hydrochloric acid. Plaster is soluble in much water, the solution giving a white precipitate with chloride of barium, and sand is quite insoluble in water and acids. Lead may be detected in some refined sugars by passing through the solution a current of sulphuretted hydrogen, whereupon, if that metal be present, the liquid will become more or less darkly colored or precipitated, according to the amount present.

Before the sugar duty was repealed, the muscovado and coarse sugars were enormously adulterated with glucose. It is doubtful, however, whether this sophistication is much carried on at the present day, the cost of starch-sugar being nearly as much as that of cane-sugar. It may be detected by dissolving 15 grammes of the suspected sugar in 30 c. c. of water, and adding thereto 1 c. c. of a saturated solution of caustic potash, and boiling. If the sugar be pure cane-sugar no change will take place, but if glucose be present the solution will assume a brown color, more or less intense according to the percentage of glucose present.

Grape or starch-sugar may be quantitatively estimated in the presence of cane-sugar by means of a standard compound copper solution. (*See* VOLUMETRIC ANALYSIS.) The operation is based upon the fact that glucose reduces cupric to cupreous oxide at temperatures below a boiling heat, while cane-sugar has no reducing effect until the solutions have been boiled for some time.

Should the solution of the sugar be darkly colored, it is necessary to clarify it prior to the application of the copper test. This is best done by heating quickly just to the boiling point, adding a few drops of milk of lime, and filtering through animal charcoal. In estimating glucose in raw sugars, it must be borne in mind that all sugars, even the best, contain a little glucose.

Cane-sugar should be sparkling, crystalline, and dry. It should be completely soluble in water, and the solution thereof should be transparent and not too darkly colored. When adulterated with glucose it is not so sweet as when pure, cane-sugar being two and a half times sweeter than starch-sugar.

TAPIOCA.

PROBABLE ADULTERANTS. — *Sago, potato starch.*

ANALYSIS.—Both of these are easily detected by the microscope. The starch grains of tapioca are small, with a central hilum, while those of sago are much larger, and the hilum consists of a point, or more often a cross, slit, or star. (*See* Fig. 8). *See* SAGO and ARROWROOT.

TEA.

PROBABLE ADULTERATIONS.—The leaves of the *willow*, *elder*, *sloe*, *hawthorn*, *beech*, *oak*, *elm*, *poplar*, *plane*, "*Chloranthus inconspicuus*," "*Camellia sasanqua*," *exhausted tea-leaves*, faced with *Prussian blue*, *chromate of lead*, and *plumbago ; rice husks*, faced or unfaced, *iron filings*, *spurious stalks*, *&c.*

There is, perhaps, no article of food more subject to adulteration than tea. That imported into this country generally receives an extensive addition before it leaves its native soil, and, on arrival in England, is still further sophisticated and doctored by home dealers and retailers. It is gratifying, however, to note that the Legislature is at last commencing to exercise its authority in the matter, and perhaps we may shortly begin to hope that "the cup which cheers but not inebriates" will no longer be defiled by the pestilential rubbish so much of which is consumed in the present day.

ANALYSIS.—The first and most crucial test of the genuineness of tea is the character of its infusion. Buyers on the large scale always depend on this. It should be fragrant to the smell, not harsh or bitter to the taste, and not too dark in color.

The amount of extract from good ordinary congou obtained by the repeated action of boiling water ranges from 22 to 28 p. c. In specimens adulterated with exhausted teas, the amount of extract is of course much less.

The tea should be carefully treated with warm water, and the action thereupon noticed. Some spurious teas, made up of tea-dust or ground rice and gum, instead of uncurling and exhibiting their leafy structure, become disintegrated and fall to powder. The insoluble mineral and other heavy matters may now be easily separated from the leaves by means of a perforated spoon. Gypsum and chromate of lead may be tested for as in confectionery. Plumbago may be recognised in the insoluble portion or ash of the tea by its glistening black appearance. Iron filings are attracted or separated from the tea-dust by means of a magnet.* The ash of good tea does not amount to more than 5 or 6 p. c. Having acted on the tea with warm water and unfolded the leaves, these latter should be examined as to their form and size. This is done by spreading out the leaf in a glass slide, covering with

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* Magnetic oxide of iron has recently been discovered to be a natural constituent of tea.

a thin glass, and observing the border and venation when held up to the light.

The border of the tea-leaf is serrated to the stalk, nearly, but not quite; the primary veins run out from the mid-rib nearly to the border, and then turn in. The length of the leaves varies in different teas from three-fourths of an inch to three and a half inches in length. Genuine tea leaves and their substitutes are shown in the accompanying figures. (*See* Figs. 19 to 22.)

The character of the dust sifted from the dry tea should also be observed under the microscope. Here angular particles of sand, glistening plumbago, Prussian blue, iron filings, rice husks, silkworm droppings, larvæ of insects, &c., may be detected. A low objective should be used, say one having a focal length of two inches.

There are two classes of Chinese tea, the black and the green. These are again subdivided and named after the various portions of the plant they represent. Thus in black tea the earliest bud is called

"Flowery Pekoe," the partially expanded bud "Orange Pekoe," the earliest leaf "Pekoe," the half-matured leaf "Souchong," and the matured leaf "Congou." In green tea the names, taken in the same order, are, "Young Hyson," "Gunpowder," "Hyson," "Imperial," and "Twankay."

VINEGAR.

Probable Adulterations.—*Sulphuric acid* (in excess of $\frac{1}{1000}$ part by weight), *hydrochloric acid*, *tartaric acid*, *pyrolignous acid.*

Sulphuric acid (oil of vitriol) is unfortunately permitted by the Legislature to be added to vinegar, in the proportion of 1 to 1,000 by weight. This mixture is held as necessary to prevent a peculiar fermentation, said to take place in vinegar not so fortified. It is, however, doubted whether the addition is really necessary; and, indeed, on the Continent it is not allowed, and is justly stigmatised as positively injurious to the consumer.

Analysis.—A known quantity of the

vinegar is distilled at a low heat, the distillate being well condensed, and kept cool. When all the acetic acid has distilled over, sulphuric and tartaric acids may be tested for and estimated in the remainder in the retort, as follows :—

The total acidity is determined by a standard solution of caustic soda (*see* chapter on VOLUMETRIC ANALYSIS), and the sulphuric acid then precipitated separately with a solution of chloride of barium and nitric acid, and estimated as sulphate of barium. (*See* AERATED WATERS). The difference between the first and second estimation will represent the acidity due to tartaric acid. Hydrochloric acid is estimated in the distillate from the above by means of a standard solution of nitrate of silver (*see* chapter on VOLUMETRIC ANALYSIS). Its presence is indicated when the silver solution gives a white curdy precipitate with the vinegar. The extract of malt and wine vinegar should not have an empyreumatic odor, as this would be indicative of the presence of pyrolignous acid, or wood vinegar, as an adulteration. Good malt vinegar, Nos. 23 and 24, should contain about 5 p. c. of pure acetic acid, while the weaker kinds contain about 3 p. c. The percentage of acetic acid is determined by a standard solution of caustic soda. (*See* above.)

WHISKY. *See* SPIRITS.

WINE.

PROBABLE ADULTERATIONS.—Extracts of *rhatany*, *logwood*, *brazil-wood*, *elderberry*, the berries of the *virginian poke*, *purple holyoak*, *&c.*; *alum*, *glucose*, *cider*, *plain spirit*, *caramel*, *catechu*, and *water*.

In some wines that have been spoilt, either in their process of manufacture, or by their faulty preservation, acetate of lead has frequently been added, to neutralise acidity and prevent putrefactive decomposition.

Many so-called wines, especially port, consumed in Britain, contain the genuine article only in a homœopathic proportion;

the bulk of liquid being made up of glucose, cider, plain spirit, sloe-juice, and other coloring materials. Alum is frequently found in highly-coloured wines, added for the purpose of brightening the tint, and as much as two grammes per bottle have been discovered by M. Barbier while experimenting on some wines at Lyons.

ANALYSIS.—The processes for the detection of foreign and spurious coloring materials in wines are as yet in their infancy, and the results obtained in their application are, at the most, only indicative in their characteristics. It would be unwise and rash to denounce as adulterated a wine suspected or indicated to be so, after either one chemical or optical examination only. For the purpose, therefore, of distinguishing between the genuine coloring matter of the wine and the spurious, it will be necessary to perform a series of experiments, each confirmatory of the other.

According to Chevallier, caustic potash

does not cause a precipitate in genuine port or other red wines, but the color changes from red to bottle-green, and, after some time, to a brownish green or black. When an artificial coloring matter has been employed, the colors produced on the addition of the reagent are as follows :—

When wine has been colored with—	Color produced by potash—
Elder-berries	purple
Logwood	reddish purple
Brazil wood	red
Beetroot	red
Litmus or orchil	light violet

But none of these substances yield the dark greenish hue assumed by genuine red wine under the same treatment.

Esenbach's method consists in treating the wines with alum and carbonate of potassium.

Two solutions are made, one of alum, 1 to 11, and the other of carbonate of potassium, 1 to 8, of water. The process is conducted as follows :—The wine is mixed with its own volume of the alum solution, and carbonate of potassium is slowly poured into it, care being taken not to add an excess. The alumina is precipitated, forming a lake with the coloring matter present, which, in the case of a pure wine, is of a dingy grey color, soluble in new wines in excess of the reagent.

Wines colored with—	Give a—
Petals of red poppy .	greyish brown precipitate, becoming black with excess of alkali
Privet berries . . .	precipitate purplish brown
Myrtle ,, . . .	,, greyish blue
Elder ,, . . .	,, purple
Brazil wood . . .	,, violet grey
Logwood	,, pink.

From this table we may assume that wines which, when treated with carbonate of potassium and alum, yield either blue, violet, or red precipitates, may be suspected of being artificially colored.

Dr. Muter gives, in the *Food Journal*, vol. ii. no. 13, a mechanical process for the detection of elderberry in port wine. The process is based upon the fact that a fully fermented and unadulterated wine will float for a time on the surface of water; but when it has been falsified by the addition of elderberry *jerupiga*, or brandy, it will sink at once to the bottom. The test, which the doctor affirms has long been found to be reliable, is performed in a two-bulb glass vessel, shaped like a sand-glass, and open at the top. To use this instrument, the lower globe is filled with pure water, and the wine to be examined is then gently poured into the top, and the whole allowed to rest for a few minutes. Pure port will remain for a considerable period without displacing the water, but an adulterated wine falls rapidly and displaces the water in the lower globe.

M. Lapeyrière, in the *Journal de Pharmacie et de Chimie*, April 1870, proposes to discriminate between genuine wine and that adulterated or colored with logwood by means of its reaction with neutral acetate of copper. In order to apply the test, it is only necessary to place strips of good filtering paper, Swedish being preferred, into an aqueous solution of neutral acetate of copper, and, after drying, to use one of these slips to test the wine suspected to be adulterated with logwood color, by dipping the paper into the wine, and on removing from that fluid, taking care to cause the adhering drop of wine to flow backwards and forwards over the paper, which is next rapidly but carefully dried. If the wine be as it naturally ought to be, the color exhibited after drying will be grey, or rose-red greyish: but if logwood be present, the tinge will be distinctly sky-blue. In the *Berichte der Deutsche Chemischen Gesellschaft zu Berlin.* MM. Cottini and Fantogini state that when 50 c. c. of the red wine to be tested are mixed with 6 c.c. of nitric acid, sp. gr. 1·412, and heated to about 90° to 95° C., it will, if artificially colored, become decolorised in five minutes, whereas pure and unadulterated wine is not so affected even after heating for the space of an hour.

A singularly interesting fact, discovered by Dr. F. Vorwerts, and described in the *Neues Jahrbuch für Pharmacie*, December, 1871, is, that in grape-wine the phosphoric acid present is combined with magnesia; while in wines manufactured from other fruits, such as British port, &c., the acid is combined with lime. The simple addition, therefore, of ammonia to the former will cause a precipitate of the well-known triple phosphate, while in the latter case the precipitate will consist of bone phosphate. The difference between these two is easily distinguishable under the microscope, the triple phosphate being crystalline, while the bone phosphate is amorphous in its structure.

Dr. Phipson, in an article on artificially colored wines (*Chemical News*, Nov. 12th, 1869), states that at Fismes and Poitiers, in France, regular establishments exist where coloring matter for wines is manufactured on a wholesale scale. The elderberry and beetroot appear to be chiefly used, but logwood, Brazil wood, &c., also claim their share of attention. He notes that when a pure wine is examined by means of the spectroscope, no distinct absorption-band is shown, but the rays of light are generally absorbed, the intensity of absorption gradually increasing towards the violet end of the spectrum. An aqueous extract of the flowers of the purple holyoak (*Althæa rosa*), containing a little alum, gives a distinct and wide absorption-band in the neighbourhood of the solar line D: and logwood and Brazil wood give similar bands when treated in the same manner, with a little alum.

Sorby, in "The Technical Application of the Spectrum Microscope" (*Chemical News*, vol. xx., p. 305), gives the following directions for the detection of the admixture of foreign coloring bodies in wines:—

"In order to detect logwood or Brazil wood, a small quantity of the wine should be agitated in a test-tube with an equal volume of ether, which rises to the surface in an almost colorless state if the wine be pure, but is tinged with a more or less strong yellow when either of the above-named substances is present. The ethereal solution should be transferred to a small evaporating dish by means of a pipette, and a fresh quantity of ether agitated with the wine and added to the other. The most useful kind of pipette for this and similar purposes is one with a small vulcanized india-rubber top, so arranged that, after having been compressed, it may, by its own elastic force, draw up the liquid.

"After evaporating the solution to dryness, a small quantity of the color should be dissolved in water in an experiment cell, and treated with bicarbonate of ammonia. In both cases this develops a single very distinct absorption-band in the green, that characteristic of logwood being situated at $4\frac{3}{8}$ of my scale, whilst that of Brazil wood is farther from the red end, at $5\frac{1}{4}$; and the solution is strongly fluorescent, of a peculiar orange color. These spectra are so characteristic, and can be so easily compared with those of the substances themselves, that an extremely minute quantity of either could be detected with certainty.

"The color of rhatany root does not give any well-marked band in an aqueous solution, either acid or alkaline; but when dissolved in alcohol and slightly acid, it shows a moderately distinct band between the yellow and green, at $3\frac{3}{4}$ of my scale, and a fainter at $7\frac{1}{4}$. In order to detect this substance the wine should, therefore, be evaporated to small bulk, and re-dissolved in strong alcohol, and after this has stood in a test-tube until the insoluble matter has been deposited, and the solution has become quite clear, the absorption-band at $3\frac{3}{4}$ may be more or less distinctly recognised, according to the amount of rhatany root present; but the natural color of the wine makes it impossible to detect a very small quantity.

"The dark crimson berries of the Virginian poke are remarkable for containing a color belonging to my group C; whereas those of nearly all fruits of that tint belong to group B. It shows two absorption-bands, which are more distinct in an alcoholic than in an aqueous solution, and are $4\frac{5}{8}$, $7\frac{5}{8}$. To detect this substance we ought, therefore, to adopt the same process as in the case of rhatany root, and endeavour to see those bands, which may sometimes be made more distinct by adding a little water and sulphite of soda."

The amount of alcohol in wine should be determined by the methods under the heading SPIRITS.

Ports	yield from .	16·62	to 23	per cent. by volume
Sherries	,, .	16	,, 25	,,
Clarets	,, .	7	,, 13	,,
White French wines	,, .	11	,, 19	,,
Champagnes	,, .	6	,, 13	,,
Rhine wines	,, .	6	,, 16	,,

For the detection of cider or perry, the wine should be evaporated, when the peculiar smell of the liquids will become evident.

Alum is detected as in bread. The wine is evaporated to dryness, the ash incinerated, and the analysis proceeded with as directed under that heading.

Lead is precipitated by sulphuretted hydrogen. The wines containing it are mostly light in color (sherry), and the precipitate is thus easily visible. Should the wine, however, be dark, it must first be decolorised by agitation and filtration through bone charcoal.

VOLUMETRIC SOLUTIONS

REQUIRED IN THE FOREGOING EXAMINATIONS.

I. Standard Acid.

Sixty-three grammes of re-crystallized oxalic acid are dissolved in 1 litre of distilled water at a temperature of 15° C. (60° F.)

1 c. c. of this solution, containing ·063 of acid, is equivalent or will perfectly saturate ·053 of carbonate of sodium $Na_2 CO_3$, ·017 of ammonia NH_3, or ·04 grammes of caustic soda Na HO. The direct application of this solution to the estimation of an alkali has not been treated of in these pages, and the only use it is here proposed to put it to is in the manufacture of the more important solution, that of caustic alkali. It may, however, occur that the analyst has

occasion to use the standard acid for other purposes. When this is the case he will remember that the process is conducted in a precisely similar manner to that we are about to describe under the next heading.

II. SODIUM HYDRATE.

About 42 grammes of pure hydrate of sodium (caustic soda) free from carbonate are taken and dissolved roughly in a litre of water, and the solution filtered through a funnel, the shank of which is stopped with a plug of asbestos; 25 c. c. of the filtrate are then poured into a beaker capable of holding at least one half a litre of fluid, and a few drops of a neutral solution of litmus are added.

A Mohr's burette, graduated to 50 c. c. (those provided with a glass stop-cock are the best), is now filled with the standard oxalic acid, and the level of the liquid accurately adjusted to the first mark on the tube. The beaker containing the soda having been brought underneath the burette, the acid is cautiously allowed to flow into it, until a time arrives when the blue color of the litmus just changes to a purple hue.

The operation must now be stopped, as the liquid is exactly neutralised. The number of cubic centimètres required to bring about this neutralisation are now read off, and a calculated amount of distilled water added to the original soda solution, in order to bring it to such a strength that it shall require 50 c. c. of standard acid to be added to a similar quantity of soda solution before the exact point of neutralisation is attained. Thus, supposing that in the first instance it required 27 c. c. of standard acid to complete the reaction on 25 c. c. of alkali, half a litre of the soda solution would require the addition of 40 c. c. of distilled water to bring it to the proper strength. One litre of this adjusted solution therefore contains 40 grammes of pure hydrate of sodium, and

1 c. c. is equal to 0·063 of crystallized oxalic acid, 0·06 of glacial acetic acid, 0·192 of citric acid, 0.15 of tartaric acid, 0·04 of sulphuric anhydride, and 0·049 of sulphuric acid.

It will often be found advisable in estimating small quantities of acid, to dilute this solution to ten times its bulk previous to titration.

The standard solution of caustic soda is liable to absorb carbonic acid from the atmosphere. This does not impair its alkaline qualities, but the evolution of carbonic acid gas, during the process of titration, is inconvenient, as the liberated carbonic acid itself exercises an action on litmus.

Error in this case may, however, be obviated by boiling the solution under examination after each addition of the test, whereby carbonic acid is driven off and the litmus assumes its natural color; but the best method is to prevent the absorption of carbonic acid in the solution at all, by keeping it in a glass vessel provided with a stop-cock at the bottom where the liquid may be drawn off when required, air being let into the top of the vessel through a vent to which a **U** tube filled with lumps of caustic soda has been fitted.

Example.—Supposing it is desired to estimate the total acidity in a sample of white vinegar: 50 c. c. of the vinegar are accurately measured off and put in a beaker, and sufficient tincture of litmus to give a distinct red is added to it. The test solution is then dropped in from the burette, the vinegar being constantly stirred after each addition, until the red color changes to a purple.

Now 1 c. c. of the alkaline solution is equivalent to ·06 of hydrated acetic acid, therefore, supposing that 24 c. c. have been used to neutralise the 50 c. c. of vinegar, the latter will contain ·06 × 24 = 1·44 or 2·88 p. c.

III. NITRATE OF SILVER.

A decinormal solution of nitrate of silver is prepared by carefully weighing out 17 grammes of the pure, dry, re-crystallized salt (that used by photographers is the best), and dissolving in a litre of distilled water at the temperature of 15° C. (60 F.); 1 c. c. of this solution is equivalent to 0·00585 of chloride of sodium Na Cl, or 0·00365 of dry hydrochloric acid, HCl. A strong solution of neutral chromate of potassium is also prepared, to act as an indicator of the end of the reaction between the silver solution and that of the material under examination. The operation of estimating chlorine is thus conducted:—A convenient weighed or measured quantity of the material, if not already in solution, should be dissolved in distilled water, and have sufficient solution of neutral chromate added to it to give it a decided yellow color. The beaker is then brought underneath the burette and the silver solution is gradually dropped in until a reddish color becomes apparent, which does not disappear on stirring. The formation of this color is indicative of the end of the operation. The quantity of silver solution is then read off, and the amount of substance sought calculated. Thus, supposing we have used 11 c. c. of silver solution to obtain the red tint, we find by multiplying 0·00365 by 11 that 0·04015 grammes is the amount of hydrochloric acid in that portion of the fluid we have titrated. The *rationale* of the process is this:—Nitrate of silver causes a white insoluble precipitate with solutions of chlorides, and a dark red one with solutions of chromates; silver has, however, more affinity for chlorine than for chromic acid, and thus all the chlorine in the liquid must be first combined with silver before the chromate can take up any. Hence, directly we perceive the permanent formation of the red chromate of silver we conclude that sufficient silver has been added to combine with the whole of the dissolved chlorine in the liquid, and that any more silver solution dropped in would be in excess. The operator, therefore, should stop at the first lasting tinge of red, and not continue to add the test solution until a full red is developed, or the result will be too high. It is important that the solution to be tested should be used as dilute as possible, as the extreme turbidity of the water due to the precipitation of chloride sometimes masks the red color when it is produced. The chromate should itself be previously tested as to its purity and freedom from chlorides.

IV. PERMANGANATE OF POTASSIUM.

About 10 grammes of permanganate of potassium are dissolved in one litre of water.

A piece of pianoforte wire, about 0·2 grammes, is then accurately weighed and dissolved in a small flask in 20 c. c. of dilute sulphuric acid, at a gentle heat. When the iron is dissolved, the solution is transferred to a beaker, and made to about 250 c.c. in bulk. The permanganate solution is then run in from a burette, the fluid being constantly stirred. The iron becomes gradually oxidized at the expense of the permanganate and the solution acquires a yellow tint. Directly, however, that oxidation is complete, the pink color of the test replaces the yellow in the beaker, and the operation is at an end. The amount of permanganate is then read off, and the value of the solution marked on the bottle, thus: —supposing that 14·5 c. c. of permanganate are required to oxidize the 0·2 grammes of iron operated on, we find on calculation that 1 c. c. of the same equals $\frac{\cdot 2}{14\cdot 5}$ = ·001379 of iron.

The permanganate solution is liable to deteriorate by keeping; it is advisable, therefore, occasionally to re-standardize it in the above manner.

In preparing solutions of iron for estimation by this method, the material should always be dissolved in sulphuric acid, hydrochloric acid vitiating the accuracy of the test. A large excess of acid is beneficial. Dilute solutions will be found to work better than those that are more concentrated.

The method of applying this test to the estimation of iron may be thus described. From ·5 to 1 gramme, according to the amount of iron presumed to be present, is weighed out and dissolved, by the aid of a gentle heat, in sulphuric acid. Should the material be insoluble in that acid, it must be previously fused in a platinum crucible with three times its weight of bisulphate of potassium, to render it soluble. A rod of pure zinc is now placed in the solution in order to reduce the persulphate of iron to the protosulphate. The action of the zinc is allowed to continue as long as a drop of the solution, taken out on the end of a glass rod, gives a red coloration with a similar drop of a solution of sulphocyanide of potassium. When the reduction is complete, the zinc may be taken out, the solution largely diluted with water, and tested with the permanganate, the operation being stopped directly the slightest tinge of pink becomes perceptible.

V. STANDARD COPPER SOLUTION FOR THE ESTIMATION OF SUGAR.

34·639 grammes of crystallized sulphate of copper are dissolved in 200 c. c. of distilled water; 173 grammes of Rochelle salt (tartrate of sodium and potassium) are dissolved in another vessel with 600 c.c. of a solution of caustic soda (1 in 10). The two solutions are then mixed, and the bulk diluted to 1 litre at 15° C. (60° F.): this solution should be kept in a cool, dark place, in a well-stoppered bottle, but, in spite of these precautions, it soon deteriorates.

The analysis is thus performed:—10 c.c. of the copper solution are put into a flask—40 c. c. of distilled water are added, and the mixture is then heated to gentle boiling. A burette is filled with the sugar solution, and the latter is slowly added to the copper solution, which should be kept boiling. The addition of sugar is continued until, on allowing the precipitate to settle, and tilting the flask, no greenish tint is observable in the clear supernatant fluid. If the experiment appears to be finished, it is advisable to pour off some of the clear fluid, and test it with the sugar solution. It should now give *no* precipitate. The amount of the sugar solution required to react completely with 10 c. c. of the copper solution is then noted, and contains either ·05 grammes of grape or fruit-sugar, or ·0475 grammes of cane or milk-sugar. With these data it is easy to calculate the percentage.

Cane and milk-sugar must be boiled for half an hour with dilute sulphuric acid, in order to convert them into grape-sugar, prior to estimation. Grape or starch-sugar is used without this preparation; but the solutions should be in all cases very dilute.

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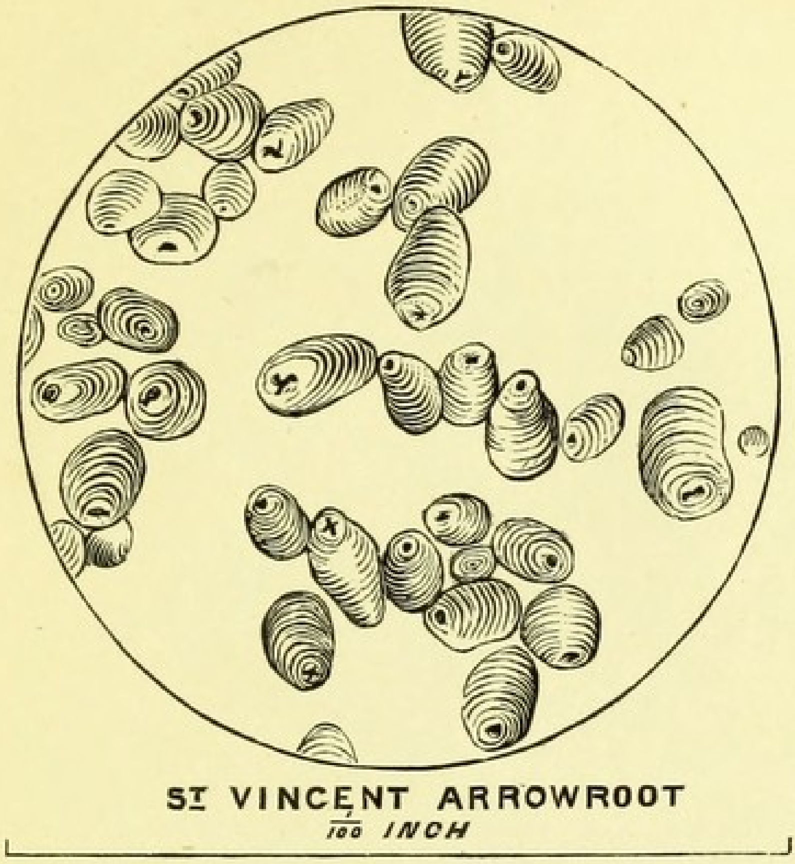
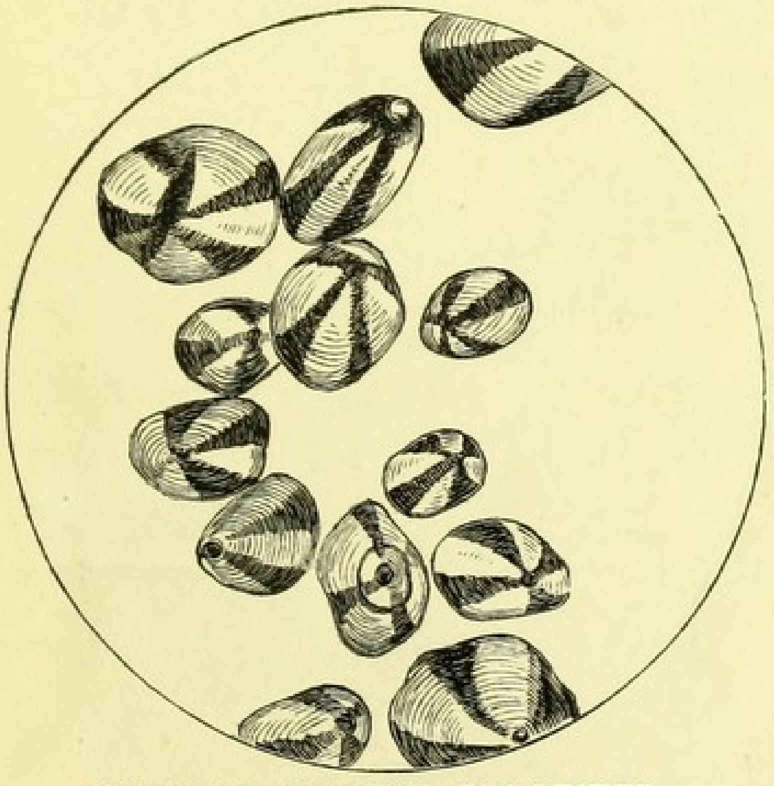
Fig. 1.



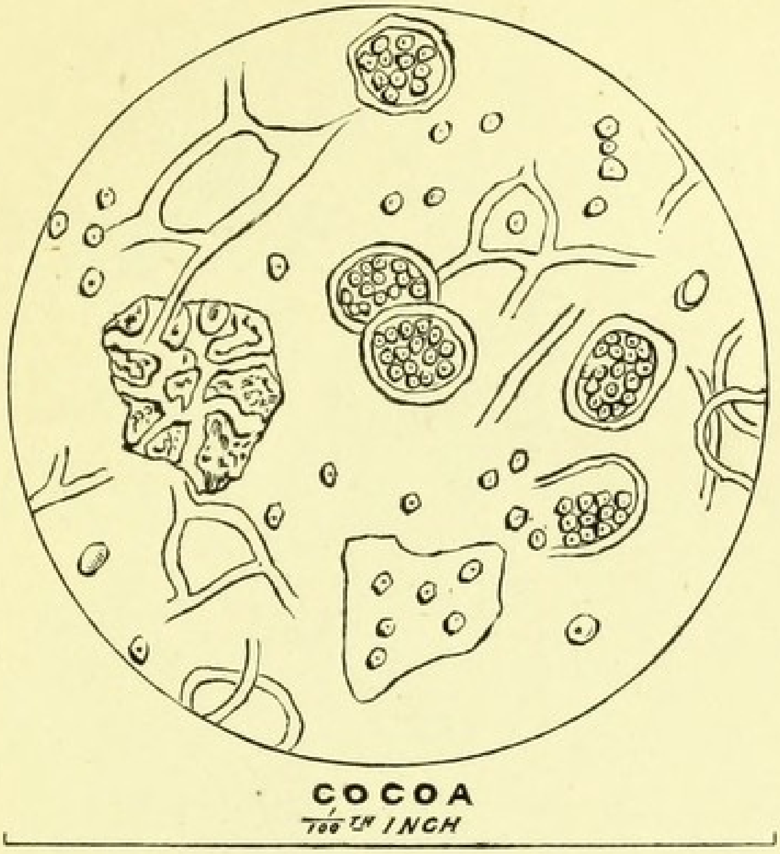
ST VINCENT ARROWROOT



POTATOE STARCH POLARIZED

Fig. 2.

Fig. 3.



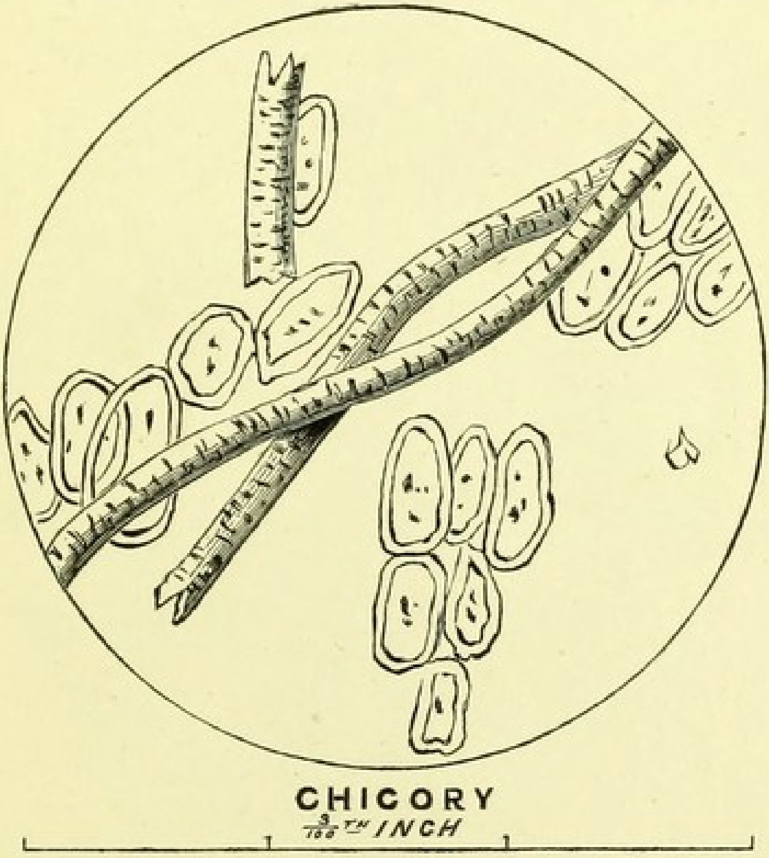
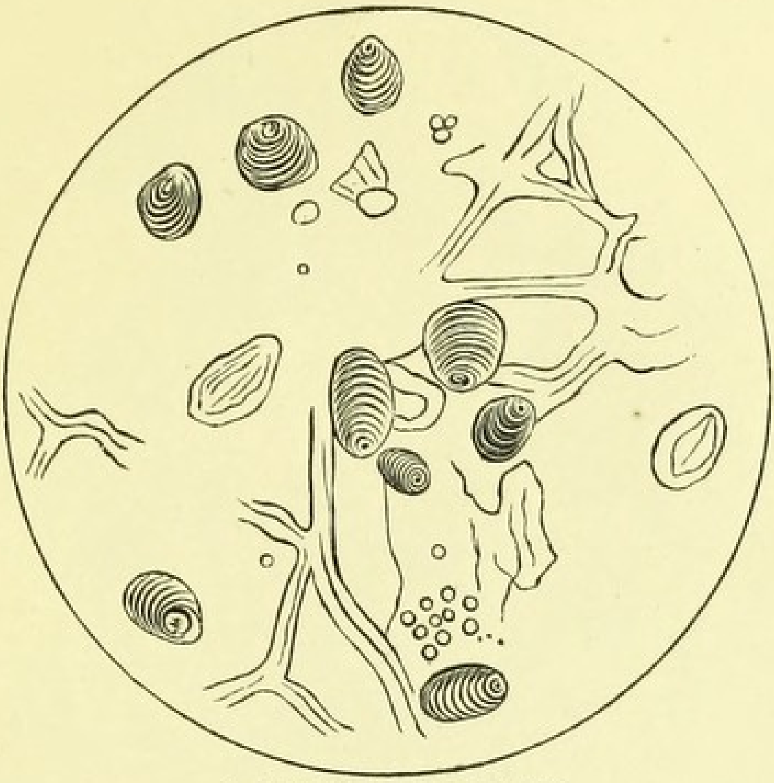


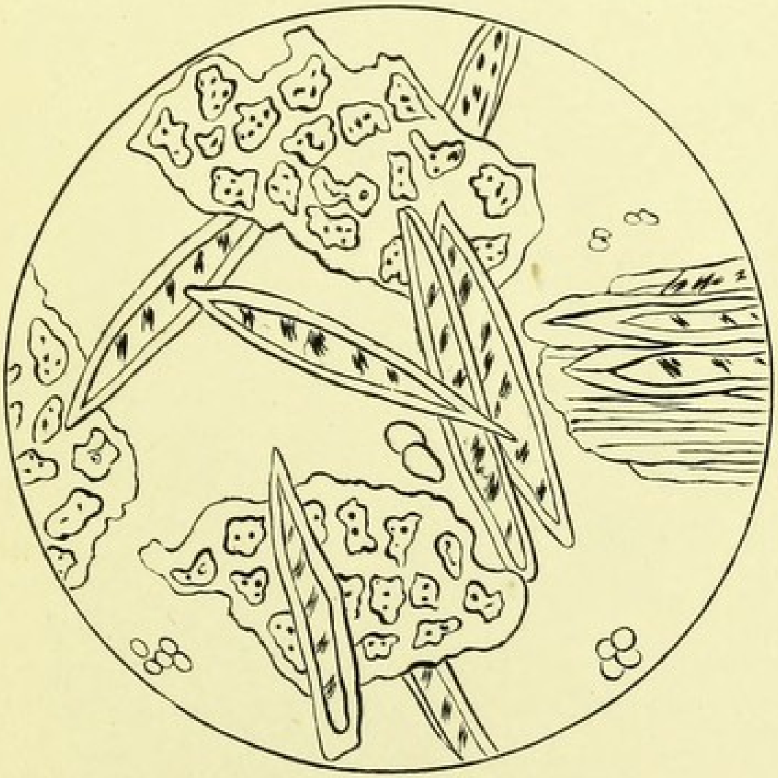
Fig. 4.

Fig. 5.



LENTIL FLOUR

$\frac{1}{100}$TH INCH

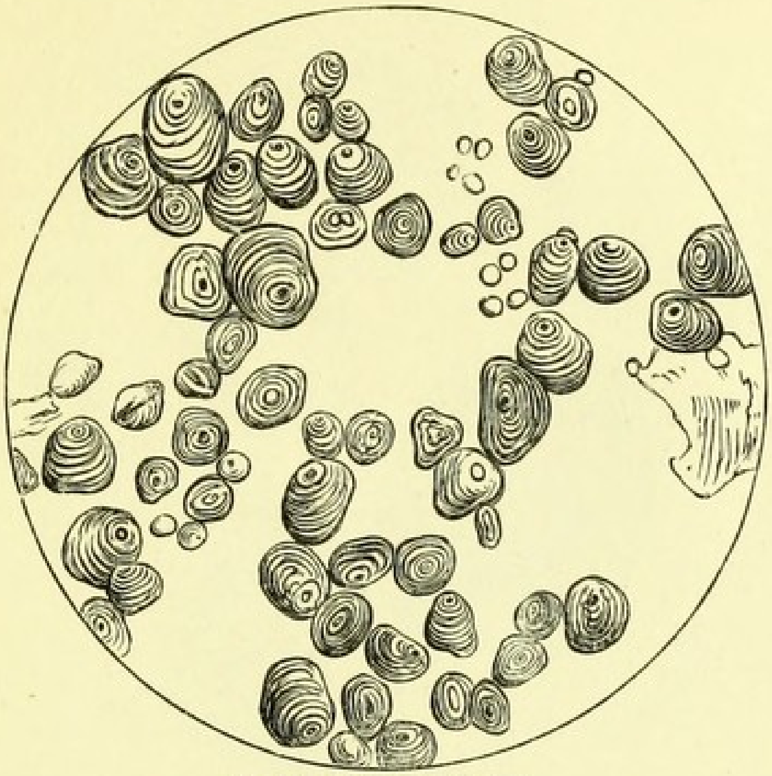


COFFEE

$\frac{3}{100}$TH INCH

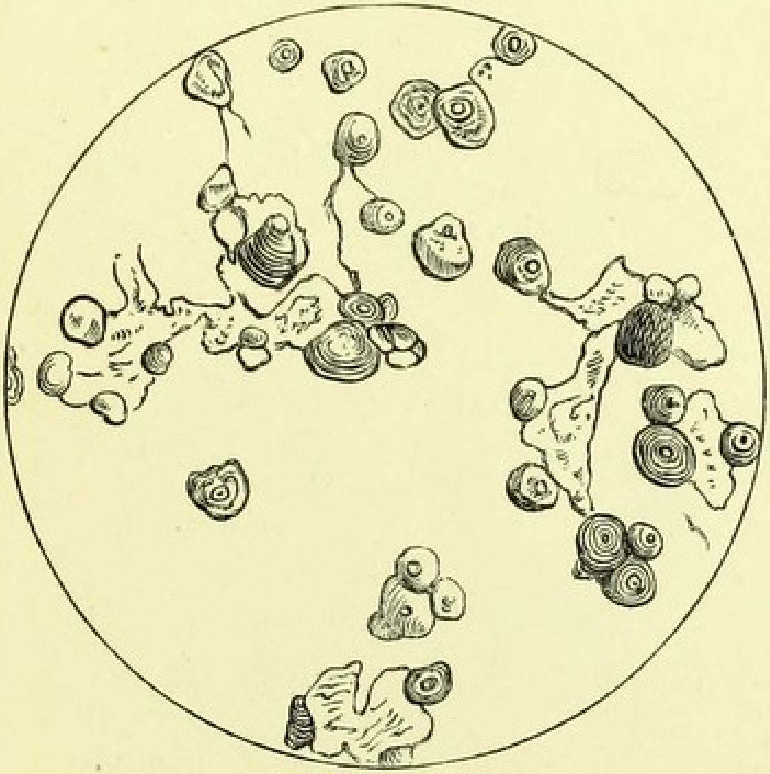
Fig. 6.

Fig. 7.



WHEAT STARCH

$\frac{1}{100}$ INCH

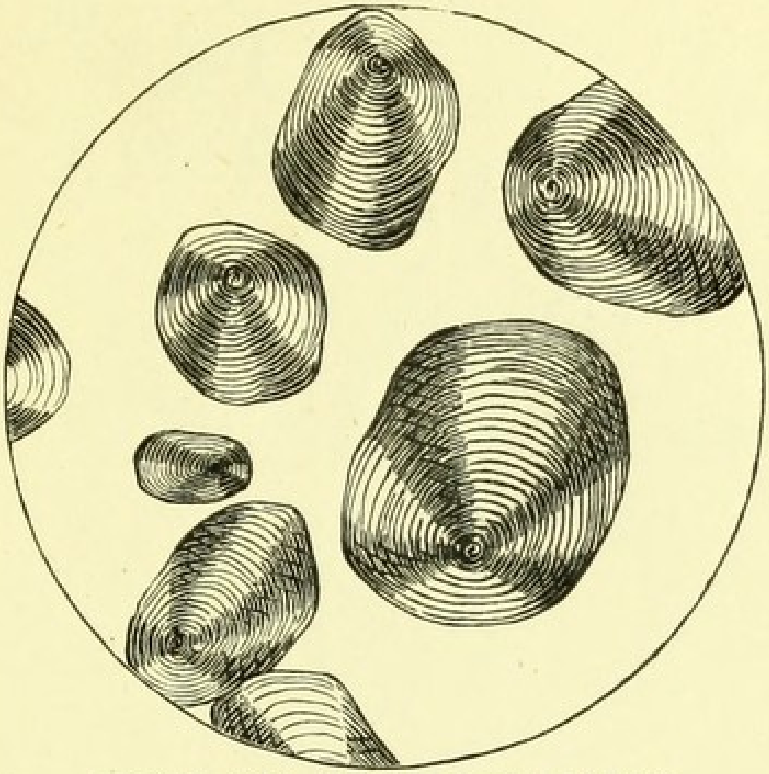


TAPIOCA

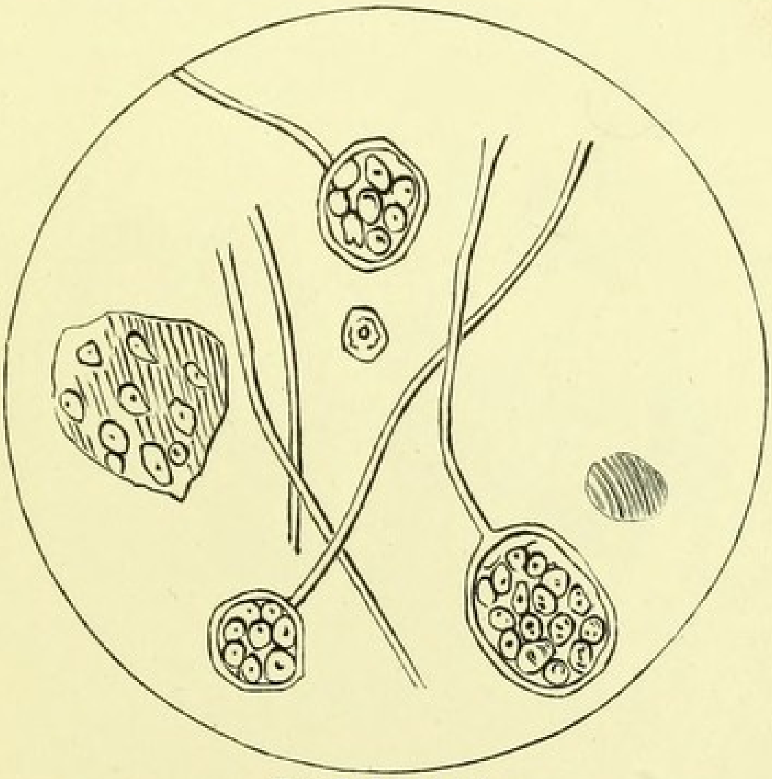
$\frac{1}{100}$ INCH

Fig. 8.

Fig. 9.



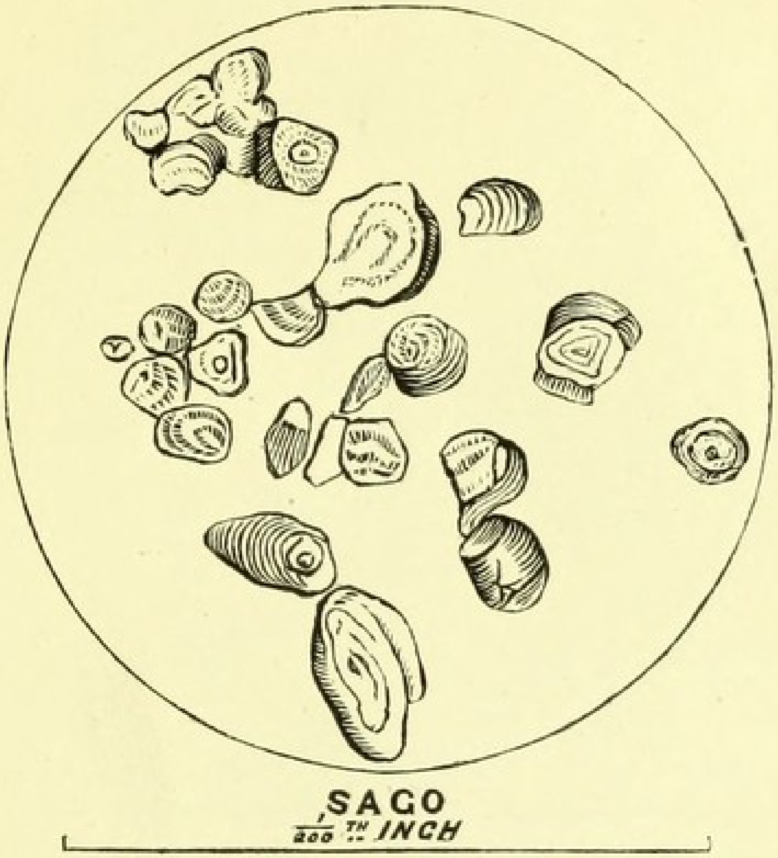
TOUS LES MOIS, POLARIZED



PUCCINIA

Fig. 10.

Fig. 11.



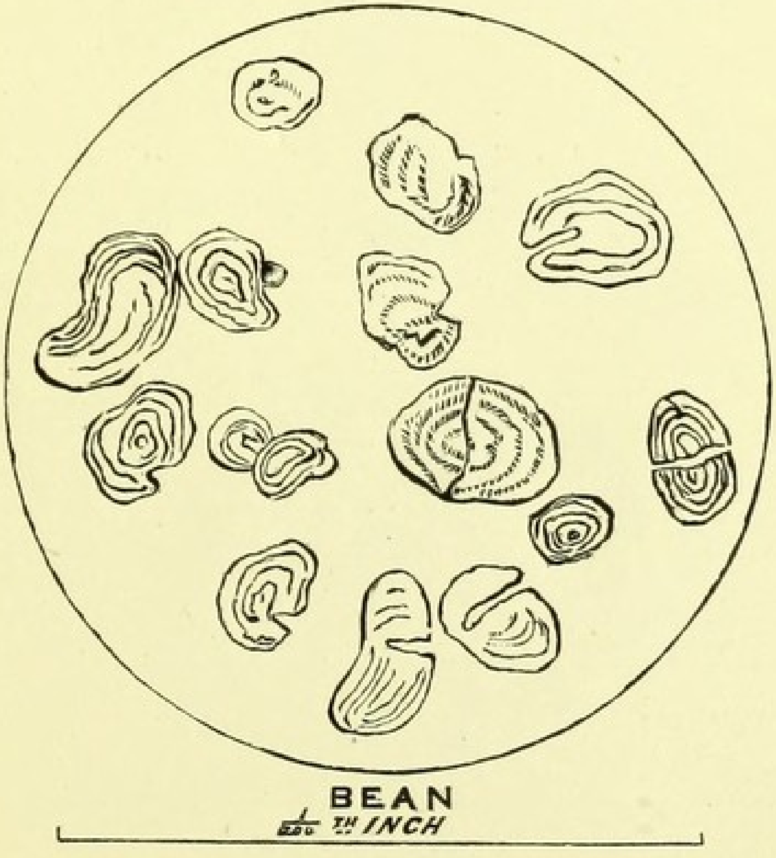
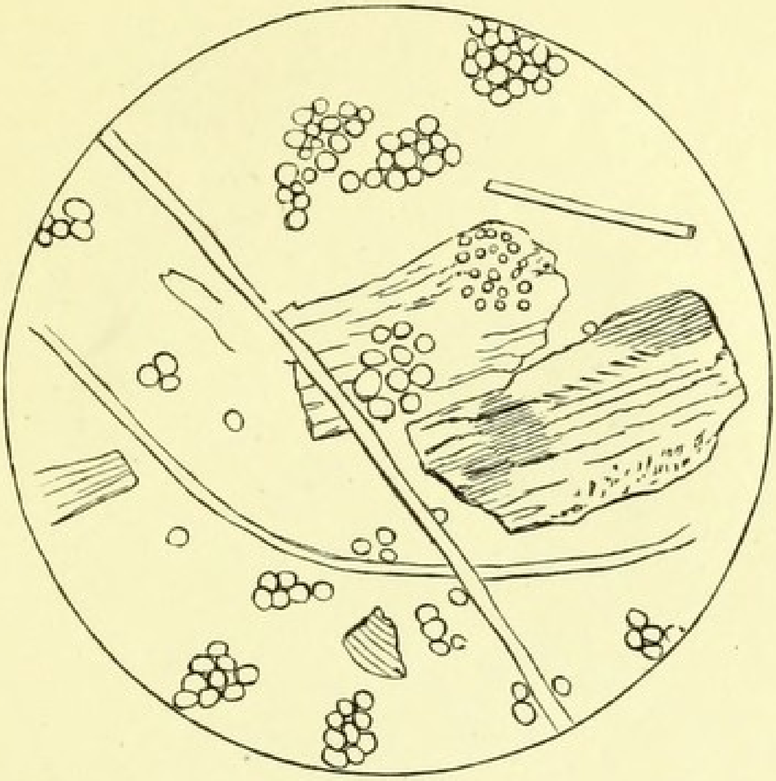


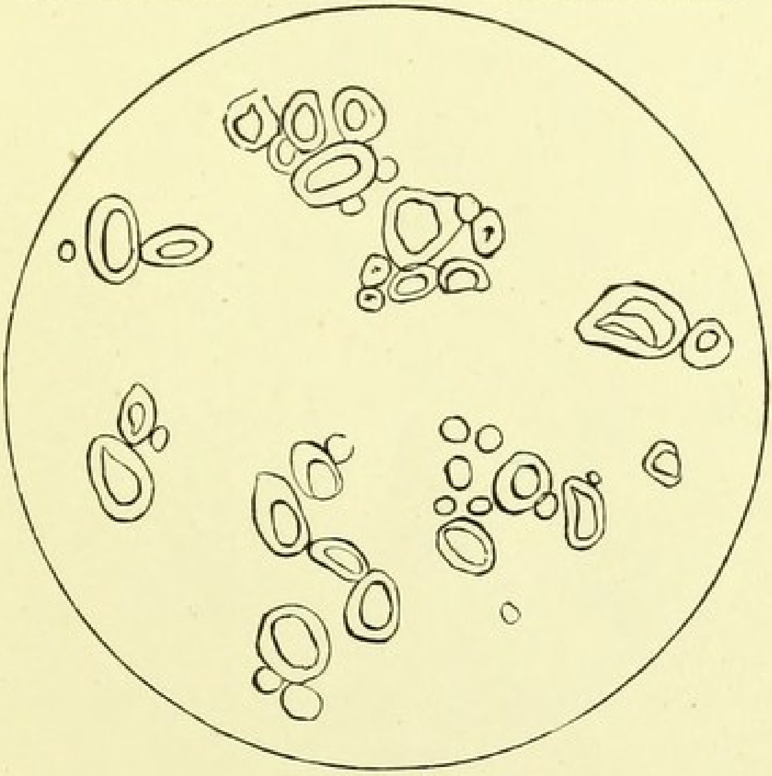
Fig. 12.

Fig. 13.



OATMEAL

$\frac{3}{400}^{\text{THS}}$ INCH

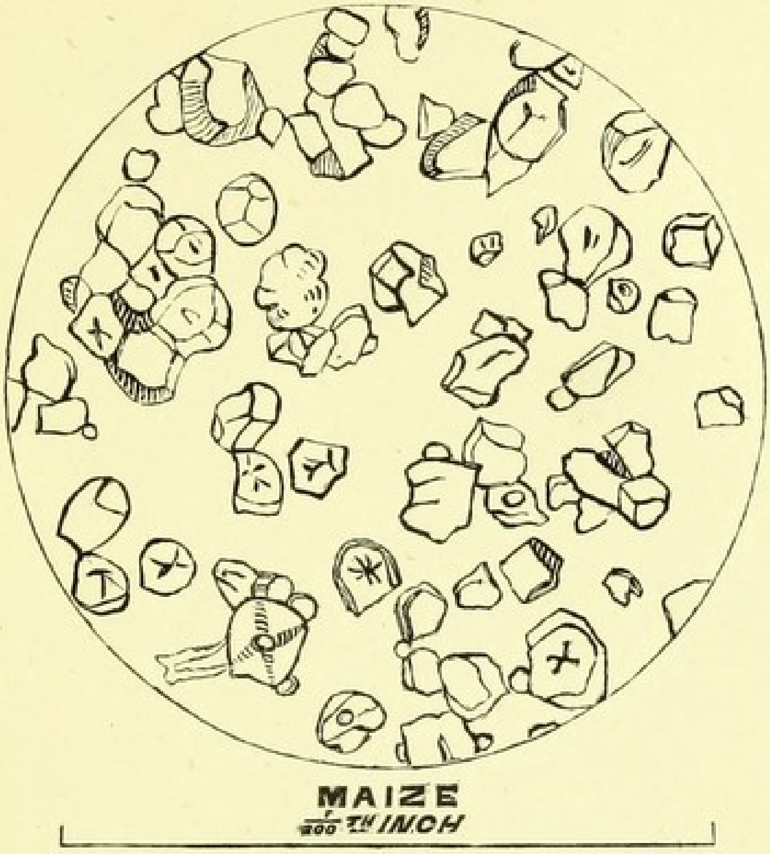


CHESTNUT

$\frac{1}{200}^{\text{TH}}$ INCH

Fig. 14.

Fig. 15.



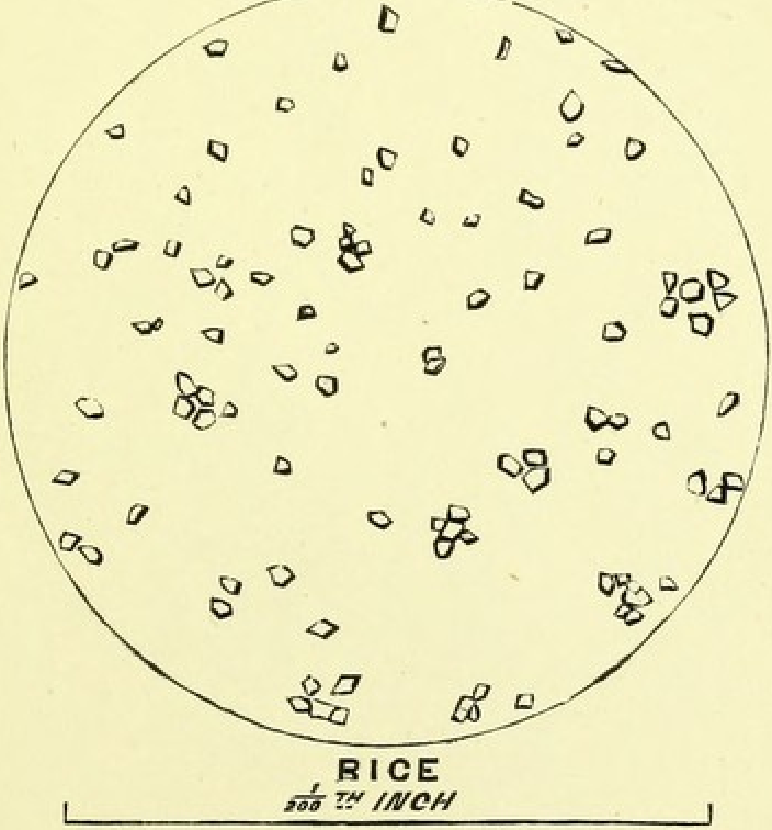
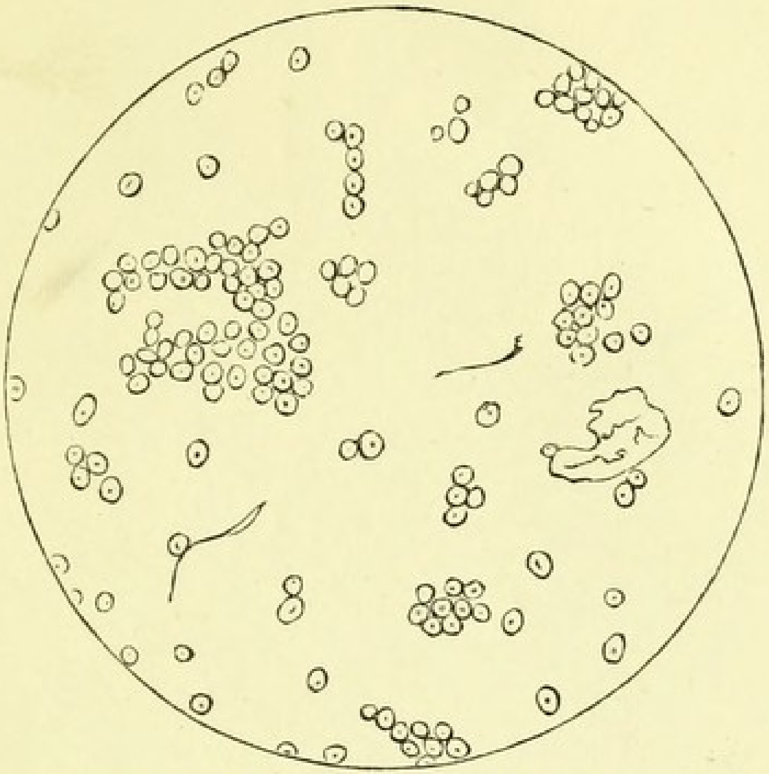


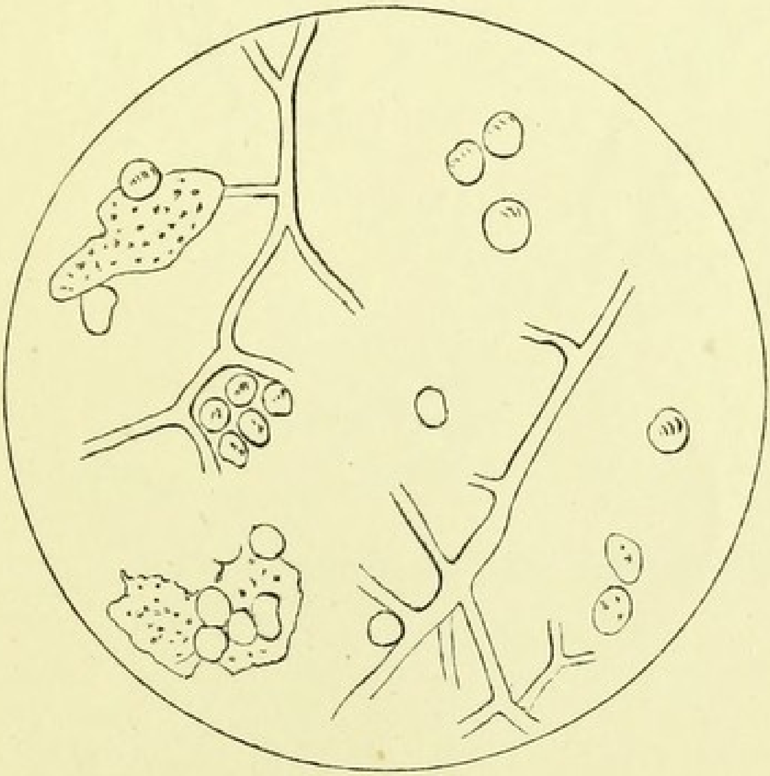
Fig. 16.

Fig. 17.



PEA FLOUR, DRY.

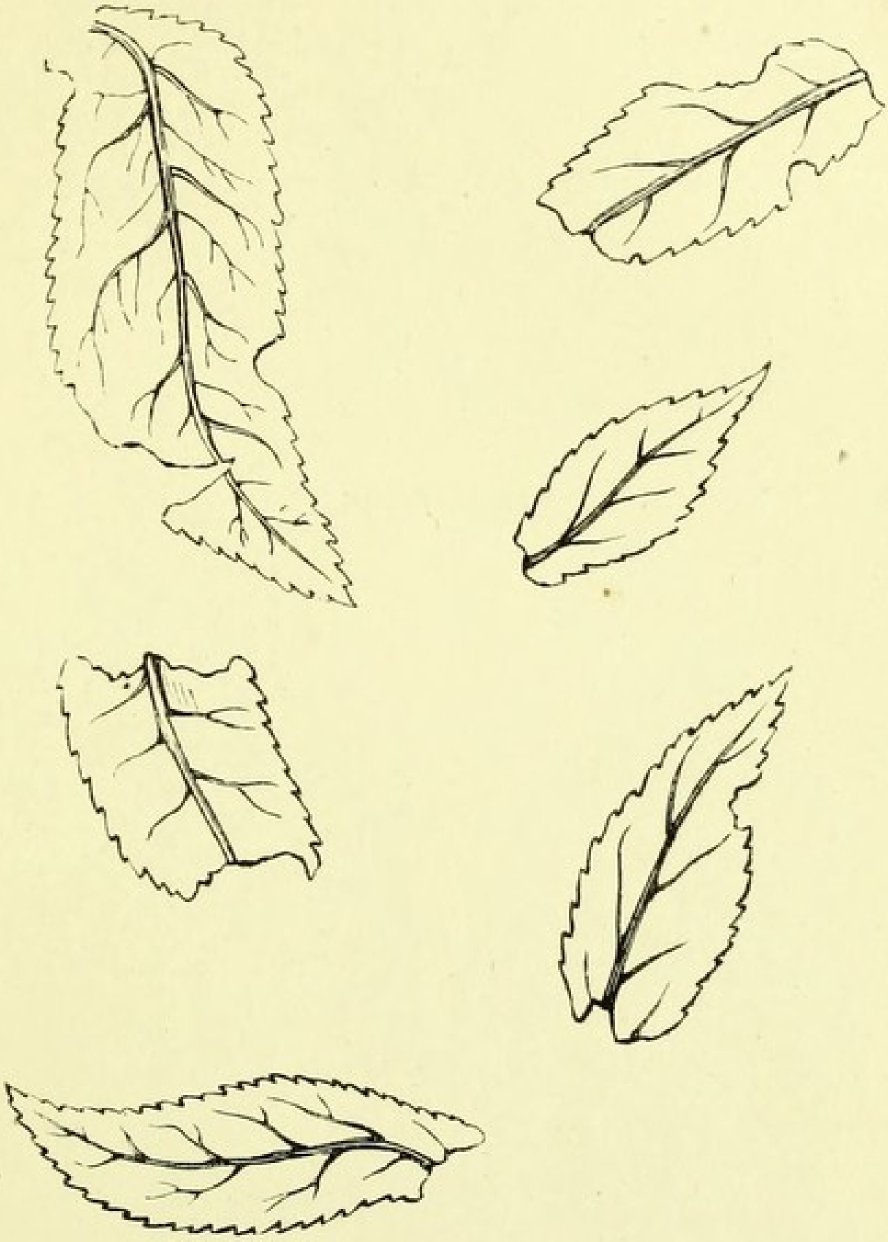
$\frac{1}{100}$ TH INCH



BARLEY.

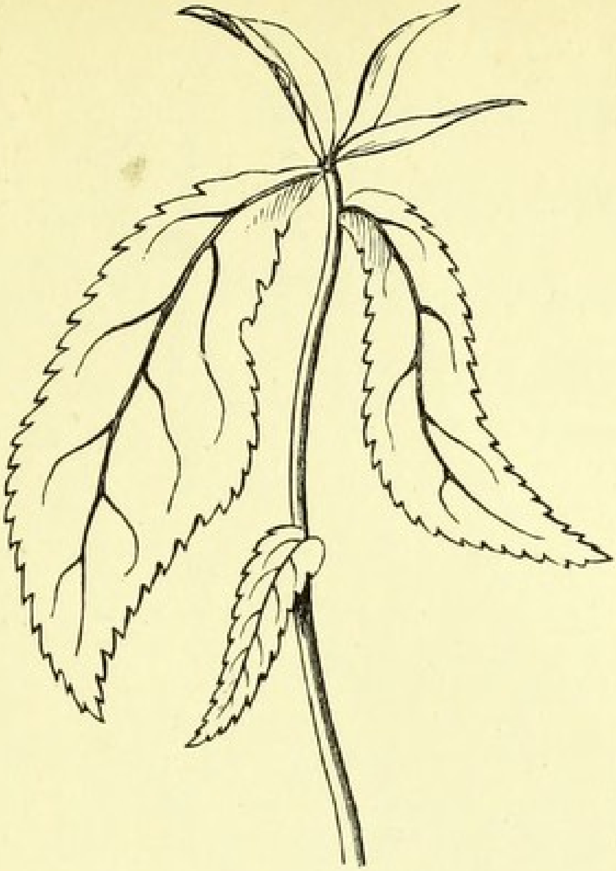
$\frac{1}{100}$ TH INCH

Fig. 18.

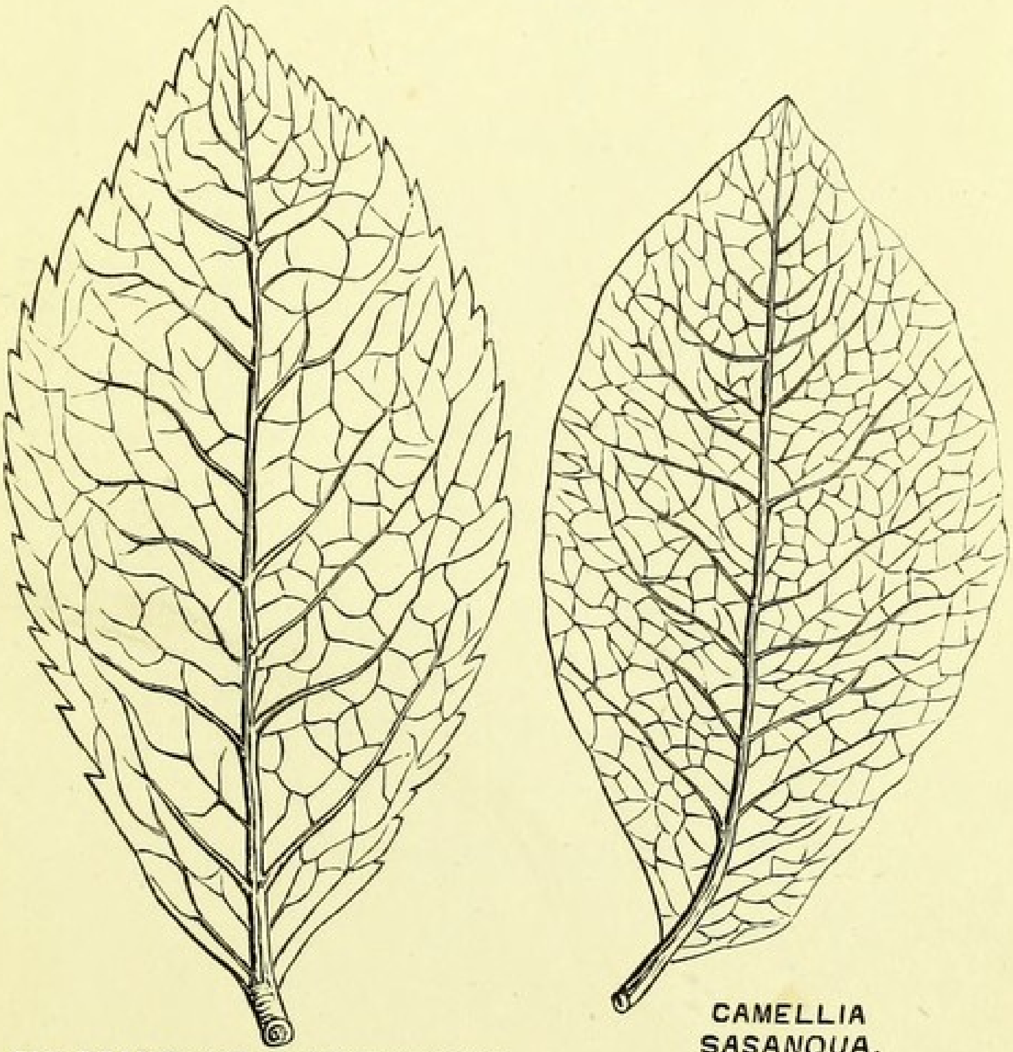


TEA LEAVES AFTER INFUSION.

Fig. 19.



TEA PLANT

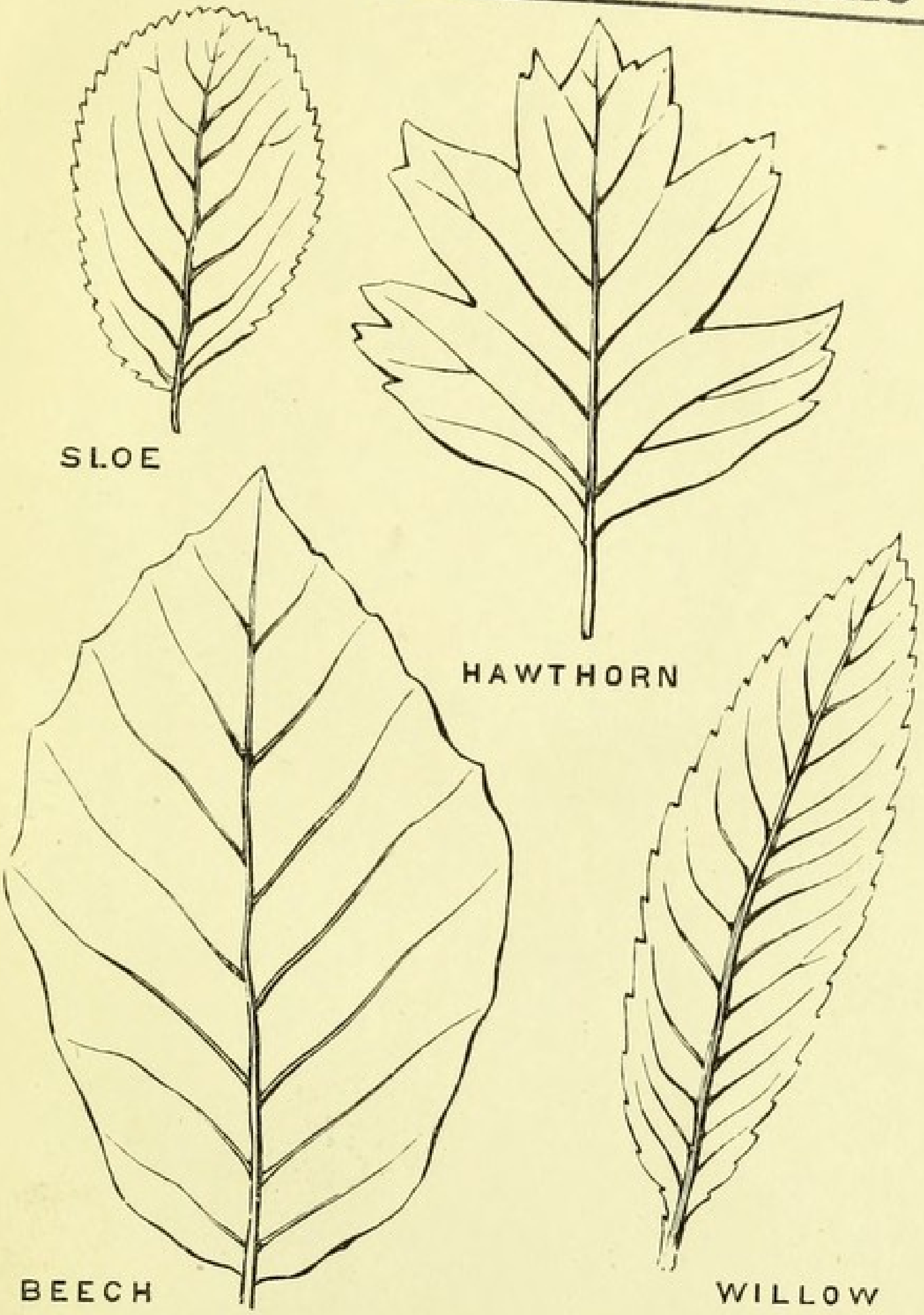


CAMELLIA SASANQUA.

CHLORANTHUS INCONSPICUUS

CHINESE ADULTERATIONS *DRAWN FROM HASSALL*

Fig. 22.



ENGLISH ADULTERATIONS.

Fig. 21.