Starch, as a Food.

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Definition.

Starch is an organized product of the vegetable kingdom, forming one of the most important and characteristic elements of plant life and an abundantly stored reserve material for discharge of vegetative functions.

General Note.

Starch is widely disseminated thruout the vegetative world. It is found to be present, during some period, in the life of every plant that has been examined, except fungi. It is formed from the protoplasm contained in the chlorophyl cells, and is a carbohydrate formed by decomposition of carbon dioxide and water, under the influence of sunlight, or by red, orange, or yellow rays of the solar spectrum.

These organs which serve as reserve material, from which the young shoots of the plant obtain nourishment, are rich in starch; hence it collects in the medullary rays of the wood.

in tubers, and roots and in many fruits and seeds, and in the bark of some plants.

The starch of fruit, as pear, banana, and bread fruit, changes into sugar, as the fruit ripens and becomes sweet.

The solid particles of starch, being the first recognizable products of assimilation, are noticed beneath the surface of the green chlorophyl corpuscles. Each solid particle grows into a starch granule, which only increases in size as long as it is in contact with the protoplasm and on exposure to light, at suitable temperature, ranging from 15° to 25°. This formation may be followed thru the various organs and tissues of the plant.

The plants contain different quantities of starch at different periods of the day, or according to the weather. The rapidity and completion of the process depends wholly upon the weather. The starch granules grow in part at the expense of the chlorophyl corpuscles and of the starch formers; in both cases the protoplasm becoming altered and diminished in quantity.

If leaves of certain plants be covered so that no direct light will fall on them for some time, it will be seen that the starch granules have disappeared, but will appear very rapidly, if again exposed to sunlight. The starch disappears from the leaves in the form of glucoses which travel by way of the vascular bundles into the stems and thus pass to places where they are used up in growth.

In the same space and light, the proportion of starch found is approximately the same

History.

Starch was known to the ancient greeks, and to the Islanders of Chios we owe the discovery of extracting it from wheat. The Venetian traveler, Marco Polo, who visited China and some parts of the East Indies in the fifteenth century, describes the method of extracting it from sago palm. Starches of various colors were imported into England from Holland in 1564, mostly for starching clothes, however.

Manufacturing.

For manufacturing, starch is usually obtained from wheat, maize, rice, and potatoes in Europe; and from the stems of the palm, and tubers of various plants, in tropical countries.

There are two processes for manufacturing:-

1. Fermentation Process
2. Mechanical means, without the preliminary fermentation.

The oldest method is that of acid fermentation. Process still used in some places.

The grain is softened by steeping, and when soft, it is crushed between rollers, then coarsely ground and moistened with water, after which it is placed in a large vat, where fermentation sets in. Acetic, lactic, and butyric acids are then formed from the sugar, and from part of the starch, while the gluten loses its tenacity so as to admit of separation of the starch by washing. The mass is then washed and the milky liquid allowed to settle in a vat in which the starch having settled down is [illegible] by decantation

Various processes are used in different places.

General principles in starch making, to obtain a superior quality of starch are:- the corn must be properly steeped, and operator must have skill, and experience. It must then be properly ground. Next important step is sieving; the smallest hole will admit impure matter. Particular attention is required in the precipitation of the starch on the inclined plane. Great attention must be paid to temperature of dry room; too high will scorch; too low, will mould

Properties.

Starch is a glistening white powder, which, except in case of potato, contains a trace of a volatile oil, is devoid of taste and smell.

The granules have the power of polarizing the light like a doubly refracting crystal. When starch is brought into contact with certain ferments, the granulose dissolves completely, while the starch cellulose remains behind in the original form of the granule. Iodine vapor colors starch yellow, or brown on surface; a solution of iodine in strong alcohol imparts scarcely any color; but in presence of water, it yields a violet, or blue tint, while rich starch paste or soluble starch, it

gives a deep blue color, which is temporarily removed by heating.

In the form which colors brown the proportion of amylodextrin is very large. The red starch is characteristic of a large number of saprophytes, but has been found in less than a ~~dozen~~ of higher green plants.

Thingaste is precipitated by alkalies, and soluble starch is blackened by concentrated sulphuric acid.

Composition and Structure.

The size of starch granules vary from .002 of a millimeter in rice, to 1 millimeter in sago. The high magnifying power is not required, save for minute granules, such as Egyptian rice.

The granules vary, also, in shape, some being small and circular, others large, oval, and oyster shaped.

Starch granules when seen under the microscope consists of grains or which is perceived in center, or near the end a small ring, groove, slit, star, or crack, termed hilum [illegible] which may [illegible]

noticed faint rings, plications, or folds.

Dr Allan Dublin states that:-

1. The starch granules consist of a series of lamellae in form of closed hollow cells, included one within the other, the most internal cavity filled with starch.

2. That while the lamellae appear to be all identical in chemical constituents, yet internal differs from external in consistency.

3. That order of position of lamellae is centripetal

4. That while starch granules is thus lamellae vesicle, it must be included in the category, not only in absence of a proper nucleus, but in presenting no chemical differentiation between membrane, and contents of the true vegetable cell, from which it differs.

The different starch granules may be determined by the following classes:-

I. Hilum and concentric rings clearly visible, all oval or ovate - group includes canna arrowroot potato, dhuba, orrisroot, arrowroot, ginger, galangal, and turmeric.

II - The concentric rings all but invisible, hilum stellate; to this belongs the starches of bean, pea, maize, lentil, dari and nutmeg.

III Starches having concentric rings and hilum invisible in majority of granules, - This important class includes wheat, barley, rye, chestnut, acorn and a variety of starches derived from medical plants.

IV All granules truncated at one end. Includes tapioca, sago, and arrow besides several drugs.

V - In this class all the granules are angular in form; includes oats, lycea, rice, and pepper.

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Starch is resolved into two constituents, an insoluble starch cellulose which constitutes the outer layers of the granule and a soluble starch or granulose which forms the nuclei.

Shape and size of granule has a considerable influence on character of

of vegetable organs, in which it is stored up. Hardness of rice, for instance, being due to fact that granules are minute and fit together closely, whereas in potato, the granules are large and with interspaces filled with water, so it is of a soft mass.

But notwithstanding their outward appearance, the chemical composition is the same - consisting of carbon, six parts, hydrogen and oxygen in proportion of water. Similar to sugar in composition only less water in proportion to carbon, in starch, than in sugar.

Cooking.

To fit starch for digestion it must be dissolved, or softened by cooking, especially in wheat, corn, peas, and potatoes. The starch is contained in cells, the walls of which are acted upon comparatively slow by the digestive juices. By cooking, the cells are disrupted and the starch itself undergoes a more or less chemical change, so that it is more easily acted upon by the digestive ferments.

Cooking changes the texture of the food, making it more digestible, it does not add to the amount of nutritive material, except in so far as it may increase the proportion which is actually digestible.

When vegetables containing starch are cooked, the cell contents expand, and burst thru the walls. The starch takes up the water and assumes a soft, pasty condition which is necessary for its transformation into soluble dextrin and sugar.

Cooking is a preparatory process. The starch of peas, beans, farina, and bread are used for thickening soups, and flour, which is composed chiefly of starch, for making puddings, cake, omelet, pie, macaroni, etc. Hence we see the amount of starch eaten every day, and its necessity to the human race. Comprises about two thirds of food for human race. Wheat is the staff of life in temperate zones, and rice in the tropical regions. Grains are very widely used in Northern Asia, where the lichens are used by travelers. Cereals, which form such a prominent place in our diet, are composed chiefly of carbohydrates in the form of starch

By baking and roasting of starchy foods, some starch is also converted into more assimilable dextrin, as in hard brown crust of bread, and outside of baked potatoes. In bread making, the starch cells not only burst, but are acted upon by a ferment, supplied by the yeast, which aids farther in the digestion by converting starch into alcohol and carbon dioxide, the latter generates carbonic acid upon contact with the moisture of the dough.

When starch is heated, it swells, and to 100° most starch forms a semi solid in water. If heated to 160° or 205° C it forms a transparent mass, consisting wholly of dextrin; at 220° to 288° still further change, result is pyro-dextrin, a substance easily soluble in water and with a composition of $C_{48}H_{36}O_{30}HO$; at still higher temperature there is a carbonization and the formation of a product similar to that caused by decomposition of sugar.

Sugar and starch are burned in the body to yield heat and power, and are consumed more or less directly.

Food is a material, which taken into the body serves either to form tissue, or yield energy, or both. This includes starch and sugar because

they yield energy and form fatty tissue.

Starch is carbonaceous, as their service is to give heat, rather than to build up or repair flesh and muscle. The nutritive value is low, but they are valuable on account of the organic salts they contain; of the bulk which they give to the food; and of their stimulating effect upon peristaltic action of the intestines.

In its combined condition in cereals, etc, it is certainly the greatest and foremost of all the elements of nutrition. It is unstimulating, entirely negative in character, and has little or no plastic matter. The addition of carbohydrates to a diet assists in an increase of weight, as they shield these substances from destructive metabolism, and indirectly assist in storage of proteid material

Digestion.

Starches are digestible in proportion to their tenderness and readiness with which they can be broken up into fluids. In digestion, starch first enters the mouth

and is mixed with saliva, which consists of fast water, little salts, and a peculiar substance called ptyalin, a specific ferment which possesses the property of changing starch into sugar, the change being accomplished most completely when starch is dissolved or cooked, heat of life is largely dependent. This show the necessity of chewing food well before swallowing.

The change which takes place is represented by following formula:-

$$C_6H_{10}O_5 + H_2O = C_6H_{12}O_6$$

Starch + water = dextrose

$$2\,C_6H_{10}O_5 + H_2O = C_{12}H_{22}O_{11}$$

= maltose

Miahle discovered that the human saliva when filtered and mixed with six times its weight of alcohol, a small quantity of a floculent body is deposited. This is insoluble in strong alcohol, but partly soluble in water and weak alcohol. If one part of this body was added, it would convert two thousand times its weight of starch into sugar.

The first action of a ferment upon gelatinous starch converts it into soluble starch

When starch and saliva enter the stomach the acidity of the gastric juice will gradually stay the action of the salivia. The gastric juice or bile has no action on starch, and it remains unchanged until it reaches the intestine where the pancreatic juice reaches it. This contains a diastatic ferment - amylopsin, which possesses the power of hydrolizing the starch to maltose, similar to the action of saliva.

The amylopsin is absent from infants; thus is the reason starchy foods are not easily digested by small children and should not be given in the diet.

When starch passes on, it is acted upon in the intestine by intestinal juices secreted in mucous lining, also a powerful inversion of sugars. This mucous lining will transform starch thru all its stages to sugar.

In fats the diastatic ferment changes starch as the other ferments do, and makes it soluble by a process of decomposition in which the starch molecule splits into dextrin and

and sugar.

Myers says it is purely a katabolic process and in every respect analagous to the katalytic action of acids, except it is more easily influenced by external conditions

Under diastatic action amylose takes up water and splits into two molecules; amylodextrin, which is transformed into isomaltose and dextrin, both of these substances pass into maltose.

Starch is a colloid, totally incapable of absorption. In acts of digestion as already described, it is converted into dextrin, then to grape sugar. Thus converted the grape sugar is promptly absorbed, by the capillaries of the villi, and passed thence into the portal veins and liver.

The abundance of grape sugar found in liver after death, and even found there when the animal is fed for a non-nitrogenous diet, is very much increased by the use of amylaceous and saccharine food.

In liver - living, sugar is not stored up as such, but escapes in

glycogen. This glycogen is being constantly converted into sugar, which is passed into blood and out of the liver by the hepatic vein.

Pavy says that the glycogen thus resulting is there converted into fat. This may be drawn upon by the tissues and especially muscular tissue, which is known to contain sugar, and which it may require as an essential element of its contractile substance. In either event the glycogen may be looked upon as a reserve fund of carbohydrate material

Adulterations.

Adulterations are commonly resorted to by some manufactures for the purpose of selling more readily, by asking a lower price, and meeting the pecuniary demands of some people.

Adulterations can be easily detected by the use of the microscope, if person is acquainted with the size and shape of the different

starch granules. Very often a cheaper grade of starch will be added to a superior variety.

Chief characteristics in examination for adulteration are size and shape of granules, position and size of nucleus, and rings, effect of polarization with or without selenite.

Other Uses.

There are various other uses, besides the use as a food, such as thickening material in calico printing, for dressing and finishing many textiles, for laundry purposes, adhesive paste, and powder; indirectly used for preparation of dextrin and British gum, and starch sugar, paper sizing, and for dusting forms in metal founding.

In preparation of starch the object is to burst the vegetable cell walls and liberate starch granules, and free them from the other cell contents. Laundry starches now

used are commonly made from rice and pulse.

The starch sugar is made by boiling starch with a week solution of sulphuric acid the operation being conducted under pressure. Used as a substitute for malt in brewing beer, in confectionary, for making table syrups, artificial honey and in doctoring of wine; likewise used in calico printing for the reduction and fixation of indigo

Consumption.

There being as many different kind of starches used, necessarily there would be need of numerous manufactures. These we have, there being about thirty large factories in the United States, for the manufacture of starch, from corn, alone. The total capacity of mills is about two hundred and fifty million pounds per annum. A great deal being exported.

The con-

in the United States is about one hundred and sixty million pounds per annum, or an average of three pounds for each person.

Hence we may see the importance of starch in our dietary, and the necessity of proper preparation and assimilation for the betterment of the human race. As an economic product starch in the pure state, is a most important, alimentary substance