STARCH, an organized product of the vegetable kingdom, forming one of the most important and characteristic elements of plant life. It originates within the living vegetable cell through the formative activity of chlorophyll under the influence of light, and is consequently an unfailing characteristic of all plants containing that body. Starch found within leaves and other green parts of plants is assimilated and transformed with great rapidity; accumulations of it are carried as starch-formers, and redeposited as starch in special reservoirs or portions of plants as the period of maturity approaches. In this way the body is found to gorge the stems of certain palms—the sago, &c.—just before these plants begin to form their fruit; it is the principal constituent of the underground organs of biennial and perennial plants, tap-roots, root-stocks, corms, bulbs and tubers; and it is abundantly stored in many fruits and seeds, as in the cereals and pulses, in bananas, bread-fruit, &c. It occurs in minute granules varying in diameter from ·002 to ·185 millimetres; and the granules from different sources have each a distinct microscopic character. Under the microscope these granules are seen to consist of a nucleus or hilum surrounded by layers arranged concentrically or excentrically, and the relations of hilum and layers are the most distinctive features of individual starches (see H. Galt, *Microscopy of the Starches*, 1900). Starch consists of a white or yellowish-white glistening powder. It is only slightly acted on by cold water, but under the influence of heat in water it swells up, forming according to the proportions of starch and water a clouded opalescent paste. The soluble portion is called granulose, and the insoluble starch-cellulose; from the aqueous solution alcohol precipitates soluble starch. Iodine acts on it in water, producing a brilliant blue coloration, this reaction forming a very delicate and characteristic test. The colour disappears on heating, but is recovered when the mixture is cold. Diastase and dilute boiling sulphuric acid convert starch into a form soluble in hot water, whence it passes into a series of easily soluble dextrins, and finally into the condition of the sugars, dextrose and maltose. Chemically, starch is a carbohydrate with the formula $(C_6H_{10}O_5)_n$, where n is four or more.

As an economic product starch in its separate condition is a most important alimentary substance, the chief pure food starches being arrowroot, sago, tapioca and cornflour. In its combined condition, in cereals, &c., starch is a useful nutritive element. In its other industrial relations starch is used: (1) directly, as a thickening material in calico printing, for the dressing and finishing of many textiles, for laundry purposes, adhesive paste, and powder; and (2) indirectly, for the preparation of dextrin and British gum and starch sugar. Indian corn, wheat and rice starch are principally employed for the direct applications; and for the dextrin and starch-sugar manufacture potato starch is almost exclusively selected.

In the preparation of starch the object of the manufacturer is to burst the vegetable cell walls, to liberate the starch granules, and to free them from the other cell contents with which they are associated. When, as in the case of the potato, the associated cell contents, &c., are readily separated by solution and levigation the manufacture is exceedingly simple. Potato starch is prepared principally by carefully washing the potatoes and in a kind of rasping machine reducing them to a fine pulp, which is deposited in water as raw starch. The impurities of this starch—cellulose, albuminoids, fragments of potato, &c.—are separated by washing it in fine sieves, through the meshes of which the pure starch alone passes. The sieves are variously formed, some revolving, others moving horizontally or in such manner as to keep the material in agitation. The starch is then received in tanks, in which it settles, and so separates from the soluble albuminoids and salts of the potatoes. (The waste pulp which passes over the sieve is pressed, dried quickly, and sold as a low-grade cattle food.) The settling of the starch is much retarded by the dissolved albuminoids, and to hasten the separation small quantities of alum or sulphuric acid are employed. Alum coagulates the albumen and to that extent contaminates the starch, while the acid acts on the starch itself and is difficult of neutralization. After the starch has settled, the brown-coloured supernatant liquor is drawn off and the starch again washed either in tanks or in a centrifugal machine. Finally it is dried by spreading it in layers over porous bricks (a process not required in the case of starch washed in a centrifugal machine) and by exposure to the air, after which it still retains a large proportion of water, but is in a condition for making dextrin or starch-sugar. For further drying it is ground to a rough powder, and dried thoroughly in a hot chamber, then reduced to a powder and sifted. Potato starch is also made by a "rotting" process, in which potatoes are reduced to a pulp by slicing and are then heaped up till fermentation takes place; 100 lb of potatoes yield 15–16 lb of dry starch.

In dealing with the starches of the cereals, there is greater

difficulty, owing to the presence of gluten, which with water forms a tough elastic body difficult of solution and removal. The difficulty is experienced in greatest measure in dealing with wheat, which contains a large proportion of gluten. Wheat starch is separated in two different ways: (1) the fermentation method, which is the original process, and (2) by mechanical means without preliminary fermentation. In the fermentation process whole wheat or wheaten meal is softened and swollen by soaking in water. Wheat grains are, in this condition, ground, and the pulp, mixed to a thickish fluid with water, is placed in tanks, where it ferments, developing acids which dissolve the gummy constituents of the wheat, with part of the gluten, and render the whole less tenacious. After full fermentation, the period of which varies with the weather and the process employed, the starch is separated in a washing drum. It is subsequently washed with water, which dissolves out the gluten, the starch settling in two layers—one comparatively pure, the other mixed with gluten and some branny particles. These layers are separated, the second undergoing further washing to remove the gluten, &c., and the remaining operations are analogous to those employed in the preparation of potato-starch. By the mechanical process wheaten flour is kneaded into a stiff paste, which, after resting for an hour or two, is washed over a fine sieve so long as the water passing off continues milky, whereby the starch is liberated and the greater part of the gluten retained as a gluey elastic mass in the sieve. The starch is subsequently purified by fermentation, washing and treatment in centrifugal machines. The gluten thus preserved is a useful food for diabetic patients, and is made with flour into artificial macaroni and pastes, besides being valuable for other industrial purposes. The fermentation process gives about 59 lb of starch and 11 of bran from 100 lb of wheat, whilst the mechanical process gives about 55 lb of starch and 12 of gluten.

Maize (Indian corn) starch is obtained by analogous processes, but, the proportion of gluten in the grain being smaller and less tenacious in its nature, the operations, whether chemical or mechanical, present fewer difficulties. Under one method the separation of maize starch is facilitated by steeping, swelling and softening the grain in a weak solution of caustic soda, and favourable results are also obtained by a process in which the pulp from the crushing mill is treated with water acidulated with sulphurous acid.

In the preparation of rice-starch a weak solution of caustic soda is also employed for softening and swelling the grain. It is then washed with pure water, dried, ground and sifted, and again treated with alkaline water, by which the whole of the nitrogenous constituents are taken up in soluble form. An acid process for obtaining rice-starch is also employed, under which the grain, swollen and ground, is treated repeatedly with a solution of hydrochloric acid, which also dissolves away the non-starchy constituents of the grain. The yield is about 85 lb per 100 of rice. Laundry starches are principally made from rice and from pulse.

See O. Saare, *Die Fabrikation der Kartoffelstärke* (1897).