THE PRINCIPAL STARCHES USED AS FOOD

W. GRIFFITHS

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STARCH FROM FRUIT OF POTATO,

× 160 POLARISED.

From preparation mounted by the late Mr. Vance Smith, of Carmarthen.

THE PRINCIPAL STARCHES USED AS FOOD,

ILLUSTRATED BY PHOTO-MICROGRAPHY.

WITH A SHORT DESCRIPTION OF THEIR ORIGIN AND CHARACTERS.

BY

W. GRIFFITHS.

1892.

CIRENCESTER:
BAILY & SON, MARKET PLACE.

To

WILLIAM THOMAS SUFFOLK, Esq., F.R.M.S.,

this Collection of Photo-micrographs is dedicated as an imperfect expression of appreciation of the valuable assistance given to the author in his Microscopical Studies, extending over a period of thirty years.

PREFACE.

In placing this little work before Analysts and others interested in food products, the author would like to acknowledge the valuable assistance he has received from Professor Kinch, of the Royal Agricultural College, Cirencester, through whose instrumentality he has been able to obtain some authentic specimens of Starch herein illustrated, which, in the ordinary course, it would be difficult to obtain. The value of the carbo-hydrate, starch, as a heat-giving food has been so ably described by Professor A. H. Church, in his work on "Food," published in connection with the Food Department of the Bethnal Green Museum, that any lengthened notice on that part of the subject is unnecessary.

The object of the author in publishing these Photo-micrographs is to facilitate the identification of Starch when used either for purposes of substitution or adulteration. Its use for diluting mustard and similar condiments is well known, and any means by which its fraudulent use can be detected must necessarily prove useful, especially when it enables the analyst, not only to detect Starch, but also to trace its origin to the plant from which it is derived. It is not possible, by chemical means, to discriminate between the Starch of one plant and that of another, but in most cases

the microscope is a reliable guide, often enabling us to refer the Starch, not only to the natural order of the plant producing it, but also to the genus and species.

The chemistry of Starch, its relation to chlorophyll, its method of growth, and the part it plays in vegetable nutrition, are dealt with in most works on Vegetable Histology and Physiology, and any one requiring further information on this part of the subject will find it exhaustively treated in SACH'S "Text Book of Botany," and more concisely in THOME'S "Structural Botany." Its physical structure has been a subject of much discussion among Botanists, and there still appears to be room for further investigation.

The theory of its formation in layers round a central point called the *hilum*, thus giving rise to the concentric lines, has given way to the belief that it is formed by a process of intussusseption, similar to that of the thickening process of the cell wall, and that the markings are due to the unequal distribution of water, thus producing the appearance of layers. The reason given by THOME for this hypothesis is that perfectly dry Starch grains are unstratified. But the author has a preparation of Starch from the fruit of the Potato mounted without water treatment in a solution of Gum Dammar, in which the markings are distinctly visible.

Anyone wishing further to investigate this matter will find an excellent Starch for experiment in the pulpy part of the nearly ripe fruit of the Potato, an illustra-

tion of which is given in the frontispiece, and another will be found on page 59.

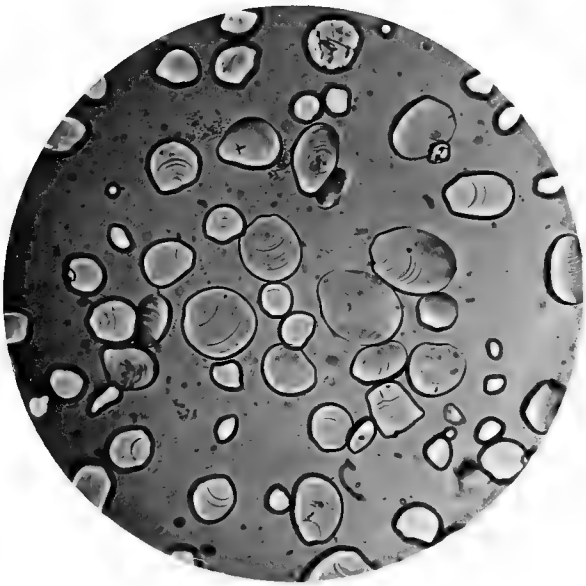
The Starches here illustrated are grouped in the Natural Orders from which they are derived, as in most instances there is a similarity in the starches obtained from plants of the same Natural Order; but as some exceptions occur, this generalization must not be absolutely depended upon as a guide to their identification. Thus it will be seen that the *Graminiæ* have two types of Starch granules, the circular and the angular; while in the *Leguminosæ* the granules are oval and rather large, except in the Ground Nut or Monkey Nut *(Arachis hypogæa)*, in which they are round and small.

A short account of the origin of the Starch is given with the illustrations, and each is magnified 160 times linear. The author has so far found that the best medium for mounting permanent preparations of Starch, and vegetable tissues containing it, for the microscope, is a mixture of one part of glycerine with seven parts of camphor water or carbolic acid water. A solid medium is much wanted on account of the decreased liability to damage, but all those so far suggested are too refractive, and nearly or completely obliterate the finer details. A series of Starches mounted in glycerine and camphor water has been in the cabinet of the Royal Microscopical Society for about 20 years, and when examined a short time ago were found to have suffered little or no deterioration.

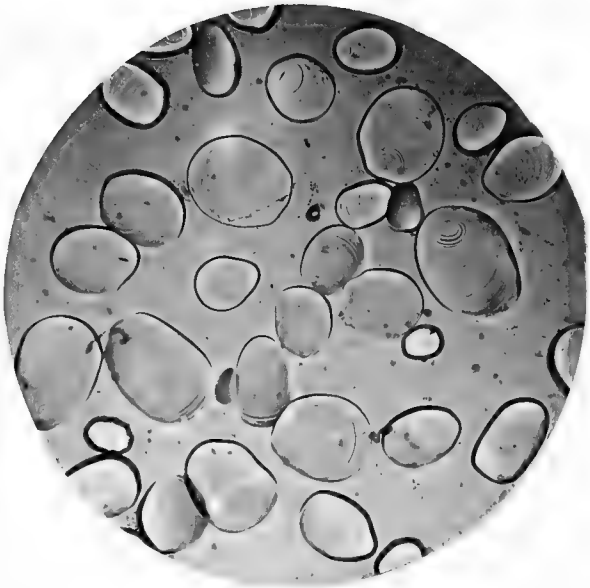
1.—CANNA INDICA.

Nat. Ord.—Marantaceæ.

The plants of this order yield most of the Arrowroots of commerce, and although closely allied to the *Zingiberaceæ*, are, as a rule, destitute of aromatic properties. They are natives of most tropical regions. The Starch of *Canna Indica* exhibits, more prominently than any other, the characters of the Starches of this order. The granules are of large size and great beauty, the concentric lines are more distinct than in *Canna edulis*, which most nearly resembles it. The hilum, both in this and "Tous le mois," is round, and in some of the granules double (two good examples of this are seen in the illustration). This double hilum also occurs in other Starches, and appears to arise from the coalescence of two young granules and is not the result of multiplication by sub-division. The Starch is obtained from the rhizome and tubers, as in others of the same natural order. The Starch from which this photograph was taken was obtained from a plant cultivated in England. The ripe seeds are known as Indian Shot, from their black colour and great hardness.



1.—CANNA INDICA.
× 160.



2.—CANNA EDULIS.
× 160.

2.—CANNA EDULIS.

NAT. ORD.—**Marantaceæ.**

The Starch of this plant is very nearly allied, in its general characters, to that of *Canna Indica;* it is quite as large, if not rather larger, than the latter, but the concentric markings are more delicate and regular. The differences are quite sufficient to render their discrimination, under the microscope, comparatively easy.

It is known in commerce as "Tous le mois," and is extensively used in this and other countries as an Arrowroot. The commercial article is possibly obtained from other species of *Canna* besides *Canna edulis.* The Starch is obtained by crushing the rhizome and tubers, mixing with water, and straining out the fibrous matter, it is then washed by agitation and subsidence, and subsequently dried.

A specimen placed in my hands some years ago, labelled Australian Arrowroot, and imported from Brisbane, consisted entirely of this Starch.

3 & 4.—BERMUDA ARROWROOT, AND ST. VINCENT OR WEST INDIAN ARROWROOT.

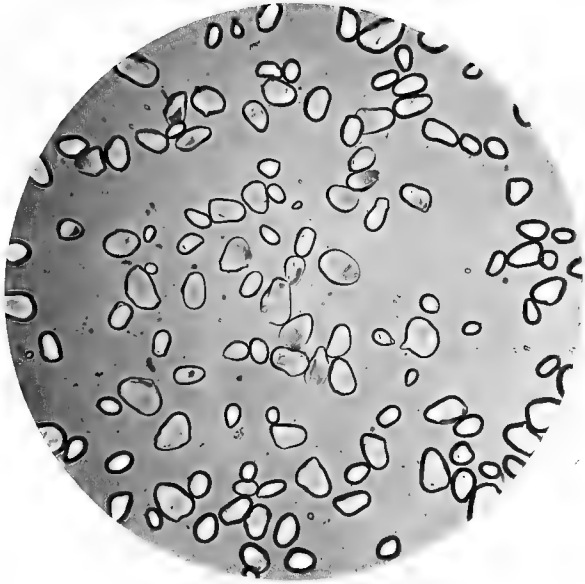
NAT. ORD.—**Marantaceæ.**

Maranta arundinacea.

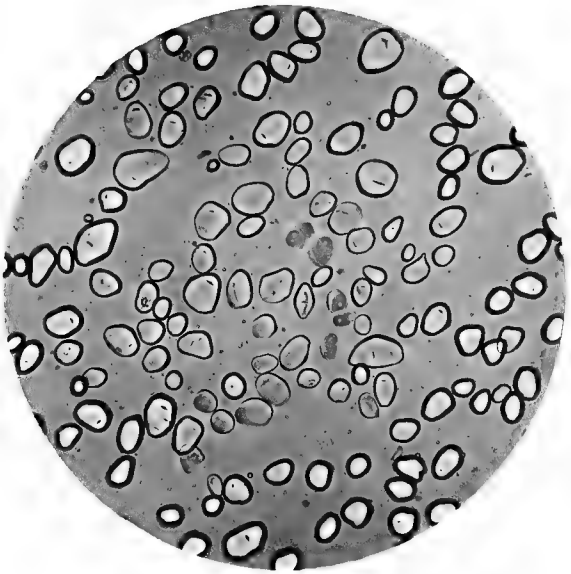
These Arrowroots, although commercially distinct, are here classed together on account of their identity of origin. Both are obtained from *Maranta arundinacea* and other allied species. The granules of Starch are much smaller than the two species previously described, the concentric lines are much less distinct, but the hilum is prominent and frequently takes the shape of a well defined slit instead of the usual round spot; small protruberances may also be frequently observed in these starches; these are very characteristic of West Indian Arrowroots.

The process of manufacture is much the same as that of "Tous le mois," viz., by straining out the fibrous matter from the crushed rhizomes and tubers when mixed with water, and then washing by agitation and subsidence.

These, and the South African Arrowroots, are more extensively used as invalid food than any other Starches, the variety known as Bermuda,



3.—BERMUDA ARROWROOT.
× 160.



4.—ST. VINCENT OR WEST INDIAN ARROWROOT.
× 160.

standing at the head of the list in point of market value, possibly on account of more than ordinary care being taken in the manufacture. They form a firm semi-translucent jelly when mixed with a small quantity of boiling water, and are palatable and digestible, although it must be remembered that these and all other Starches of themselves are by no means a perfect food, being destitute of nitrogenous or flesh-forming material. They therefore require the addition of other substances rich in albuminoids, such as meat, pulse, &c. They are, however, invaluable as heat producers, and it is in this respect that they are essential to nutrition. It may here be mentioned that the name Arrowroot is derived from the fact that the natives of the countries producing it, use the bruised rhizome as an application to wounds caused by their arrows, and the term is now applied to many other Starches used as food. The *Marantaceæ* are destitute of any other properties of economic value.

It is impossible to detect, microscopically, any difference in the varieties of West Indian Arrowroot, their sources being the same.

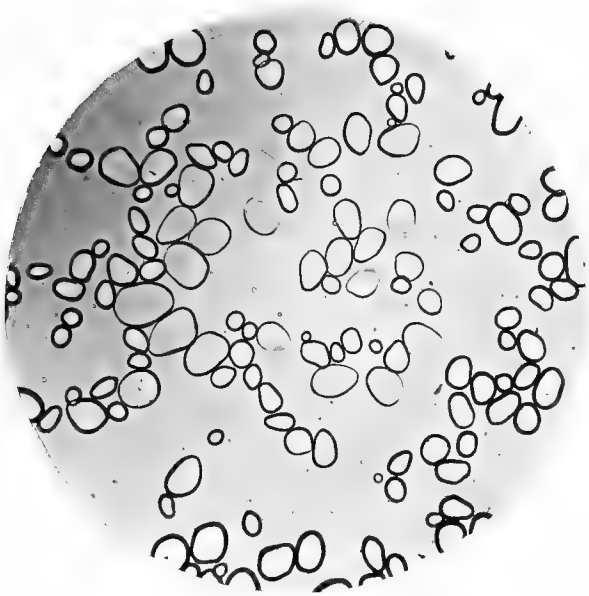
5.—NATAL ARROWROOT.

Nat. Ord.—Marantaceæ.

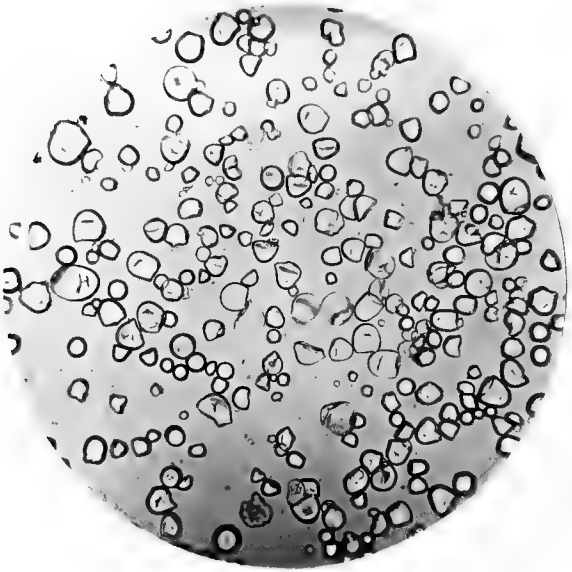
The cultivation of the various species of *Maranta*, yielding Arrowroot, has now been carried on for some years in our South African Colonies with considerable success, and Natal or African Arrowroot occupies an important commercial position, being met with quite as often as the West Indian varieties.

The cultivation of the plant has resulted in a considerable alteration in the physical characters of the Starch, so much so that one can be distinguished from the other with comparative ease. The granules more nearly approach to a circular form, the concentric lines are much more distinct, and the hilum is in most cases circular and prominent; comparatively few exhibit the slit-shaped hilum common in the West Indian kinds.

There appears to be no fundamental difference in the dietetic value of these Arrowroots, any that may exist probably arises from more or less care having been used in the process of washing and consequent absence or presence of foreign matter.



5.—NATAL ARROWROOT.
× 160.



6.—MADAGASCAR ARROWROOT.
× 160.

6.—MADAGASCAR ARROWROOT.

NAT. ORD.—**Taccaceæ.**

Tacca pinnatifida.

Some years ago a specimen, marked Madagascar Arrowroot, was placed in my hands by Mr. W. T. SUFFOLK. On comparing it with a specimen of Starch from *Tacca pinnatifida*, kindly sent to me by Mr. JACKSON, of Kew, it at once became evident that it was obtained from that plant or an allied species.

The type of the starch granule is quite different from that of the *Marantaceæ*, many of the granules being what may be called muller-shaped, with a prominent hilum. The concentric rings are fairly distinct. I have not heard of the Starch as a commercial article of late years, although it would appear probable, now that Madagascar is advancing in civilization and commercial importance, that it may be again introduced.

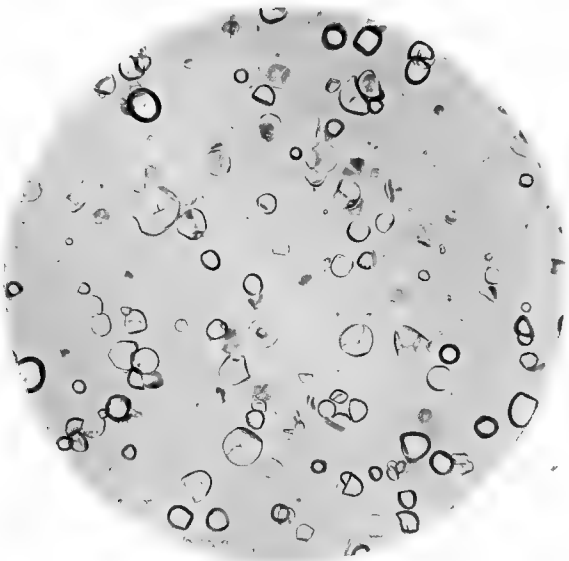
It may here be noted that the peculiar muller-shaped Starch granule is with the exception of Tapioca peculiar to the Monocotyledonous plants of tropical countries.

7.—TAHITI ARROWROOT.

NAT. ORD.—**Taccaceæ.**

Tacca pinnatifida.

The plant from which this is obtained is a native of the tropical parts of India, Africa, and the South Sea Islands. Cakes made from the Starch are eaten as food by the natives of Otaheite and other Society Islands. The identity of this and the preceding Starch is apparent when the photographs are compared. The Starch is obtained from the roots, which, in their native state, contain certain acrid and bitter principles, but these are to a large extent lost in cultivation, and the remainder are separated in the process of washing. This Arrowroot does not appear to be a commercial article in this country.



7.—TAHITI ARROWROOT.
× 160.

8.—PLANTAIN MEAL.
× 160.

8.—PLANTAIN MEAL.

NAT. ORD.—**Musaceæ.**

Musa paradisaica.

The fruit of some species of this order are important articles of food in tropical regions, while many species yield fibres suitable for manufacture into textile fabrics. The fruit of allied species, *Musa sapienta*, is the well-known Banana. The fruit of *M. paradisaica* is the part of the plant from which the Starch known as Plantain Meal is obtained. The granules are principally remarkable for their long and narrow shape, the lines are fairly distinct and regular, with a small somewhat indistinct hilum. The plant and its products are used principally in tropical regions.

9.—TAPIOCA.

Nat. Ord.—Euphorbiaceæ.

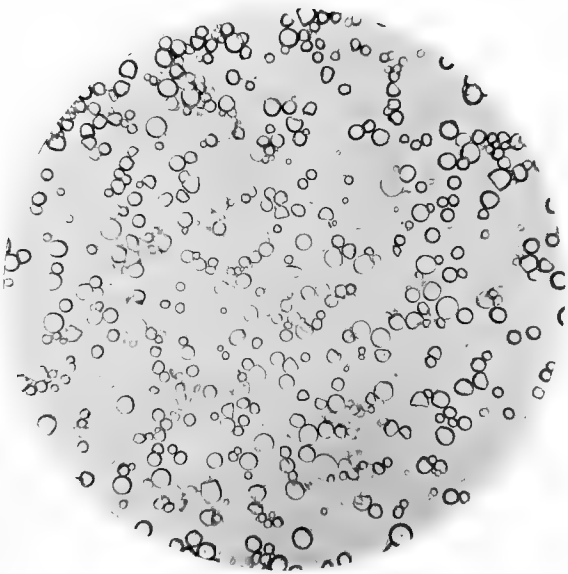
Manihot utilissima.

The plant from which this Starch is obtained is the only one of the order which yield a food product that is used to any extent.

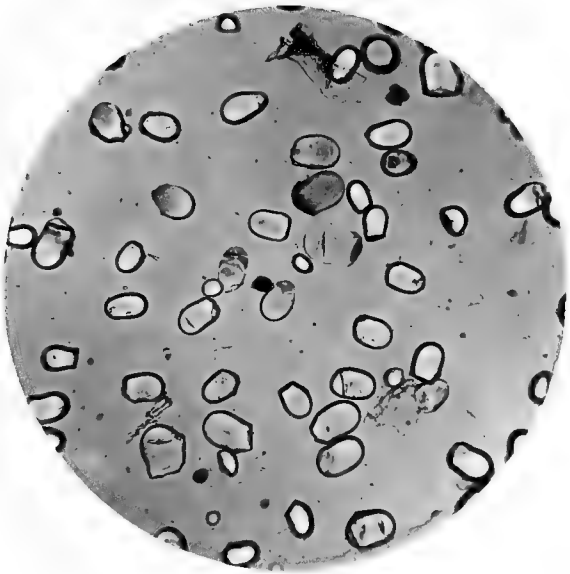
The whole order, almost without exception, possesses acrid properties, and some species are very poisonous.

The roots and expressed juice of *Manihot utilissima* are, owing to the presence of Hydrocyanic acid, of a poisonous nature, but this is destroyed in the process of manufacture. The Tapioca of commerce is prepared by submitting the Starch to heat while moist, by which the granules are broken up, and become agglutinated into little masses. The microscopic characters are therefore lost. The plant is a native of tropical America, where it is known as Bitter Cassava, and the meal made into Cassava bread is extensively used as a food by the inhabitants. The starch is also known as Brazilian Arrowroot.

The physical characters of the Starch granules partake somewhat of the nature of those of *Tacca* Starch, but they are rather smaller; many of the granules are circular, with a distinct hilum in the centre, which sometimes appears as though split into an irregular star.



9.—TAPIOCA.
× 160.



10.—SAGO.
× 160.

10.—SAGO.

Nat. Ord.—Palmaceæ.

Metroxylon sagu.

The specimen from which this photograph is taken, was obtained direct from the pith-like portion of the stem of *Metroxylon sagu*, for which I am indebted to Mr. Jackson, of Kew.

The Starch is a large and rather coarse one, containing many muller-shaped granules, which shape appears to be the outcome of a process of sub-division, as is illustrated in the photograph.

The Sago of commerce having been subjected to heat and moisture in the process of manufacture, the characters of the Starch are, as in Tapioca, lost to a great extent. Sago is grown principally in the Moluccas and Sumatra, whence, in its rough state, it is sent to Singapore, where it is granulated by the same process as Tapioca and then re-exported. In its prepared state it is extensively used in this and other countries.

Sago is the only Starch food derived from the *Palmaceæ*, although for variety of products there is no other order, except perhaps the *Gramineæ*, so useful to man.

11.—WHEAT.

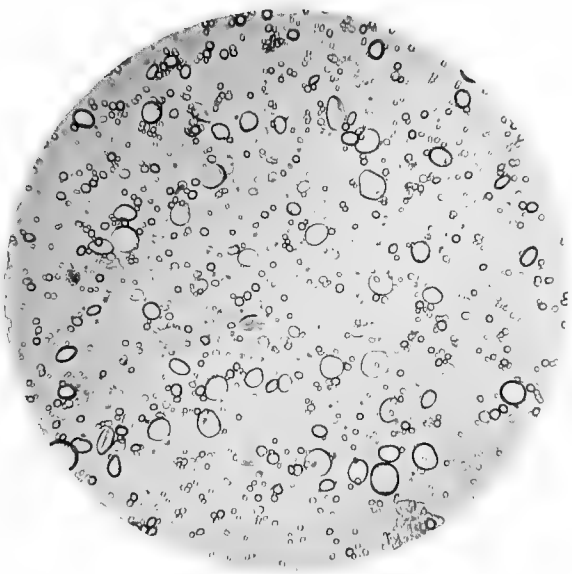
Nat. Ord.—Gramineæ.

Triticum vulgare.

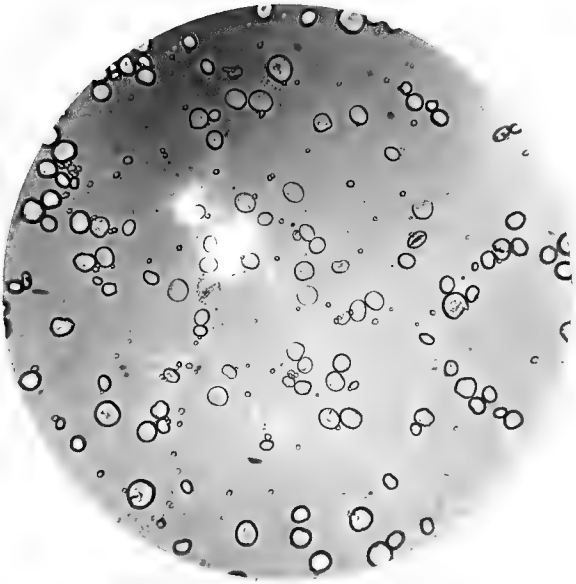
This Natural Order contributes more to the wants of man than any other, moreover, some or other species are capable of being cultivated in every part of the globe.

The Starches so far described are used as food in the pure state, but we now come to a class of food products in which that substance occupies a less prominent position. In the cereals about to be considered the whole seed, deprived of the outer integuments is ground into meal, and this contains, in addition to Starch, important nitrogenous substances or flesh-forming material, thus making the meals far more perfect foods in themselves than the Arrowroots.

The Starches of this Natural Order may be divided into two well-defined classes, the circular and the angular granules. Of the former class Wheat Starch is the most characteristic; it consists of, as it were, two sets of granules, both circular, but one much larger than the other, with very few of intermediate size. Pure Wheat



11.—WHEAT.
× 160.



12.—BARLEY.
× 160.

Starch forms the basis of the best "Violet Powder" and kindred preparations, although Maize Starch and Rice Starch are now much used for the same purpose. The British Pharmacopeia also recognises the two latter Starches as permissible for use in medicinal preparations into which Starch enters. The amount of flesh-forming material or albuminoids in the cereal grains generally ranges from about 9 to 14 per cent.

12.—BARLEY.

NAT. ORD.—**Gramineæ.**

Hordeum vulgare.

This cereal is very largely grown for brewing into beer, although many other substances are said now to enter into that useful beverage besides malt and hops. Deprived of the husks it is known as Pot Barley, and still further treated to remove all the integuments and polish the grain as Pearl Barley, which is used in soups and puddings. Inferior or weather-stained barley, which is unfit for malting purposes, is largely used for making barley-meal used in feeding pigs and other animals.

The microscopical appearance of Barley Starch is very similar to that of Wheat, but the small granules are still smaller than in the latter, while the large ones show concentric rings rather more distinctly.

Barley Starch is not met with in commerce in the pure state, as is the case with Wheat Starch.

13.—RYE.

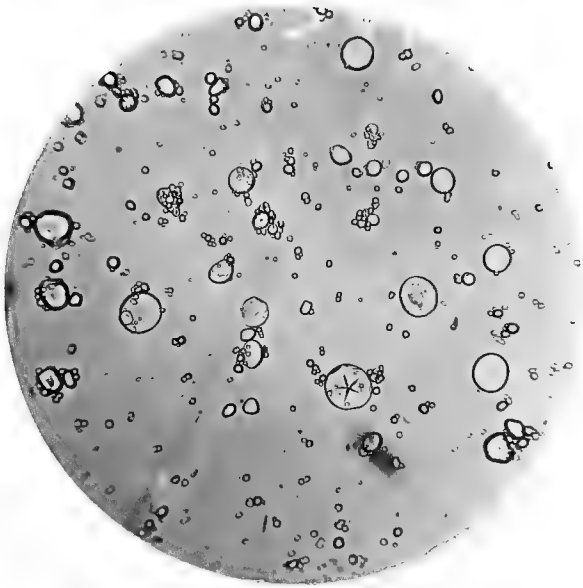
Nat. Ord.—Gramineæ.

Secale cereale.

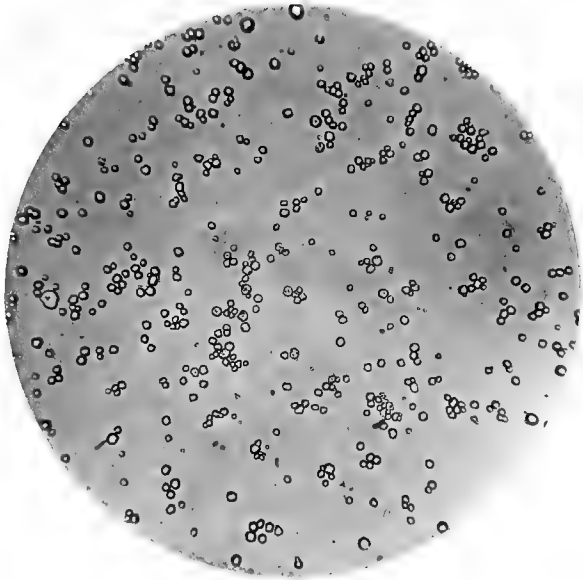
Rye bread or black bread, as it is called, is an important food in some northern countries, but its use in this country is very limited. In this country the use of Rye is practically confined to green producing fodder for cattle.

Rye, among the grasses, is specially liable to the attacks of a fungus which entirely alters the character of the grain, which becomes blackened. It is then known as *ergot*, and is used somewhat extensively in medicine. Ergoted grain is quite unfit for human food.

The microscopic appearance of Rye Starch presents the same general characters as that of Wheat and Barley, but the large grains are larger than in either, and the position of the hilum is in a few of the granules occupied by an irregular cross. These characters are sufficiently distinct to render the detection of a mixture of Rye with Wheat Flour quite possible.



13.—RYE.
× 160.



14.—INDIAN MILLET.
× 160.

14.—INDIAN MILLET.

NAT. ORD.—**Gramineæ.**

Panicum miliaceum.

This grain is only used in this country as food for poultry, but is here illustrated on account of its being a good example of the angular-shaped Starches of this order, the granules are about the same size and shape as in the Oat, but are not so adherent in circular masses as in that Starch. Millet is used as food in some countries, and its nutrient value as a food is about the same as Wheat.

Many species of *Panicum* yield Millet besides *miliaceum*, and the grains of various species of *Sorghum* and of *Setaria* are known in this country as Millet.

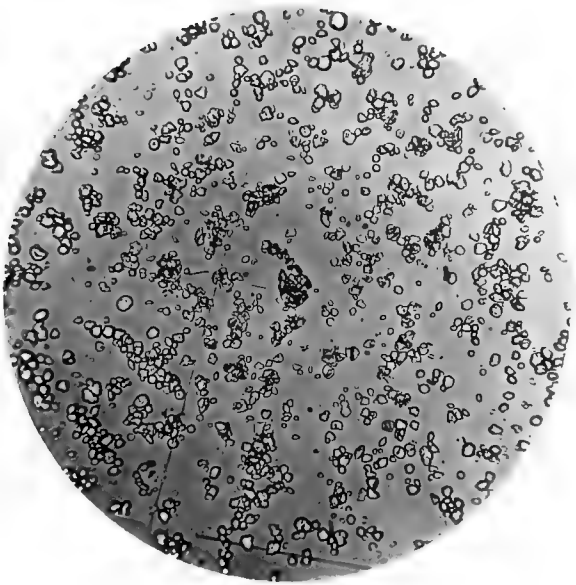
15.—OAT.

Nat. Ord.—**Gramineæ.**

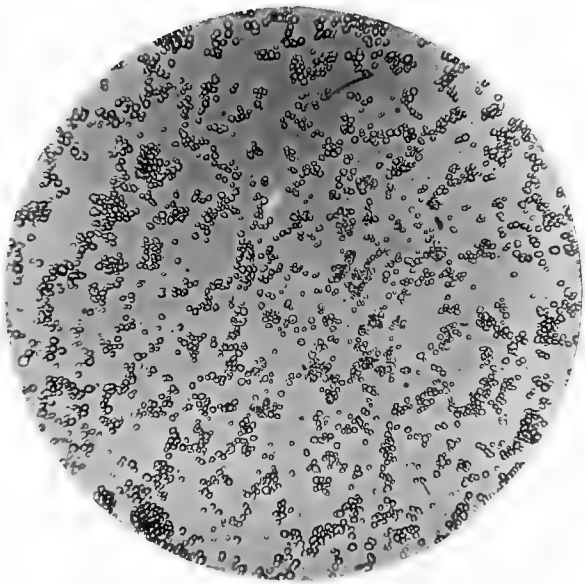
Avena sativa.

This useful grain is used both as fodder and as human food. It possesses a higher food value than the other cereals. Deprived of the outer husk and crushed, it forms the well-known and nutritious Oatmeal, which, when made into porridge, form such a valuable food, especially for children. In many parts of Scotland Oatmeal porridge and Oatmeal cakes form the staple articles of food.

In shape, Oat Starch is very similar to that of Millet, but the granules are, to a certain extent, adherent in circular masses; this character is best seen when the Starch is obtained from the grain without pressure or grinding, as the masses are easily disintegrated, in which condition they could not be distinguished from those of Millet.



15.—OAT.
× 160.



16.—RICE.
× 160.

16.—RICE.

NAT. ORD.—**Gramineæ.**

Oryza sativa.

This cereal, although only grown in tropical and sub-tropical countries, is perhaps more universally used as a food than any other grain. As it is deficient in albuminoids and fat it is far from being a perfect food, and requires to be eaten with other substances containing a larger proportion of those materials.

Rice Starch, though exceedingly small, possesses well marked characters. The granules are even in size and distinctly angular in shape, two marks which enable it to be easily distinguished from other Starches in common use. This fact is all the more valuable, as Rice Starch is often used as an adulterant.

The Starch used in the preparation of the various toilet powders generally consists of this Starch, either alone or mixed with Maize Starch. It is fast displacing Wheat Starch on account of its cheapness. There is, moreover, no objection to its use for this purpose.

17.—MAIZE.

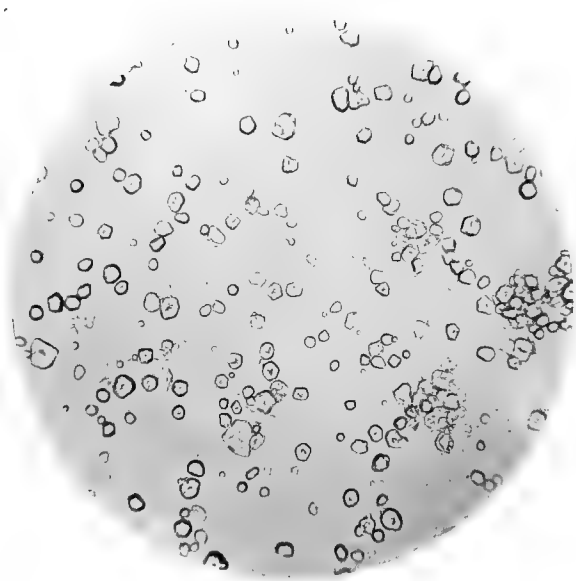
Nat. Ord.—Gramineæ.

Zea Mays.

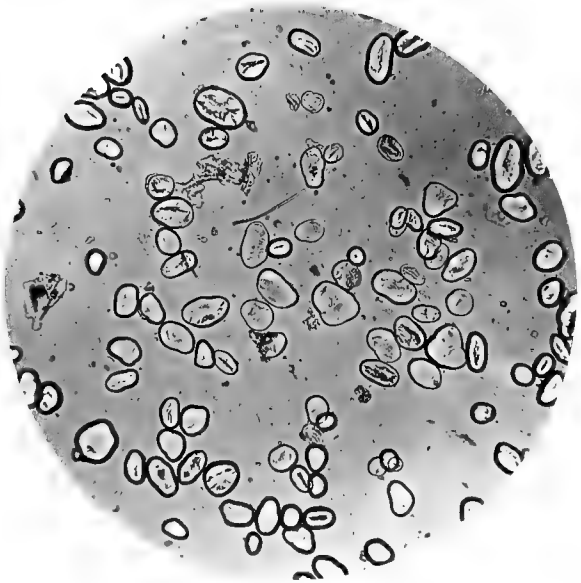
This grain is popularly known under the name of Indian Corn, and is extensively used in this and other countries as an article of food. The preparations of Maize used in this country are known by various names, such as *Corn Flour, Maizena, Oswego, Polenta, &c.*

The plant is a native of America, but it is extensively cultivated in the warm parts of the Old World. Attempts to cultivate it in England have, to a great extent, failed on account of the uncertainty of our climate.

Maize Starch may almost be described as magnified Rice Starch, although the granules are not so uniform in size, but they are very characteristic in appearance and easily identified. The hilum is prominent and sometimes takes the appearance of an irregular cross. It is, perhaps, the best example we have of a polygonal granule, and may be taken as the type of angular Starches of this order, as Wheat Starch may of the circular.



17.—MAIZE.
× 160.



18.—PEA.
× 160.

18.—PEA.

Nat. Ord.—Leguminosæ.

Pisum Sativum.

The Starches of this Natural Order possess peculiarities which readily distinguish them from those of other Natural Orders. The Seeds differ from those of the cereals by containing a much larger proportion of albuminoids, consequently they occupy a most important position as articles of human food. Dried ripe Peas, when split and well cooked, are well-known in the form of Pea Soup and Pease Pudding, when ground they are known as Pea Flour.

The Starch of the Pea and Bean are very similar, being rather large and oval in shape, with some feint traces of concentric lines, and the place of the hilum is frequently occupied by an irregular slit, giving the appearance of a process of breaking up having commenced. The adulteration of other substances with the ground seeds of either Peas or Beans would be an easy matter, as no other Natural Order of Plants produces Starch at all similar.

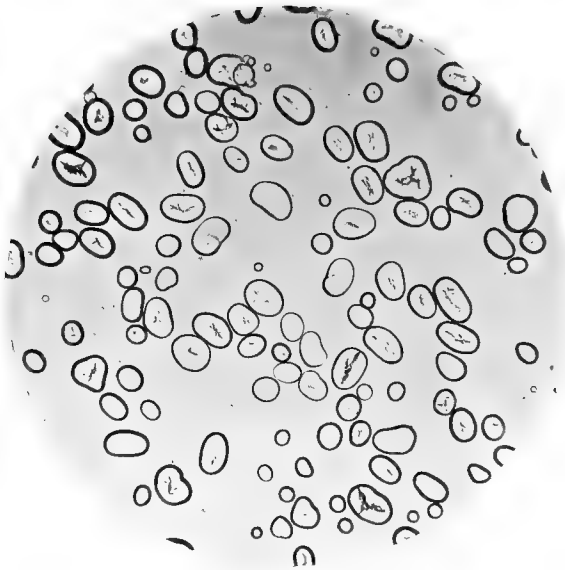
19.—HARICOT BEAN.

Nat. Ord.—Leguminosæ.

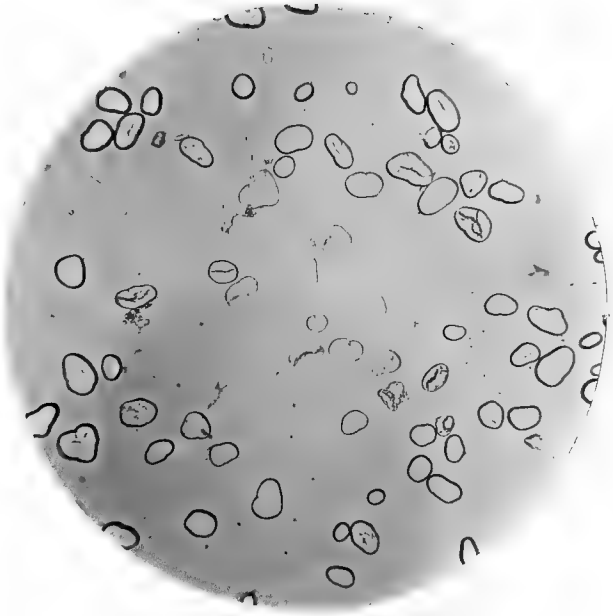
Phaseolus vulgaris.

Varieties of this plant are known as French Beans and Kidney Beans, and have all been obtained from the same species. The whole fruit, when unripe, is much used as a green vegetable, but they do not then contain the same proportion of nutrient qualities as the ripe seeds. Professor Church says in his work on Food, that the Haricot Bean should receive more attention than it at present does in this country; he gives the proportion of albuminoids as 23 per cent.

The character of the Starch do not differ from those of Pea Starch.



19.—HARICOT BEAN.
× 160.



20.—BEAN.
× 160.

20.—BEAN.

Nat. Ord.—Leguminosæ.

Faba vulgaris.

This Bean is cultivated on a large scale, principally as food for horses, the garden varieties known as Broad or Windsor Beans are used when quite young as a green vegetable.

The Starch of this species cannot be microscopically distinguished from those of the two preceding plants.

21.—LENTIL.

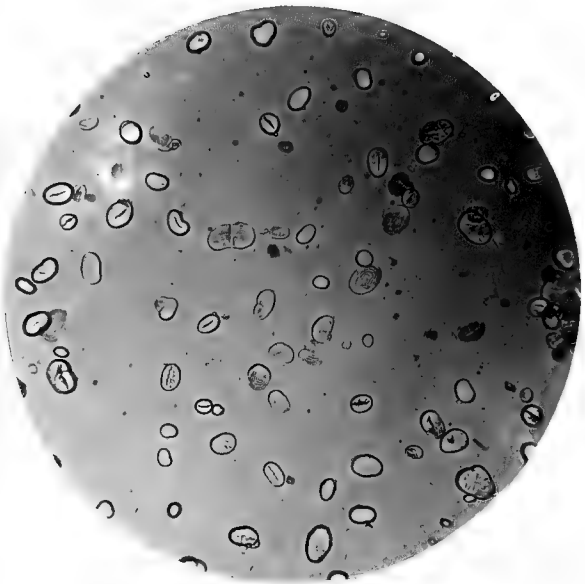
NAT. ORD.—**Leguminosæ.**

Lens esculenta.

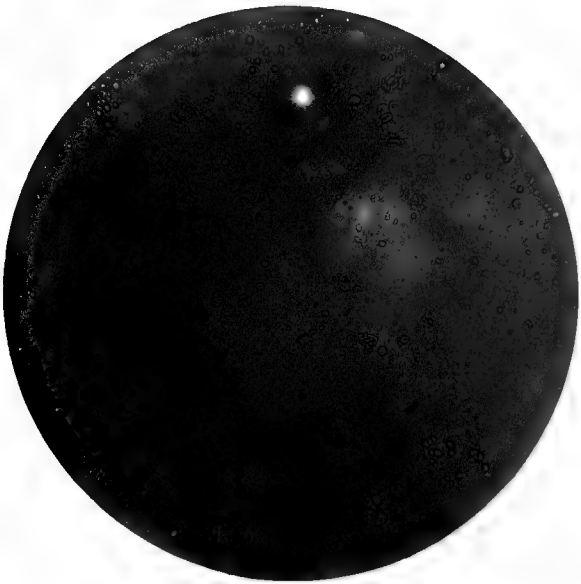
The Lentil is much used as food in the South of Europe, and when deprived of the outer covering they yield a valuable article of food, very rich in flesh-forming material.

An effort has been made of late years to introduce the Lentil more extensively into this country. There are preparations of it known as "Revelenta Arabica," "Ervelenta," &c

Although the Starch of this plant possesses the same character, as those of other Leguminous Starches, it is rather smaller in size, and the concentric lines are in some of the granules more distinct.



21.—LENTIL.
× 160.



22.—GROUND NUT.
× 160.

22.—GROUND NUT.

Nat. Ord.—Leguminosæ.

Arachis Hypogia.

The Starch in this Nut exists only in small quantities, the amount being about 10 per cent. It is illustrated here to show that it differs considerably from other Leguminous Starches, being small and circular, with a distinct round hilum, and that it is therefore not safe to trust entirely to general characters when tracing a Starch to its source. The nut is valuable principally for the large amount of oil it contains, considerable quantities of which are imported into this country from the West Coast of Africa. The residual cake, after the oil has been extracted, is used for feeding cattle. The plant has a peculiar way of ripening its seeds, the stem bearing the unripe pods bends over and forces itself under ground, where the fruit is matured, hence the name Ground Nut or Earth Nut. The fruit is also known as Monkey Nut.

Before leaving the *Leguminosæ* mention may be made of the Soy Bean, *Soja hispida*, a seed containing a very large quantity of albuminoids and oil, together with an active ferment, which, acting on the Starch, seems to convert it into sugar and dextrin. Several beans were examined without any Starch being discovered.

23.—POTATO.

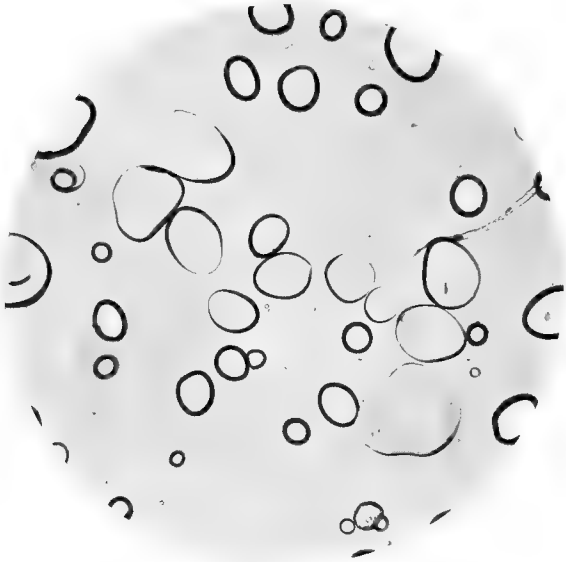
Nat. Ord.—Solanaceæ.

Solanum tuberosum.

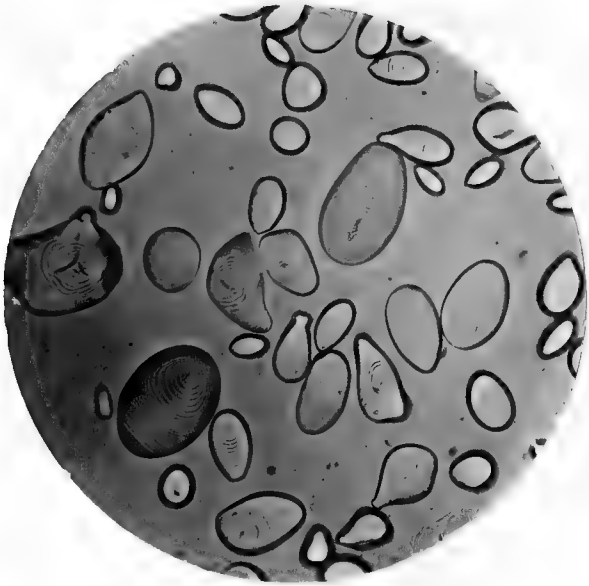
This important tuber owes its dietetic value principally to the Starch it contains. Flesh-forming material is present only in a small quantity, so that it cannot be exclusively used as food, but requires the addition of substances rich in albuminoids, like pea flour, meat, &c. The Potato has, however, many uses besides that of a table vegetable. The Starch is a cheap substitute for Arrowroot, and when submitted to a dry heat for a lengthened time is converted into dextrin, called also British Gum.

The spirit known as British Brandy is prepared from Potato Starch. The Starch of the Potato possesses characters which readily distinguishes it from any other.

The granules are very variable in size, some being quite as large as the *Canna* Starches, but the appearance of the concentric lines is quite different, being more irregular and in many cases not so well defined; the distinctness of the lines does not depend upon the size of the grain, as they are frequently quite as much or even more pronounced in the small than in the large granules. There is no difficulty in detecting Potato Starch when used as an adulterant.



23.—POTATO.
× 160.



24.—FRUIT OF POTATO.
× 160.

24.—FRUIT OF POTATO.

NAT. ORD.—**Solanaceæ.**

Solanum tuberosum.

The existence of this, the most beautiful of all Starches, does not seem to be generally known. A preparation of Potato Starch, mounted by the late Mr. VANCE SMITH, of Carmarthen, in order to illustrate fig. 42 in THOME'S Structural Botany, was obtained from the Fruit and not the Tuber, and the illustration in THOME'S book appears to be a copy of it, as it is quite unlike the tuber Starch. The photograph which forms the frontispiece was taken from the original specimen prepared by the late Mr. VANCE SMITH, and the accompanying illustration is from the Starch obtained by the author, from the pulpy part of the fruit when nearly ripe.

The great size of the granules and the characteristic breadth and distinctness of the concentric lines make it a handsome object for the Microscope, especially when examined by polarised light. It would be the most suitable Starch on which to carry out an investigation on the physical structure of that substance. The fact

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BAILY AND SON, MARKET PLACE, CIRENCESTER.