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POTATOES, SWEET POTATOES, AND OTHER STARCHY ROOTS AS FOOD.

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CONTENTS.

INTRODUCTION.

Among vegetable food products those plants are very important which lay up a supply of edible material during the favorable days of summer in the form of thickened roots or underground stems and bulbs. These root vegetables have different habits and characteristics and accordingly belong to separate botanical groups; some are well known the world over, while others are rarely seen outside of their native country. For convenience in discussing food problems they may be divided into two groups: (1) Those which, like potatoes and sweet potatoes, contain a fairly high proportion of food material, chiefly starch and other carbohydrates; and (2) those like beets, turnips, parsnips, and so on, which, although they resemble the first group in many ways, nevertheless are different from them in other respects, being more succulent, quite commonly of higher flavor, and used in the diet in a somewhat different way. This group is discussed in another department bulletin.[1]

[1] U. S. Dept. Agr., Bul. 503.

Note.—This bulletin, which is a revision in part of Farmers' Bulletin 295, summarizes the results of experimental and other data regarding the nature and uses of potatoes and other starchy roots as food, and is primarily of interest to housekeepers and to teachers and students of home economics.

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In the pages which follow attention is paid particularly to the potato, sweet potato, and Jerusalem artichoke; and more briefly to the yam, cassava, dasheen, taro, and yautia—roots commonly known in our island possessions and to at least a limited extent in the United States proper. It is almost needless to say that the white, or common, potato, judged both by the extent to which it is grown and by its food value, is by far the most important representative of the starchy-root group. Next in importance comes the sweet potato, which is well known all over the country and is a staple root crop in a large area of the more southern portion of the Southern States. What a prominent place these two together hold in the diet may be seen from the fact that in 376 American dietary studies they were found to furnish an average of 12.5 per cent, or about one-eighth of the total food material, and 8.3 per cent, or about one-twelfth of all the carbohydrates eaten.

POTATOES.

HISTORY AND EXTENT OF CULTIVATION.

The potato, called in different regions white potato, Irish potato, English potato, or round potato, was first introduced into Europe from America toward the close of the sixteenth century by both the Spaniards and the English, in the latter case as a result of the expeditions sent by Raleigh to the Virginia colony. It is believed to be a native of western South America, where wild forms are still found.

In 1915 the potato crop in the United States totaled, in round numbers, 359,000,000 bushels, valued at $221,000,000. Part of the annual crop is used for feeding farm animals, and the poorer grades of tubers for manufacturing purposes, but the greater part is served on our tables.

STRUCTURE AND COMPOSITION.

The food value and cooking quality of a potato depend upon its structure and composition. The tuber is in reality a modified stem, shortened and thickened to form a storehouse for material held in reserve for the early growth of new plants. As in all other plant forms, the framework of the tuber is made up of cellulose, or crude fiber. This carbohydrate forms the walls of the multitude of tiny cells, which make up the structure of the tuber and which vary in shape and size in different sections of the tuber according to the part they play in its life. The tuber has several distinct parts not all equally nutritious. If a crosswise section of a raw potato be held up to the light four distinct parts may be seen (fig. 1). The outer skin consists of a thin, grayish-brown, corky substance corresponding roughly to the bark of an above-ground stem, which is of

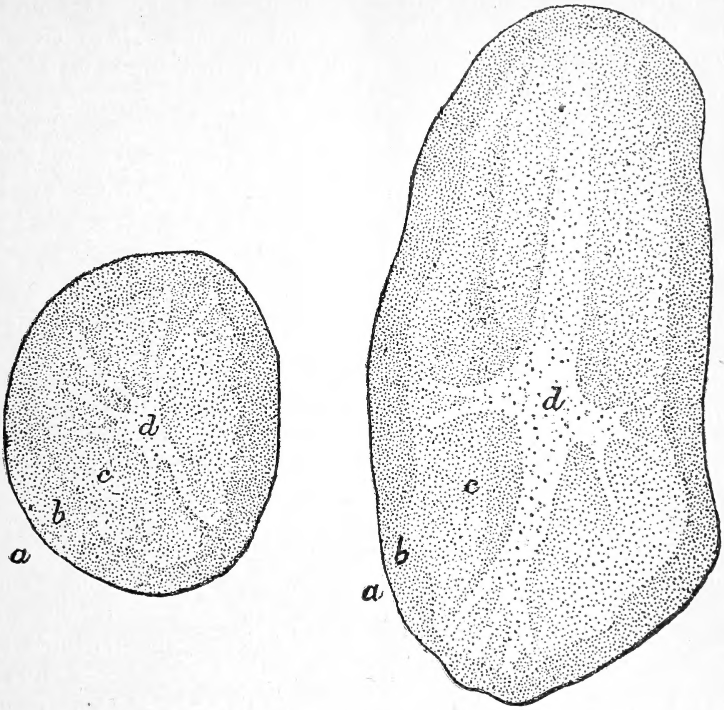

Fig. 1.—Transverse and longitudinal sections of the potato: *a*, Skin; *b*, cortical layer; *c*, outer medullary layer; *d*, inner medullary area.

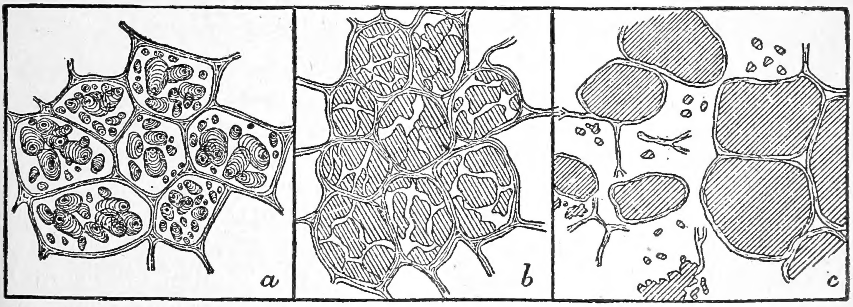

Fig. 2.—Changes of starch cells in cooking: *a*, Cells of a raw potato with starch grains in natural condition; *b*, cells of a partially cooked potato; *c*, cells of a thoroughly boiled potato.

little value as food (see p. 5). The cortical layer (bark) is next to the skin and may be from 0.12 to 0.5 inch in thickness. This layer is slightly colored and turns green if exposed to the light for some time, thus showing its relation to the tender green layer beneath the bark of above-ground stems. Besides starch the cortical layer contains a higher percentage of the mineral matter, soluble carbohydrates, soluble nitrogenous matter, and acid substances than the tuber as a whole. In the interior or flesh of the tuber lie the stored starch grains (see fig. 2). This portion is made up of two layers known as the outer and inner medullary or pithy areas. The outer one forms the main bulk of a well-developed potato and contains the greater part of the food (starch and other ingredients), the proportion of the different carbohydrates[1] varying with the stage of growth, degree of ripeness, and similar factors. The inner medullary area, sometimes called the core, appears in a cross section of the tuber to spread irregular arms up into the outer area so that its outline roughly suggests a star. It contains slightly more cellulose and water and food material than the outer medullary portion. If it is overdeveloped, the potato is likely to be soggy when cooked.

The relative proportions of the different parts of the tuber vary with variety and doubtless other factors. According to determinations made in connection with the department's studies of the food value of local-grown potatoes, it was found that the actual skin, as distinguished from the portion usually pared off and sometimes called the peel, made up about 2.5 per cent of the whole, and the cortical layer 8.5 per cent, leaving 89 per cent for the medullary areas. According to average values reported by French observers,[2] the skin made up 8.8 per cent of the tuber and the cortical layer 36.2 per cent, while the outer medullary area made up 34.2 per cent and the inner medullary area 15 per cent, or the two together 49.2 per cent.

The composition of the potato varies with the variety, the character of the soil, the climate, and other conditions under which it grows—a fact taken advantage of when the grower plants potatoes in sandy soil with the expectation of getting a mealy tuber. The needs of the potato plant, and consequently the composition of the tuber, also vary at different stages of its growth, a young potato being more watery and less starchy than one fully ripe. As a result of many analyses the average percentages of the different food ingredients in potatoes are now well established. The figures in Table I show the composition of raw and cooked potatoes and, for comparison, the composition of white bread.

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[1] In this connection it is well to recall that the carbohydrates (starch, the different kinds of sugar, pentoses, cellulose, etc.) are all closely related and that under the influence of ferments, certain acids, heat, or other agency, an insoluble form, such as starch, may be changed into a soluble form, such as sugar, or vice versa—a kind of change which takes place in nature, as for instance in the developing and ripening tuber or seed and is also important in food manufacture and in digestion and assimilation.

[2] Coudon and Bussard. Ann. Sci. Agron, 2. ser., 3 (1897), I, No. 2, p. 250.

TABLE I.—*Composition of raw and cooked potatoes.*

Kind of food.	Refuse.	Water.	Protein.	Fat.	Carbohydrates. Sugar, starch, etc.	Carbohydrates. Crude fiber.	Ash.	Fuel value per pound.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Potato, as purchased	20.0	62.6	1.8	0.1	13.8	0.9	0.8	305
Potato, edible portion	....	78.3	2.2	.1	18.0	.4	1.0	375
Potato, boiled	....	75.5	2.5	.1	20.3	.6	1.0	430
Potato, mashed and seasoned	....	75.1	2.6	3.0	17.8		1.5	490
Potatoes, fried in fat (potato chips)	....	2.2	6.8	39.8	46.7		4.5	2,595
Baked potatoes	....	74.0	3.0	....	22.0		1.0	455
Potato starch (potato flour)	....	7.1	.1	....	92.8		....	1,685
Potato meal and flakes	....	7.6	4.6	.3	82.3	1.8	3.4	1,620
Potato, evaporated	....	7.1	8.5	.4	80.9		3.1	1,640
White bread, for comparison	....	35.3	9.2	1.3	52.6	.5	1.1	1,185

As the table shows, the refuse, that is, the part removed in preparing potatoes for eating either before they are cooked or at the table, makes up on an average about one-fifth of the whole tuber, and the part commonly eaten, that is, the edible portion, four-fifths. Water is the most abundant constituent of the potato and forms about three-fourths of the edible substance. The remainder is mostly starch, though there is a little nitrogenous matter (protein) and fat. The amount of mineral matter (ash) is actually small, but as compared with that in other foods it is relatively high, and is of much value in nutrition. Figure 3 represents in graphic form the composition of the edible portion of the potato and shows even more plainly than the table that the bulk of the potato tuber is water.

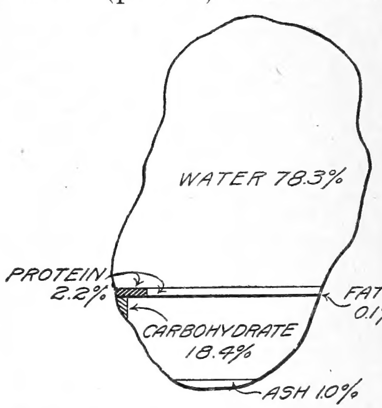

FIG. 3.—Percentages and loss in digestion of nutrients of the potato. Shaded portion shows a loss in digestion of 15 per cent of the protein and 1 per cent of the carbohydrates.

Theoretically, the skin is the only refuse or inedible material in the potato, but in practice a considerable part of the edible portion is removed with it (fig. 4). When the surface is irregular, or the tubers have shriveled in storage, a much greater proportion of the flesh is likely to be cut off with the skin in paring than is the case when the tubers are smooth and in good condition. It is estimated that in paring raw potatoes by household methods the loss is about 20 per cent. This includes not only all of the skin and the cortical layer, but also 9 per cent of the flesh. When we recall how large is the proportion of water and how low that of nutrients in the tuber, and also that the larger proportion of the protein and mineral matters is in the outer layers, this waste appears more important than is generally realized. The mechanical potato parers now available usually remove the skin with much less loss of edible material, and they have the further advantage of saving time for all but very skillful workers. There are a number of kinds on the market, which either pare the potatoes in much the same way as is done by hand or else rub off the skin.

The carbohydrates stored in the potato form 18.4 per cent of the edible portion. Most of this is starch, though there are also small quantities of soluble carbohydrates or sugars. Young tubers have a larger proportion of sugars and less starch than mature potatoes. If the tuber lies in the ground the starch content increases for a time, but when it begins to sprout part of the starch is converted by a ferment in the tuber into soluble glucose. Thus, both young or early potatoes and old ones have a smaller proportion of starch and more soluble sugars than well-grown but still fresh tubers.

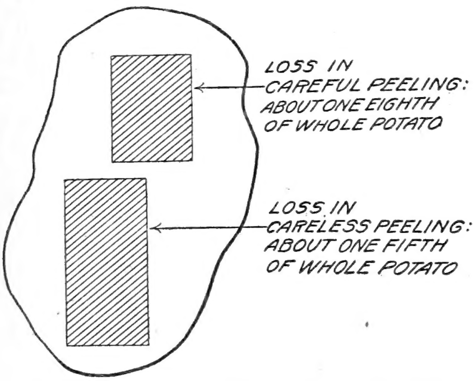

FIG. 4.—Loss of weight in peeling potatoes.

Less than 0.5 per cent of the carbohydrates is cellulose, yet one sometimes hears the statement that potatoes are indigestible on account of the large quantities of cellulose which they contain. In reality there is no more cellulose in the potato than occurs in most of the cereals and in other vegetable foods, and so such a criticism of the potato has no warrant in fact.

Besides the carbohydrates mentioned, potatoes also contain a little pectose, the French investigators quoted above reporting the presence of 0.2 to 0.4 per cent. Pectose, which is so important in jelly making when it occurs in quantity, as in fruits, is believed to have practically the same food value as other carbohydrates.

Fat appears in such small quantities in potatoes that it may be practically neglected in discussing their food value, especially as the greater part occurs in a waxlike form in the inedible skin.

The protein bodies are rather small in quantity, as compared with those of cereals and such vegetables as peas and beans, and only about 80 per cent of the total amount present is available protein; that is, protein in a form which can be used for the building and repair of body tissues. This means that a pound of potatoes furnishes only about 0.2 of an ounce of available protein and emphasizes the statement that potatoes alone make a very incomplete diet; only a very small amount of nitrogenous material would be obtained from a quantity of potatoes sufficient to supply the body with all the energy-yielding material required.

The protein has been found to consist in part of a form of globulin, for which the name tuberin has been suggested. Other nitrogenous compounds present are a proteose, asparagin, and amino acids.

The most important mineral matters found in potatoes are potassium and phosphorus compounds. There are several organic acids (such as citric, tartaric, and succinic acid[1]), which vary in tubers of different ages and account in some measure for the flavor of potatoes.

The potato, like many other foods, also contains minute amounts of physiologically active substance or substances valuable in nutrition and commonly called vitamins.[2]

The question is often asked, why the outer surface of freshly pared potatoes turns brown. According to experimental evidence this change is due to the action of enzyms, or ferments, naturally present in the plants. In the presence of the oxygen of the air they work upon tannin-like bodies in the tuber in such a way that the latter change color. This browning may be prevented by putting the pared tubers into plain cold water or, better, into salted water.

COOKING.

When boiled, the temperature of the interior of the potato does not exceed 212° F. (the temperature of boiling water). When baked, the temperature of the interior of the potato reaches 212° F., but does not exceed it, if cooked only until it is done. If overcooked, the temperature may be considerably higher, which may account for changes which cause the peculiar taste of overbaked potatoes. The heat affects the various constituents of the potato in different ways. The water expands into steam, part of which evaporates from the surface. Within the minute cells making up the tuber it presses so hard against the walls that the tough cellulose is ruptured, just as any air-tight vessel may be broken by the pressure of expanding steam. The starch grains inside the cells are thus released, some of them being also disintegrated, while part are changed into the soluble

[1] In proximate analyses such as those given on page 5 these acids would be included in the "carbohydrates," a matter of analytical convenience, not of chemical accuracy. Proximate analyses, it should be remembered, are designed to show group characteristics, and not the individual compounds which more detailed analyses would deal with.

[2] The vitamins are apparently in part dissolved in the juice and in part stored with the starch of the cortical layer of cells. Exactly what is their nature and the part they play in human nutrition is not yet fully understood, but recent investigations suggest that they do important work in regulating cell metabolism and are possibly concerned in the process of growth. It is not unlikely due to some of these compounds that potatoes prevent scurvy on shipboard or in other circumstances where fresh fruits and vegetables are not to be had.

form of dextrin by the heat, and part absorb water and swell. Protein coagulates or hardens, much as the white of egg does when cooked, and at least a part of it is broken down into simpler bodies. The mineral salts are probably less affected, but some are broken down and form new compounds, at least a little sulphur being driven off in volatile form when the potatoes are boiled. As is the case with other vegetables, this sulphur no doubt contributes to the odor of the potatoes while cooking. It is the sum of these and minor changes which accounts for the difference of flavor and texture in a raw and a cooked potato. As may be seen from the figures in Table I (p. 5), the cooked potatoes, which contain no added fat or other materials, do not differ much from the raw as regards composition. The effects of cooking on the mechanical condition of the potato cells is shown in figure 2, page 3.

The figures show the great changes in the mechanical condition of the potato flesh under the influence of heat, the broken cell walls and the increased bulk of the starch grains being particularly noticeable. The mealy, soft, porous mass of the cooked potato is in a favorable condition for the action of the digestive juices, as moisture readily penetrates to all parts of it, while this is not the case with the rather tough flesh of the uncooked tuber. It is commonly said that raw starch, like that found in the potato, is not digestible, but investigations indicate that this is not the case and that the digestive juices will dissolve the starch, provided the cell walls are ruptured by chewing or in any other way so that the ferments may come in contact with it.

One of the great advantages in cooking potatoes and similar vegetable foods is the improvement in flavor. This is due in part to the development of the cooked-starch taste, which is much more pleasant than that of raw starch. It is also due to changes in the flavor-yielding bodies. Raw potatoes, especially old ones, often have a decidedly bitter and disagreeable flavor (see p. 13), which is less marked after cooking, because some of the flavor-yielding bodies are removed. The reason why so many housekeepers consider boiling better for old potatoes than baking is that the boiling extracts more of the disageeable elements. This also explains the common custom of soaking old potatoes before cooking and that of throwing away the water in which potatoes have been boiled.

There are also disadvantages in the results of cooking, and, though they are less important than the advantages, they influence the food value somewhat. There is some reason for believing that the protein of the potato is stiffened by heat and becomes less readily digested than when raw. A much more serious matter is that considerable quantities of the nutrients may be lost during cooking (fig. 5). Several series of experiments have been made by investigators of the Department of Agriculture and by others to determine just how much of the different nutrients is lost when the potatoes are cooked in various ways. It was found that the loss is much the same whether the water is hard or soft. Soaking the potatoes in water before boiling greatly increases the amount of nutrients extracted. When they are put in cold water and brought to a boil they lose twice as much of their protein (15.8 per cent) as when they are plunged at once into boiling water; the loss of mineral matter is about 18 per cent of the total present by both methods. On account of these losses in boiling potatoes many persons consider steaming preferable.

The tests just noted were all made with pared potatoes, but another series was made with unpared ones, in which it was found that when boiled in their jackets potatoes lose only 1 per cent of their protein and a little over 3 per cent of their ash, no matter what the temperature of the water is at the start. Almost no starch is removed when potatoes are boiled in their skins, but when pared the mechanical action of the boiling water wears off the outer surface, and in this way as much as 3 per cent of the carbohydrates may be lost.

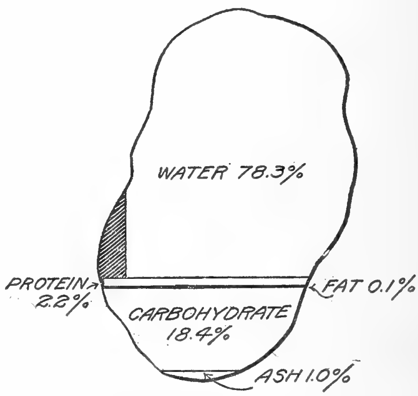

FIG. 5.—Composition of the potato and loss of nutrients when it is boiled without paring. Shaded portion shows loss in boiling of 2.8 per cent of the water and 1 per cent of the protein. Unless portions break off no starch (carbohydrate) is lost. A little over 3 per cent of the ash is lost in boiling.

Evidently, then, by far the most economical way to boil potatoes is in their jackets. When they are cooked this way they should, of course, be thoroughly scrubbed before cooking and are sometimes, particularly in the case of new potatoes, scraped to remove the greater part of the skin. In some families it is a common practice to remove a section of the skin at each end of the potato or to pare a ring around the middle of the tuber so that the moisture may escape and the cooked potato may not become soggy on standing. If they are pared before cooking, they should be placed directly in hot water.

When baked in their skins, potatoes probably undergo much the same changes as in boiling, but they lose practically none of their ingredients except a little water which evaporates through the skin. Some of their moisture changes to steam inside, and unless the potatoes are to be eaten immediately it must be allowed a way of escape or it will change back to water and make the potatoes soggy. This explains the practice of breaking, cutting, or pricking the skin of the baked potatoes when they are taken from the oven.

When raw potatoes are fried they lose some water by evaporation and may gain a considerable amount of fat. The thinner the pieces the greater will be both these changes and the crisper the cooked potato. Fried potato chips, as the table on page 5 shows, contain only 2 per cent of water and 39.8 per cent of fat, whereas the raw tubers contain about 78 per cent of water and 0.1 per cent of fat.

Potatoes may be prepared for the table in a great many ways, and this is an advantage, as it helps to give variety to the diet. Directions for some of these, along with methods of cooking other vegetables as well, have been published elsewhere.[1] When other materials are added to the potatoes—for example, when boiled potatoes are mashed with milk and butter—the composition of the finished dish will be that of plain boiled potatoes plus the nutrients in the materials added. Mashed potatoes differ in color and consistency according to the way in which they are handled. If the cooked potato is simply run through a ricer, it yields a light, white mass in which one can almost distinguish the shiny starch grains. If it is pounded with a masher the starch particles are crowded together so that they catch the light less and look darker in color. Adding milk or butter tends to make the mixture more yellow than the plain potato, but the more it is beaten—that is, the more air is forced in between the particles—the whiter and more creamy it becomes.

In this country the chief test of excellence is mealiness, which means that when cooked potato shall form a crystallinelike mass with almost distinct starch particles. This quality depends largely on the proportion of starch present. If it is abundant and evenly distributed throughout the tuber the cells burst open in cooking and a light, flaky, uniform mass results. If the proportion of starch is small in any part of the potato, water or juice is likely to replace it, which will make the potato soggy when cooked. As has been stated, fresh, mature tubers hold more starch than either young or long-stored ones, and the inner medullary layer or core is more likely to be poor in starch than the outer layer. Therefore, well-developed and well-ripened tubers are more likely to be mealy when cooked than are the new or watery tubers or those which have a large core with many long arms branching into the outer parts of the tuber (see p. 4).

This, however, does not tell the whole story. Anyone who cares for early potatoes knows that there is a quality between sogginess and mealiness that is commonly described as "waxiness," and in many parts of Europe this is preferred to mealiness. While mealiness depends on abundant starch and sogginess on a large water content, waxiness, which to some extent at least is a varietal characteristic, is attribut-

[1] U. S. Dept. Agr., Farmers' Bul. 256 (1906).

able to a large proportion of protein to starch. If the protein is sufficiently abundant it will harden in cooking to form a sort of waxy framework in which the starch will be lightly held together instead of separating into distinct flakes as in mealy potatoes, in which there is not enough protein present to resist the pressure of the starch. Such waxy potatoes retain their shape better than the mealy ones and are more suitable for garnishing meats, for salad making, and for the preparation of many fancy dishes. As has been shown, the proportion of protein to starch is greater in young than in mature tubers, and therefore, in American potatoes at least, the early varieties are most likely to have this waxiness. In point of flavor there is almost as much difference as in consistency; the nitrogenous tubers usually contain a larger proportion of acids, and perhaps also of sugars and solanin (see p. 13), than do the starchy ones.

POTATO PRODUCTS.

STARCH.

The chief article manufactured from potatoes is starch, which is used for laundry purposes, for sizing paper and textiles, and for other technical purposes; it also finds many uses in cookery, though not so generally now as before cornstarch became common. One of the good qualities of potato starch is that a relatively short time is required to cook it thoroughly, and so gravies, etc., can be quickly made with it and yet not have a raw taste.

Potato starch is sometimes marketed under the trade name of potato flour, particularly that of foreign make. The term is also applied to a different kind of product fairly well known in some European countries, which is made by grinding dried potatoes. Such a product is also called potato meal, which is perhaps a more distinctive name for it. A somewhat similar preparation is known as potato flakes. Both of these are much used in certain parts of Europe in bread making, particularly when wheat flour is scarce. Plain boiled and mashed potato may be used for the same purpose. The best results are obtained when not more than one-third of the flour is replaced by potato meal or flakes. The recipes commonly call for not more than one part of the latter to three parts of flour. Such potato bread is more moist than ordinary wheat or rye bread, the potato starch holding more water than that from the cereals. Similar mixtures of potato and flour are often used for pancakes, batter cakes, etc., and sometimes a kind of batter cake or similar dish is made from potato without flour. Many cooks think that ordinary wheat bread and rolls are lighter if the yeast is started with potato before the flour is mixed in, which would indicate that the potato supplies the yeast with better food for its growth than does the flour.

DRIED OR EVAPORATED POTATOES AND CANNED POTATOES.

Potatoes are so valuable in the diet that many attempts have been made to put them into a compact form in which they can be kept for a long time. This is usually accomplished by drying, which preserves them from decay and reduces their bulk. One of the oldest of such preparations is that long used in Peru and known as "chunno," made by freezing, thawing, and drying, which reduces the potatoes to about one-fourth of their original weight. There are a number of evaporated or dried-potato preparations in American and European markets, and although the method of preparation differs considerably in the various brands, the main principle is the same, namely, driving off water and so preventing decay. The changes which we call decay are caused mainly by the development of bacteria, molds, and yeast. These can grow and reproduce only where there are favorable conditions, of which the necessary ones are suitable food, moisture, and warmth. Therefore, if the moisture is removed, their growth is prevented or retarded. The fact that the bulk and weight of the potatoes is reduced at the same time is an advantage, because dried or evaporated foods are often useful for camping expeditions and under other conditions where fresh potatoes can not be easily procured, storage space is at a premium, or transportation is difficult. The chemical composition of such desiccated or evaporated potatoes is practically that of the original tubers minus almost all the water. (See Table I, p. 5.) Of course, if extreme heat is used in the preparation, part of the starch may be changed to dextrin, and there may be other minor changes in the chemical composition. There is no reason to suppose that drying involves a loss of nutritive material. Its influence on such substances as vitamins (see p. 7) is not definitely known.

The water content of various kinds of desiccated potatoes has been found to range from 4.8 to 7.9 per cent and their total carbohydrates from 77.9 to 80.6 per cent, showing their general composition to be not very different from that of good white flour. Desiccated potatoes are usually soaked in water before using, and the water which they take up then and during cooking brings back their water content to about that of ordinary potatoes. Their flavor and general characteristics, however, are not quite those of good fresh potatoes.

The canned potatoes found on the market are prepared for use in camps or wherever it is not convenient to cook food. In composition such goods do not differ much from similar potatoes freshly cooked.

STORAGE—ITS EFFECT ON QUALITY.

It is a fact of common experience that potatoes suffer more or less change during storage, and this is a matter of importance from the standpoint of household costs as well as of the table quantity of this important vegetable. If the tubers were originally affected with rots these will go on developing until the potatoes are quite unfit for food. If the skin, which is the natural protection of the tuber against the minute forms of life which cause decay, has been broken or bruised, the injured portion offers an entrance to bacteria, etc., which will develop in them, especially if the potatoes are stored in a warm, moist place. Aside from these abnormal changes there are others which occur under the best of conditions. The potato, it must be remembered, is not a dead thing, but one from which active plant life will be renewed as soon as conditions are favorable. Even during the latent winter period the protoplasm of the cells is constantly producing minute changes known as "after ripening," in which part of the sugar is broken down and carbonic acid and water are given off. Part of the insoluble starch is also changed into dextrin and other soluble forms. This is believed to be due to the action of ferments normally present, which aid the plant by thus changing its stored food into a form which can be used for new growth. The extent of these changes seems to depend ordinarily on the age of the tuber and the temperature at which it is kept. Everyone knows that potatoes stored where it is warm sprout more readily than those kept in a cold cellar. The older the tuber is, the more ready it will be to begin its new growth and the more abundantly will the starch be converted into sugars. This explains why old potatoes are less starchy and mealy and sometimes sweeter than fresh ones. The temperature especially affects the rapidity of new growth. This is one reason why potatoes stored in a warm place are more likely to shrink than those in a cool place. These facts also suggest why frozen potatoes have a sweet taste; the change of starch into sugar by the enzyms goes on regardless of the cold, but the activity of the cell protoplasm is checked by the cold and the sugar accumulates instead of being broken down. The sweet taste is more noticeable in tubers which have been slowly frozen than in those subjected to a sudden cold, because the sugar has had a longer opportunity to form. If frozen potatoes are left for a few days in a moderate temperature part of the sugar will revert to starch, and the sweet taste will in a measure disappear. Of course, the amount of material which is changed during storage will vary with the conditions, but sound potatoes properly stored should not shrink more than 10 or 12 per cent. The most favorable temperature for keeping potatoes is from 32° to 50° F., and if the storeroom is dry, well aired, and partly lighted, they are less likely to be attacked by disease or harmful bacteria.

Solanin, an acrid poisonous substance, which is characteristic of the nightshade family, develops in unusual quantities in sprouting potatoes and in those which have turned green from exposure to the light. A trace of it (0.01 per cent) is present in ordinary potatoes and is said to be what gives them their characteristic flavor. Such very small quantities are not harmful, and for that matter the amount which develops in sprouting or green tubers is not usually dangerous; but since the flavor is very often bad, it is a good rule to avoid green tubers or to cut out any green sections before cooking them.

The illness (often serious and sometimes fatal) attributed to green tubers, which occasionally results after eating cooked potato salad, for instance, is due, not to solanin or any other such substance, but to the rapid growth in the digestive tract of harmful bacteria (usually of the group called fecal bacteria) accidentally present on the potato or some food served with it and conveyed to the food most often by the unclean hands of some one who has handled, cooked, or served it.

SELECTION OF POTATOES FOR TABLE USE.

Appearance, taste, and consistency are the points by which we judge a cooked potato. Unfortunately, it is not always easy to tell from the appearance of raw potatoes which will prove the best, but there are certain marks which aid in making a choice.

Young or new potatoes are preferable to old or stored ones. Such tubers usually have a smoother skin, though they are not as mealy and do not keep as well as the older ones. Very large potatoes are not especially desirable, partly because it is hard to cook them evenly and partly because they are often very variable in texture. Smooth, regularly shaped tubers with comparatively few eyes are more economical than irregular ones which can not be pared without considerable waste.

Different varieties may have distinct flavors, but the soil and climate in which they are grown and the fertilizers used cause such great differences in flavor that variety alone is no sure guide. The freshly gathered mature tubers usually contain a large proportion of mineral matters and acids, and therefore have the better flavor. Tubers old enough to sprout begin to develop an acrid taste, probably due in part to an increased solanin content.

Very watery potatoes are always undesirable, because they become soggy in cooking. Young tubers are more juicy than mature ones, but their juice often holds so much more protein in solution that they cook to the well-known waxy consistency. A good potato to be mealy when cooked should feel firm when pressed in the hand. If cut, it should separate crisply under the knife and be of even density throughout. If the core is large and soft, it will make a soggy mass full of holes in the center.

In choosing potatoes, weight and size should be taken into account. As a rule, the smaller the individual potatoes the greater the weight of a bushel. The legal weight of potatoes in most States is 60 pounds[1] to the bushel, or 15 pounds to the peck, and three or four potatoes of average size weigh a pound. Hence, one may reckon 45 to 60 medium-sized potatoes to the peck. The time required for cooking, of course, depends upon the size of the potatoes, smaller ones needing less heat than larger ones. For this reason those of uniform size are usually to be preferred to large and small ones mixed. If a lot is not uniform, it is often worth while to sort them and use the large ones with roast meats, or at other times when the oven need not be especially heated, and save the small ones for occasions when quick cooking is more convenient. When the potatoes are very large, or time is pressing, it is often desirable to increase the surface exposed to the heat by cutting them in pieces before cooking, in spite of the fact that this slightly increases the amount of nutrients lost. If they are pared and cut into small cubes or thin slices, they will cook very quickly and may then be creamed, mashed, or served in other ways.

FOOD VALUE OF POTATOES.

Potatoes are an important food in so many countries that much experimenting has been done to test their nutritive value by scientific methods, and the work fully bears out practical experience in proving that they are wholesome and well digested. Many experiments show that almost all of the carbohydrates and about four-fifths of the protein which potatoes supply are actually utilized by the normal body.

There is practically no reliable evidence as to the favorable effect of cooking on the digestibility of potatoes, but what little there is suggests that the different methods have less influence than is sometimes supposed. It seems probable that well-cooked, mealy potatoes in which the starch grains are thoroughly broken open offer less resistance to the action of the digestive juices than ill-cooked, soggy ones in which the flesh is only partially broken down and which enter the alimentary tract in lumps. It is doubtful, however, if the differences are great enough to be of importance in the ordinary diet.

When potatoes are selling at a dollar a bushel 10 cents spent for them will buy about 6 pounds of tubers. The same sum spent for wheat bread at 5 cents a pound loaf will purchase only 2 pounds of material. At first glance it might seem that potatoes are much cheaper than bread, but they contain so much more refuse and water

[1] In two States, namely, North Carolina and Virginia, the legal weight of a bushel of potatoes is 56 pounds.

than the bread that the 6 pounds of potatoes furnish decidedly less protein and fat and slightly less carbohydrates than the 2 pounds of bread. It is easy, therefore, to see why, in spite of their cheapness and similar composition, they should not occupy the same place in the diet as bread. A diet of bread alone would be rather too one-sided for the best development of bodily powers, but would come nearer to supplying the required protein without excess of carbohydates than potatoes alone.

With respect to the total nutritive material they supply, raw potatoes resemble fresh fruits, such as bananas and apples, with their seven or eight parts of water to one of food substance, more than they do such foods as uncooked flour or rice, with their one part of water to nine of nutritive material. Since raw potatoes consist of only one-fifth and raw rice, for instance, of seven-eighths nutritive material, one would naturally say that rice is more than four times as nutritious as potatoes, and this is true of them as they are bought in the market. This, however, is not the case when they are compared in the state in which they appear on the table. When rice is cooked water is added to it, with the result that when it is eaten it is not very different in composition from cooked potatoes; thus a pound of boiled rice and a pound of mashed potatoes would have very much the same total fuel value, a fact which has been intuitively recognized by housekeepers, who often use them interchangeably to serve with meats, etc. They do not, however, have the same effect on the alkalinity of body tissues and fluids.

According to generally accepted standards, a man at moderately active work requires about one-fourth pound of protein a day, along with sufficient fats and carbohydrates to give the total food an energy value of about 3,500 calories. It would take about 9 pounds of potatoes to furnish this energy, but that quantity would yield much less protein than the amount called for by the standard. About 19 pounds of potatoes would be needed to yield the required 0.25 pound of available protein, an obviously impossible bulk for a day's ration. Except under stress of necessity, however, few persons try to live entirely or even principally on potatoes. Ordinarily they are eaten with other foods rich in protein, such as meat, milk, eggs, etc., and thus they supplement these nitrogenous foods by furnishing the needed carbohydrates in an easily digested form.

The abundant mineral matters which they contain also supply the body with important building materials and help to regulate its processes. As is the case with most vegetables and fruits, potatoes, when they have been digested and assimilated by the body, tend to make the tissues and fluids of the body more alkaline. Meats and eggs, on the other hand, tend to make them more acid, while the cereals (including rice) do not affect them greatly either way. Physiologists therefore speak of different food materials as being potentially alkaline, acid, or neutral. The body performs its work best when its condition is either neutral or slightly alkaline, and consequently, in the ordinary mixed diet, it is important to counteract the effect of the potentially acid foods like meats, eggs, and fish with potentially alkaline ones like vegetables and fruits. It has been estimated that a portion of potatoes large enough to supply the body with 200 calories of energy (over half a pound) would counteract the acidity from a portion of meat yielding 100 calories (about 1⅔ ounces). These conclusions are in accord with the old custom in families where living is simple of serving a goodly helping of potatoes and other vegetables in proportion to the helping of meat.

Aside from these considerations, potatoes deserve their important place in the diet for other reasons. They are easy to cook and can be prepared in so many ways that they add variety to the list of vegetable dishes, especially in winter, when green vegetables are not common. They have a mild, agreeable flavor acceptable to almost everyone and combining well with other foods, but not sufficiently pronounced to become tiresome. Owing to the ease with which they are grown and their abundant yield, they are usually a relatively cheap food. Considering all these advantages, it is not surprising that in the temperate regions of America and Europe they rank next to the breadstuffs as a source of carbohydrates in the diet.

SWEET POTATOES.

The plants known in the United States as sweet potatoes are called by botanists *Impomœa batatas* or *Batatas edulis*, and are probably natives of tropical America. They were introduced into Europe earlier than the white potato and were formerly so commonly grown in the warmer countries of Europe that when the white potato supplanted them the latter took its English name from a corruption of the usual European name of sweet potato—batatas. Since then, however, they have fallen out of use in Europe, it is said because they are considered too sweet for vegetables and not sweet enough to take the place of cakes, sweet fruits, etc.

At present the sweet potato is grown throughout the Tropics and warmer temperate zones, being a well-known food crop in the southern part of North America, in Central America, and in the West Indies, Hawaii, and the Philippines. In the southern United States they play almost as important a rôle as white potatoes do in other parts of the country and have almost usurped the name potato. Although the name yam (see p. 23) belongs rightly to an entirely different tuber hardly known outside the Tropics, sweet potatoes are sometimes so called in the United States, particularly certain of the sweeter and more juicy kinds quite generally preferred in the South, as distinguished from the dry, starchy varieties which are preferred in northern markets.

The edible portion of the sweet potato is not a tuber like the white potato, but a true root. Its internal structure is more uniform than that of the white-potato tuber, but its rôle in the life history of the plant is much the same, that is, to act as a storehouse of plant food for the growth and early development of a new crop of plants. Above ground the plant is a vine which occasionally produces flowers (and in warm countries seeds) resembling somewhat those of its relatives, the morning-glories. The first touch of frost is fatal to the vines of most varieties, so the cultivation is limited to warm countries where the plants are perennials and the growth is practically continuous, or to regions where the summer is long enough to insure the ripening of a crop. Some of the earlier maturing sorts are extensively grown as far north as New Jersey.

The color of the sweet-potato skin ranges from light tan to dark brown, or red and purplish tones, and the flesh from almost white or pale lemon yellow to a deep reddish orange. The medium and lighter shades are most frequently seen in the northern markets. The weight of the roots also varies considerably, but those which are of medium size and of regular shape are to be preferred for the table.

Although the bulk of the sweet-potato crop is used for human food, some of the coarser kinds are fed to stock, and a small part is used for the manufacture of starch.

COMPOSITION AND NUTRITIVE VALUE.

In general chemical composition the sweet-potato root resembles the tuber of the white potato, although there are important differences between them. The average composition of sweet potatoes raw and cooked is given in Table II, together with similar figures for the white potato.

TABLE II.—*Average composition of sweet and white potatoes.*

Kind of potato.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.		Ash.	Fuel value per pound.
					Sugar, starch, etc.	Crude fiber.		
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Sweet potato (edible portion)		69.0	1.8	0.7	26.1	1.3	1.1	560
Sweet potato (as purchased)	20.0	55.2	1.4	.6	21.9		.9	450
Sweet potato (cooked)		51.9	3.0	2.1	42.1		.9	905
Sweet potato (canned)		55.2	1.9	.4	40.6	.8	1.1	800
White potato for comparison (edible portion)		78.3	2.2	.1	18.0	.4	1.0	375
White potato for comparison (as purchased)	20.0	62.6	1.8	.1	14.7		.8	305

The proportion of total sweet potato discarded with the skin as refuse is probably about the same as in white potatoes, 20 per cent. The most noticeable differences between white and sweet potatoes are in the carbohydrates and water. Sweet potatoes contain on an average about 9 per cent less water and 9 per cent more carbohydrates than white potatoes. They also contain as little, or even less, protein; but the proportion of available protein is higher than in white potatoes, being about 1.3 per cent. This advantage, however, is hardly large enough to be of consequence, nor is the fact that they contain a trifle more fat.

More important than any of these differences is that in the nature of the carbohydrates. Sweet potatoes contain a slightly larger proportion of crude fiber than white, though the amount is no higher than in most vegetables. As would be guessed from their flavor, they contain considerable quantities of sugar, part of which is cane sugar and part invert sugar or glucose. The proportion of sugar and starch varies with the climate. The warmer the place in which the plant is grown, the greater the proportion of food laid by in the form of sugar. Tropical sweet potatoes sometimes contain almost equal quantities of sugars and starch. Those grown in New Jersey, on the other hand, probably do not average more than 5 or 6 per cent of sugar, or about one-fifth of their total carbohydrates.

After harvesting, sweet potatoes are put through a curing process during which they lose moisture. Sweet-potato marketing and storage are of special interest to the grower and shipper. The housekeeper who wishes detailed information on the subject will find it in earlier publications of the department,[1] as such questions have received careful study by the department specialists.

With respect to the storage of sweet potatoes in the home for family use, it seems to be generally conceded that the best results are obtained when the roots are kept in a dry, well-ventilated place, at a moderately warm rather than a cold temperature. This would mean that they should be stored in the pantry or some similar place rather than in the cellar. In handling potatoes in the home care should be taken not to bruise them, as when thus injured they are likely to spoil.

Little is accurately known about the chemical changes which take place during storage. The chief one, however, is that of starch into sugar. The most recent investigations indicate that after sweet potatoes are first harvested there occurs a rapid transformation of starch into cane sugar and reducing sugars, which is initially due to internal rather than external causes. The somewhat slower and more regular change which takes place during ordinary storage from

[1] U. S. Dept. Agr., Farmers' Buls. 324; 548.

starch to sugar seems to be associated in a general way with seasonal changes in temperature. In sweet potatoes kept in cold storage (4° C.) there is a rapid disappearance of the starch and an accompanying increase in cane sugar. It is a matter of common experience that late in the season sweet potatoes are apt to deteriorate in quality and sometimes develop a disagreeable taste, especially if they have been left in a cold place. The peculiar and characteristic flavor often noted is due to a fungus disease resembling dry rot. These undesirable changes may take place at any temperature below 50° F. To lessen the danger of shipping in cold weather, the southern sweet-potato crop is usually sent north early in the autumn and stored near the retail market.

In choosing sweet potatoes at the market, firm, fresh-looking ones should, of course, be preferred to the old and shriveled roots, and medium-sized, regular-shaped roots are more satisfactory than very large, very small, or irregular ones, for they cook more evenly, give less waste in paring, and are of better size to serve. Early in the season unripe sweet potatoes are sometimes marketed and may be recognized by cutting them; the flesh will soon turn dark green, whereas in the properly ripened roots it will not change color.

COOKING.

The changes which cooking makes in sweet potatoes are, in general, similar to those in white potatoes. One special point is generally noticeable—the longer the cooking is continued, the more moist does the root become. This is probably because part of the starch is made soluble by the heat and then dissolved in the juice, while the cane sugar is split up into simpler sugar. The very sweet southern varieties become so moist during baking that a sirup frequently oozes through the skin.

There are many different ways of preparing sweet potatoes for the table, the most common being simply boiling or baking. They are also fried, cooked with sugar and butter (when they are commonly called "candied"), used in making pies, like pumpkin or squash, or in other made dishes.

DRIED AND CANNED SWEET POTATOES.

Dried sweet potatoes were formerly prepared at home, and strings of them were hung from the rafters along with apples and other drying fruits and vegetables, but in these days of storage warehouses the custom has very largely passed away. Special devices for evaporating sweet potatoes are on the market, and desiccated sweet potatoes prepared in much the same way as desiccated white potatoes are sold to some extent.[1] Sweet potatoes cut into small cubes and roasted or parched until brown are used like parched corn as a homemade substitute for coffee.

Within recent years the practice of canning sweet potatoes has been developed with so much success that it is now an important industry. Medium-sized roots are preferred for canning and are usually put up in 3-pound tins. They are used like other canned vegetables when it is not convenient to depend upon a fresh supply. Canned sweet potatoes have been used in the Army ration in the Philippines and are said to be in demand for lumber and mining camps.

Very rarely a flour is made from sweet potatoes. Like that from white potatoes, it is prepared by slicing, drying, and grinding the root.

DIGESTIBILITY AND PLACE IN THE DIET.

Not many special experiments have been made to test the degestibility of sweet potatoes, but what little work has been done indicates a degree of digestibility equal to that of white potatoes. The protein may be sligthly less digestible, but the difference is too slight to be of practical importance.

It is a matter of common experience that sweet potatoes are wholesome, and they are ordinarily digested without distress. Many persons find the starchy varieties so dry that they do not relish them without large quantities of butter. This makes a rather rich mixture and is perhaps accountable for the digestive disturbances occasionally experienced.

Considering both composition and digestibility, it may be said that the nutritive value of sweet potatoes is much the same as that of white potatoes and that they are well fitted to occupy the same place in the diet and furnish a palatable substitute for white potatoes. Their characteristic and pleasing flavor has the advantage of giving variety to the diet. In the North they frequently cost somewhat more than white potatoes, but are still among the cheaper vegetables. In the South they are usually cheaper than white potatoes and merit their extensive use.

THE JERUSALEM ARTICHOKE.

The Jerusalem artichoke (Jerusalem being a corruption of girasole, the Italian name for sunflower) is a tuber-bearing member of the sunflower family and is entirely distinct from the French or true artichoke, sometimes called globe artichoke. Like the sunflower, the Jerusalem artichoke is of American origin and was an important

[1] South Carolina Sta. Bul. 71 (1903), p. 6; U. S. Dept. Agr. Farmers' Bul. 169 (1903), p. 25.

food of the Indian before America was discovered. Many farmers in this country are prejudiced against the Jerusalem artichoke because it spreads so rapidly and becomes a weed; but in Europe, and to a certain extent in the United States, it is considered a valuable plant, since the forage may be fed to stock, and the abundant tubers are useful as a vegetable and also for feeding farm animals. The bright-yellow flowers at the top of the tall stalks no doubt help to make the plant welcome. It is often allowed to grow on the edge of a garden or some similar place, and the tubers are dug for home use. They are also fairly common in market in certain localities. In flavor the tubers slightly resemble the true artichoke, which doubtless accounts for their name. They contain on an average 78.7 per cent water, 2.5 per cent protein, 0.2 per cent fat, 17.5 per cent total carbohydrates, of which 0.8 per cent is crude fiber, and 1.1 per cent ash. Judged by these figures the artichoke tubers are quite similar in general composition to potatoes (see p. 5). They differ very markedly, however, in respect to the nature of the carbohydrates present, inulin and levulin (which are chemically closely related to starch), and a considerable amount of pectose bodies replacing the starch which is characteristic of potatoes. Little is known regarding the digestibility of the typical carbohydrates which these tubers contain, but recent investigation indicates that they do not differ materially from starch in this respect. Jerusalem artichokes used in various ways as a vegetable give a pleasant and wholesome variety to the diet, particularly as they are not injured by frost and may be dug in the early spring when fresh vegetables are not very common. As the plant is very prolific and easily grown, the Jerusalem artichoke is not an expensive vegetable. The tubers may be boiled or steamed like turnips, creamed or fried like parsnips, or used for making soups and in other similar ways. An old-fashioned way of serving them is to slice the raw root, cover with vinegar, and serve as a relish.

SOME TROPICAL STARCH-BEARING ROOTS.

In the Tropics a very large proportion of the carbohydrates of the diet of both native and European residents is furnished by starch-bearing roots, such as the cassava, yam, dasheen, yautia, and taro. Mention may be made also of stachys (a curiously ribbed Japanese tuber long known in the United States, but chiefly as a dietary curiosity). Most of these roots are not common vegetables in the United States, though some or all are sold in the oriental quarters of our cities and sometimes in a limited way in other markets, and the cassava and dasheen are grown in the Southern States. In Porto Rico and our other island dependencies, such starch-bearing roots are very important articles of diet, and as they may be readily shipped in good condition and are known to be palatable and wholesome, it seems not unlikely that they may become important additions to the list of starchy vegetables commonly used in the United States. Most of them have two distinct uses in the diet; that is, they are used much like bread, as a common source of carbohydrate food, and, like succulent vegetables, as accompaniments of meat or other dishes.

CASSAVA.

The cassava is an American plant widely used for food purposes throughout Central America, the West Indies, and the hot regions of South America, and now cultivated to a considerable extent in Florida, but as a cheap source of commercial starch, glucose, etc., and as a cattle food, rather than as a vegetable. There appear to be two principal varieties, the sweet cassava and the bitter cassava (which is poisonous unless specially prepared, owing to the prussic-acid compound present), but only the sweet is cultivated in the United States. Both varieties (but the bitter only after proper treatment) are eaten as a vegetable, boiled, baked, fried, or cooked in other ways, and by drying and grinding are made into a flour which forms the basis of various sorts of bread and biscuits. Thin, crisp cassava cakes are not uncommonly sold in the United States under a variety of trade names.

Judged by the figures given in Table III, page 27, the cassava is as rich in starch as the potato, and like it can be classed as a succulent carbohydrate food. The amount of protein and fat present is very small, while the mineral matters are not remarkable in any way. The culture and uses of cassava and related matters have been discussed in a previous publication[1] of this department.

Cassava starch in the form of tapioca is produced in large quantities in the Tropics from the bitter cassava and is prized as a palatable and valuable food starch. It is a common article of commerce much used for making puddings and other dishes.

YAMS.

True yams, sometimes confused in name with sweet potatoes, belong to a group of tropical and semitropical climbing plants cultivated in a number of varieties and producing edible starch-yielding roots. All of the edible species are of Old World origin. These vary greatly in size, some being no larger than potatoes and others several feet in length and weighing 30 or more pounds. Yams are known in only a limited way in the United States, but are common and important

[1] U. S. Dept. Agr., Farmers' Bul. 167 (1903), pp. 32.

foods in Porto Rico, Hawaii, and the Philippines, ranking in Porto Rico, for instance, next to the sweet potato in importance.

In appearance tubers of comparable size look much like sweet potatoes, while in flavor and in composition yams very closely resemble potatoes. (See p. 27.) They have not, however, the keeping qualities of sweet potatoes, and in countries where they grow are usually left in the ground until required for use. Experience and experiment alike show that yams can be readily prepared in acceptable ways and are to be regarded as an important carbohydrate food in regions where they are available. They are prepared for the table in much the same way as potatoes and sweet potatoes.

Starch is made from the yam and also a flour used in tropical countries as a breadstuff. Like the flours and starches prepared from other edible roots, these yam products are not used alone for making yeast-raised bread, since they do not contain the gluten which is characteristic of wheat flour and which gives the light, porous texture to wheat bread. According to experimental evidence, 96 per cent of the carbohydrates present in yams is assimilated on an average.

DASHEEN, TARO, AND YAUTIA.

Dasheen, taro, and yautia are closely related botanically and are so much alike in general character and the uses to which they are put that they may be grouped together for discussion. They belong botanically to the Arum family, which includes also the large-leafed ornamental plant called Caladium or "elephant's ear," frequently seen in gardens, as well as the calla lily and the Indian turnip or jack-in-the-pulpit. Another member of the Arum family worthy of mention is the tuckahoe or Virgina wake-robin (*Pentandra virginica*), which is closely allied to the tropical America yautia. The tuckahoe grows in marshy bottoms and river banks. Its roots, like those of the yautia and Indian turnip, are very acrid when raw and are full of needles of oxalate of lime, but when cooked are of a very good flavor and much like the other aroid roots. The American Indians are said to have made a kind of bread of the tuckahoe, and, as the earlier records show, tuckahoe was of considerable importance to the pioneer settlers of the United States.

The dasheen, taro, and yautia all form large underground rootstocks or corms, in which starch is stored, and they are important food plants in many tropical and subtropical countries. Taro is an important crop in Hawaii and, indeed throughout Polynesia, and from it the Hawaiians make the cooked and slightly fermented paste called poi, a characteristic and very important article of their diet. Taro, dasheen, and especially perhaps yautia, are common in Porto Rico, and it was largely through the experiment station there that agriculturists in this country became interested in them. They grow well in wet lands and make a profitable root crop in soils too moist for potatoes or sweet potatoes, while the dasheen also has proved itself well adapted for other soil conditions. For this reason the Department of Agriculture and some of the experiment stations of the South Atlantic and Gulf States have been experimenting with them recently in the hope of developing a profitable crop for the moist, rich soils of those coast-plain areas. Particularly good results have been obtained with the dasheen.[1] The Department of Agriculture has done much to make it known in the United States, and it is quite generally liked by those who have tried it. Though particularly useful in warm localities, where white potatoes do not grow well, it can also be marketed elsewhere, for it has good shipping and keeping qualities, and while it is not expected to replace the potato crop it may well supplement it to add variety to the list of starchy vegetables.

The dasheen root consists of a large stocky central rootstock or corm, from which cormels or tubers branch out on all sides. The central corm is nearly spherical, but slightly pointed toward the top, and sometimes weighs as much as 6 pounds. It is firmer in texture than the tubers which branch off from it.

Both corms and tubers are edible, though in some varieties the tubers have a finer, more succulent flesh and a milder flavor. In general their texture may be said to resemble that of white potatoes. The flavor of dasheen is very much like that of the potato, being starchy and mild, and has little if any of the characteristic acrid taste which is common to nearly all the uncooked roots of this family of plants but which is removed by cooking. The color of the roots varies according to the variety, some being white or cream color, while others run into orange, brown, or lavender, or even show a marbled effect. The starch grains are very much smaller than those of potatoes and most other common starchy food materials. The roots also contain a gummy substance which sometimes interferes with extracting the pure starch if ordinary methods are used. These points, however, are more important in connection with starch manufacture than with the value of these roots as human food.

Recipes for cooking dasheen have appeared in earlier publications of this department.[2] Their composition, as given in the table on page 27, shows that, like the other starchy roots described in this bulletin, their nutritive value depends on carbohydrates and mineral matter rather than on protein and fat.

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[1] U. S. Dept. Agr., Bur. Plant Indus. Bul. 164 (1910) ; U. S. Dept. Agr., Bur. Plant Indus. Doc. 1110 (1914), pp. 11.

[2] U. S. Dept. Agr., Bur. Plant Indus. 1110 (1914), p. 11.

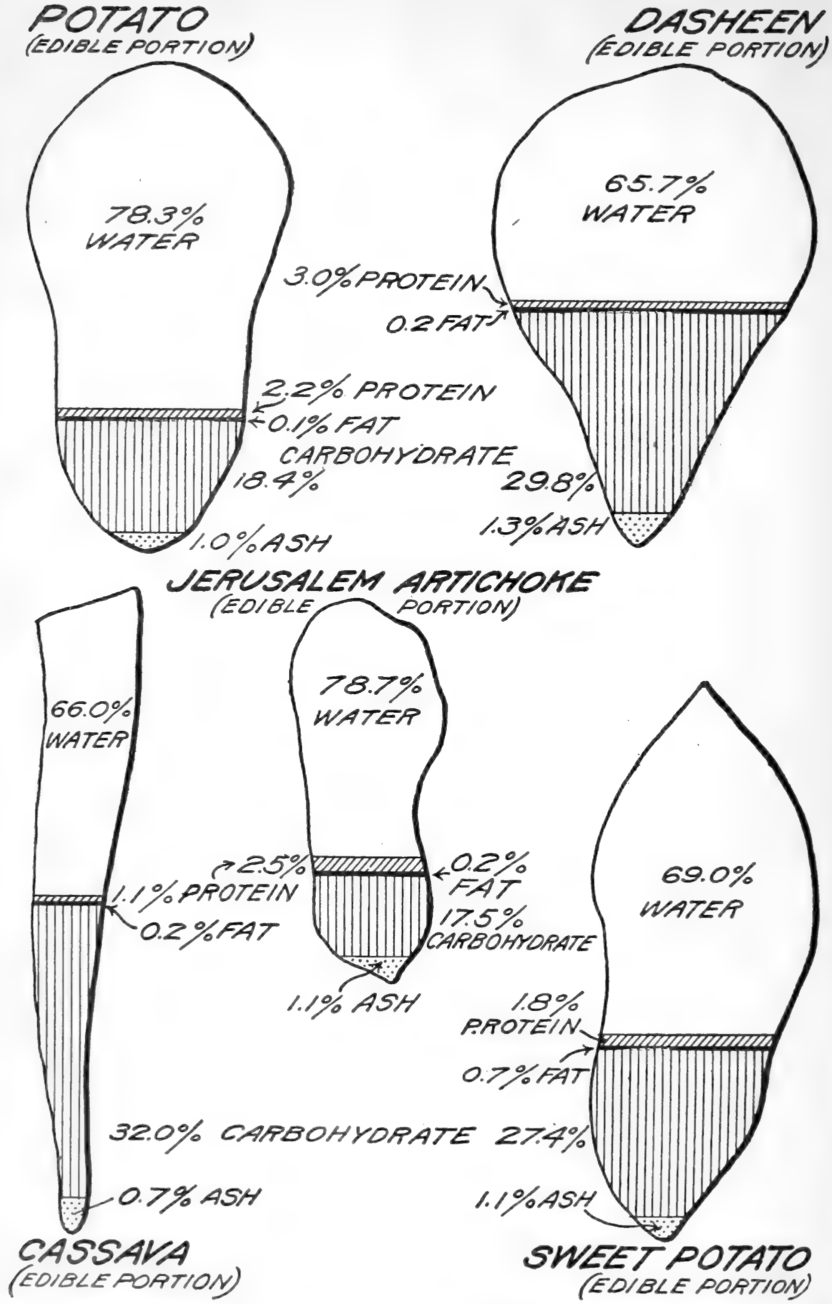

FIG. 6.—Composition of common starchy root vegetables. These outline figures show diagrammatically the proportion of nutrients present. Plain white indicates water and the differently shaded portions protein, fat, carbohydrates, and ash, respectively.

COMPOSITION AND ENERGY VALUE OF TROPICAL STARCHY ROOTS AS COMPARED WITH POTATOES AND SWEET POTATOES.

Table III shows the composition of the tropical starchy roots as compared with potatoes and sweet potatoes.

TABLE III.—*Average composition of edible portion of dasheen and other tropical starch-bearing roots.*

Kind of food.	Water.	Protein.	Fat.	Total carbohydrates.		Ash.	Fuel value per pound.
				Sugar, starch, etc.	Crude fiber.		
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Sweet cassava	66.0	1.1	0.2	30.2	1.8	0.7	610
Cassava starch	10.5	.5	.1	88.8		.1	1,625
Cassava bread	10.5	9.1	.3	79.0		1.1	1,610
Cassava cakes or wafers	10.3	1.1	.2	85.2	1.6	1.6	1,605
Yams	72.9	1.8	.2	23.3	.6	.9	475
Dasheen	65.7	3.0	.2	28.8	.7	1.3	605
Taro	70.9	1.8	.2	23.2	.8	1.2	475
Yautia	70.0	2.2	.2	26.1	.6	.9	530
Potatoes for comparison	78.3	2.2	.1	18.0	.4	1.0	380
Sweet potatoes for comparison	69.0	1.8	.7	26.1	1.3	1.1	560

The preceding diagram (fig. 6) shows in graphic form the composition of sweet potatoes, Irish potatoes, and other starchy roots, and perhaps makes clearer data such as are recorded in the table.

It is apparent from the diagram that these typical starchy roots are very similar in general composition. Degree of ripeness, length of storage, and other factors influence water content considerably. Individual specimens of any one of them would vary more or less in water content, but on the average water makes up about two-thirds to three-fourths of the total, while carbohydrates constitute the greater part of the nutritive material. These vary in the different groups, starch being the characteristic carbohydrate of potatoes, cassava, and dasheen; sugar and starch of sweet potatoes; and inulin, levulin, and pectose bodies of Jerusalem artichokes. The proportion of protein in these roots is small, but valuable in nutrition, in part because of the vitamins believed to accompany the nitrogenous material. The proportion of ash is actually small, though relatively large as compared with other foods. As a group, starchy roots are a

FIG. 7.—Energy value of some common starchy vegetables.

wholesome, palatable, and useful food, and can be prepared for the table in many acceptable forms without undue labor or fuel.

The starchy roots are important in nutrition as sources of energy. Figure 7 shows in graphic form the energy value of some of the more common of such vegetables.

As the diagram shows, the energy value varies from about 400 to 600 calories per pound. In general, the drier the root the higher the energy value, which means that potatoes, for instance, which have been harvested and dried out may have an energy value considerably higher than the value here cited as an average.

CONCLUSION.

All these starchy tubers and roots—potato, sweet potato, Jerusalem artichoke, cassava, yam, dasheen, yautia, and taro—yield the body little protein to supply nitrogen needed for building body tissue and little energy-producing fat, but on the other hand their fine-grained starch and other carbohydrates supply easily digested energy-yielding nutritive material and small quantities of valuable mineral matters which help to build the bones and are useful for other physiological purposes. Thanks to the ease with which most of them are cultivated, they are among the cheaper of our vegetables, while their usually mild flavors and the variety of ways in which they may be prepared make it possible to serve them in many combinations. They merit their extensive use because they make healthful supplements to other classes of food found in the usual mixed diet, and because they are economical and agreeable sources of body energy.

PUBLICATIONS OF THE DEPARTMENT OF AGRICULTURE OF INTEREST IN CONNECTION WITH THIS BULLETIN.

Yearbook 1900, The value of potatoes as food.

Farmers' Bul. 142, Principles of nutrition and nutritive value of food.

Farmers' Bul. 167, Cassava.

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