The Art of Drying Vegetables

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Preserving food by reducing its water content is an old art. Dried raisins and figs were used in ancient times. The American Colonists cut corn from the cob in the sugar stage and dried it in the oven. Dried meat was a food many centuries ago. Thus the art of dehydration preceded the science.

We know today that dried foods keep simply because the molds, yeasts, and bacteria in or on the foods are deprived of the water necessary for their growth. The foods are not free from live micro-organisms, but as long as the water content is kept low and the concentration of sugars and other solutes is high, the micro-organisms cannot multiply and thus give rise to fermentation or putrefaction. Conversely, the addition of water makes a dehydrated food perishable and, depending on temperature and rate of microbial growth, the rehydrated food will sooner or later harbor active micro-organisms and undergo spoilage. Because enzymes, the compounds necessary for life processes, may not be inactivated by removal of water and may bring about undesirable changes in appearance, composition, and flavor of the dried product, special methods to inhibit their activities generally must be employed. (Onions and garlic are exceptions.)

In Napoleon's day the necessities of war launched the canning industry; the Civil War saw the beginning of vegetable dehydration in the United States. In the South African War (1899–1902), some dehydrated foods were used by the British, who, as noted by Kipling, had already experimented with pea sausage (Erbswurst). The First World War greatly stimulated the production of dehydrated food; about 9 million pounds of potatoes (the largest single item), carrots, onions, turnips, and soup mixtures were shipped to the army overseas. As the foods were often of indifferent quality and appealed but little to civilians, production fell off after the war. A few specialties like dried onions and soup mixtures continued to find a market, but the total value of dehydrated vegetables produced in the United States in 1937 had shrunk to less than $150,000. The Second World War gave a tremendous impetus to vegetable dehydration. The pack in 1944 was nearly 209 million pounds, of which about 40 percent was white potatoes.

This growth was not, however, haphazard. It was guided by research in the Department of Agriculture and other agencies. The aim was to develop a sound technology to replace rule-of-thumb methods, so that the dehydrated products for the Armed Forces and lend-lease would be of better quality than before. To this end, extensive studies were made of the suitability of raw material, the effect of handling practices and method of preparation on the quality of the dried product, dehydration systems and their operation, sanitation, reconstitution of the foods, their appraisal, determination of nutritional values, packaging methods, and deterioration of commodities during storage.

Two training schools, each lasting 2 weeks, were held by the Department in 1942. They offered plant operators courses in the application of scientific findings to practical dehydration. Also, in 1944 the Department issued a 218-page manual for the guidance of the industry. As was foreseen, however, packs of dried foods decreased with the coming of peace. The national output of dehydrated vegetables for 1947 was the comparatively small total of 51 million pounds, made up almost entirely of potatoes, peppers, onions, garlic, and carrots.

Some people have the mistaken idea that inferior vegetables will do well enough for dehydration. It is true that potatoes and onions, because of their good keeping qualities, need not be freshly harvested to yield a good dehydrated product, but the green vegetables should literally be harvest-fresh. The reason is that vegetables continue to respire and deteriorate in quality after they are harvested. Peas, for example, quickly lose their sugar, and spinach its vitamin C, on standing. Furthermore, if vegetables are held for more than a few days, even at low temperatures, there is a possibility of incipient spoilage by growth of bacteria. Cull vegetables as a rule are unsatisfactory because of excessive wastes in preparation. It is well recognized that operators of dehydration plants should either grow the vegetables themselves or contract with local growers to supply material of known history and sound quality. Reliance cannot be placed on open-market purchases.

Not all vegetables are suitable for dehydration. For example, asparagus when dried does not rehydrate well and it is tough and unappetizing. Other vegetables that are not very well suited to dehydration, or at least have not been commercially dried in quantity, are brussels sprouts, cauliflower, and squash.

The better adapted vegetables are white potatoes, sweetpotatoes, cabbage, carrots, beets, peppers, onions, garlic, parsley, snap beans, green lima beans, sweet corn, and green peas.

Maturity of vegetables for dehydration is fully as important as for canning or freezing. White potatoes stored until their sugar content is high become dark when dehydrated. Woodiness in carrots and beets, or stringiness in snap beans, are serious raw-material defects that will appear in the finished product. Practical experience has amply shown that dehydration is in no sense a leveling or remedial process. It preserves defects as well as good qualities.

One of the outstanding differences in vegetable dehydration during the two world wars lies in the blanching, or preparatory heating operation. Most of the vegetables dehydrated in 1917 to 1919 were not blanched—scalded, that is. Most of those prepared from 1942 on were. Authorities agree on the value of blanching, except for onions and garlic. The advantages are easier drying, reduction of bacteria, better retention of vitamins and color, and quicker reconstitution. These outweigh the disadvantages of additional time and expense and some loss of extractives that blanching may entail.

Blanching is preferably done in steam. The times and temperatures must be carefully regulated according to the product. Underblanching does not inactivate enzymes. Overblanching destroys the texture of the vegetable and causes excessive leaching of nutrients.

Many types of food driers are in use. Some are suitable for specific purposes only. The operator selects a type combining the requirements of proved efficiency for his products and economy in operation. There are six main types of driers.

Spray driers consist essentially of a chamber into which the liquid or very finely divided material is fogged into currents of heated air. The product dries as it falls and is recovered in a collecting chamber. The system is adapted to juices and pulps.

In a drum drier the product is dried on the outside surface of internally heated cylinders and scraped off in powder or flake form.

The type in which the drying takes

place inside a revolving cylinder is generally called a rotary drier. In it, a current of heated air flows through the drier along with the wet material. Drying takes place as the material tumbles through the hot air.

Compartment driers have a drying chamber divided into several compartments in which stacks of loaded trays are run. A main duct carries heated air, which is diverted to each compartment. The air usually moves across the trays and may be discharged or reheated for further use. Compartment driers are especially suitable for small-scale operations.

Tunnel driers are the most widely used type for dehydrating vegetables. A typical tunnel is 40 feet long, 6 feet high, and 6 feet wide. It can be built of metal or of concrete and hollow tile. The product to be dried is spread on slatted trays of wood or metal, which are stacked on trucks. The tunnel accommodates 6 to 14 or more trucks. The whole string of trucks is periodically moved along one step, and a truckload of dry product is taken out at one end of the tunnel. A truck loaded with the freshly prepared vegetable is then run in at the other end. A high-capacity blower forces a strong current of heated air lengthwise in the tunnel through the spaces between the loaded trays.

The conveyor, or draper, type of tunnel drier is becoming increasingly important. In such driers, the product is spread an inch or more deep on a perforated metal conveyor belt, which moves slowly through the drying chamber. Heated air is forced through the perforations in the conveyor and through the layer of moist food. At the point where the conveyor leaves the drying chamber, the dry product falls into a collecting hopper.

Oil, gas, or coal can be used as fuel. The simplest system, direct heating, is widely used where gas or clean-burning oil distillate is relatively cheap. Hot air from the combustion chamber is mixed with fresh or recirculated air to moderate its temperature and then passed directly into the drying area. Indirect heating, requiring more complicated equipment, must be used if coal or heavy oil is the fuel. The most satisfactory indirect-heating system is a combination of steam boiler and steam radiator. In some of the older dehydrators, the air is heated by circulation over an extensive system of sheet-metal flues, which carry the hot gases of combustion from an oil-burning furnace.

The countercurrent system of air flow is the one most widely used. As the hottest and driest air is in contact with the nearly dry product, the low moisture content that is necessary for good keeping quality in dehydrated vegetables may be more certainly reached or approached. The allowable temperature of the hot air entering the tunnel is set by balancing several considerations. The hotter the air, the shorter will be the drying time and the greater will be the drying capacity of the dehydrator. The risk of scorching the product also will be greater. In practice, the best compromise has been found to lie in the range between 120° and 170° F., depending on the sensitivity of the particular vegetable to scorching.

Attainment of a sufficiently low moisture content is sometimes so difficult that a secondary final-drying step is necessary. A moderate degree of further drying—and, often more important, an equalization of moisture content and elimination of wet spots in the primary product—can be attained in a bin drier. The product from the dehydrator is charged several feet deep into a bin having a perforated bottom, and slightly warm, very dry air is blown up through the mass for several hours.

During the Second World War an entirely different method of final drying—desiccation in packages—developed by the Department of Agriculture reached the point of large-scale tests. Along with the normally dehydrated product, such as diced white potatoes, a small package of a strong water ab-

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sorber, such as quicklime, is packed in the hermetically sealed metal shipping cans. In the course of several months of storage at ordinary temperature, water vapor diffuses from the vegetable pieces to the lime, and the moisture content of the food is reduced by 3 or 4 percent.

The operator of a dehydration plant must give constant thought to sanitation. His aim should be to produce a food as free from micro-organisms and foreign matter as possible. The plant must be kept rodentproof and insectproof. Because particles of vegetables left on the preparation line soon harbor enormous numbers of bacteria, making them a source of contamination to products being handled, all machinery and carrying belts should be frequently cleaned. Plenty of hot water, a good cleanser, scrubbing brushes, and willingness to use them are indispensable. All water used should be safe to drink. Frequent removal of waste, such as trimmings and peelings, should be routine. Finally, only healthy persons should be allowed to work, and they should be encouraged in cleanly personal habits by the provision of washrooms that are convenient, adequate in size, and well appointed.

The disposal of wastes from a dehydration plant may tax the ingenuity of the sanitary engineer. Solid wastes, such as peelings, may be used for stock feed, but the voluminous liquid wastes, which contain soluble or finely divided organic matter from the washing of cut vegetables, often present a problem. It is inadvisable to run them into a stream or ditch, for the organic matter combines with dissolved oxygen in the water, so that anaerobic fermentation, which stinks and creates a public nuisance, takes place. Public sewage systems as a rule are unavailable.

Sometimes the waste water can be run into lagoons, from which it will seep away if the soil is deep and open. If that cannot be done, the engineer must fall back on a system of screening, chemical treatment, and settling in a tank. The liquid from the tank may be used for irrigation, though sometimes it must be passed over trickling filters, which permit aeration. Because a dehydration plant, using, say, 100 tons of potatoes a day, may give rise to as much waste organic matter as is contained in the sewage from a town of 40,000 population, the problem of waste disposal clearly does not admit of haphazard solution.

In drying white potatoes, the most important dehydrated vegetable, operators pay much attention to the quality of the raw material. New potatoes are not suitable. If the potatoes have been stored for a time at about 40° F., their sugar content may be too high and give rise to a dark color on drying. The condition may be rectified by holding them at about 65° F. for a few weeks.

The preliminary step is washing, usually in a "squirrel cage" machine equipped with sprays. Peeling processes were improved materially during the Second World War. Abrasive methods were generally abandoned because of excessive waste. Peeling by immersion for a few minutes in a boiling dilute caustic soda solution was widely used, and is still considered a satisfactory method. It has been partly superseded, however, by a method that loosens the potato skins by subjecting the potatoes to steam under pressure for several minutes and then quickly releasing the pressure. Subsequent spraying to remove the split and loosened skins should be prompt and thorough. Hand trimming to remove eyes and discolored spots follows. Peeling and trimming losses may run from 10 to 25 percent.

The peeled and trimmed potatoes are mechanically cut into slices not more than a fourth of an inch thick, strips not less than three-fourths of an inch in length and not more than three-eighths of an inch wide or thick, or cubes from three-sixteenths to three-eighths of an inch on a side. Surface starch is washed off in strong sprays. Cut potatoes are susceptible to discoloration; hence delays between operations must be avoided. The potato pieces are blanched, usually on a wire belt moving in a tunnel fitted with steam outlets above and below it. The operation is complete when a test for the enzyme peroxidase is negative. At that point, the product is sometimes exposed to a spray of dilute sodium sulfite solution. The slight amount absorbed helps prevent darkening of the final product and deterioration of its flavor during subsequent storage, especially if the storage temperature is relatively high. The potato pieces are loaded onto trays, care being taken to insure uniformity and suitable weight, usually about 2 pounds to the square foot.

Experience shows that during drying the temperature of potato pieces should never exceed 150° F. The rate of drying is far from constant. Loss of moisture is rapid for the first hour, but soon slows up. In the process, marked changes take place in the product. At first plump and tender, the pieces shrink in size, are distorted in shape, become firm, and end up hard, somewhat glassy, and brittle. One hundred pounds of prepared pieces entering the drier will yield about 22 pounds of dried product.

The drying of other vegetables is not essentially different from that of potatoes, although the preparation varies with the product.

For example, cabbage is trimmed, cored, and cut by machine into ¼-inch strips. Blanching time is about 2 minutes in flowing steam. Cabbage, like potatoes, is sometimes treated with sodium sulfite to give better stability during storage.

Onions and garlic do not require blanching but may be injured by a temperature above 140° F. Also, as their moisture content should not exceed 4 percent, drying is usually finished in a bin.

Yields of dried products vary with the commodity. Based on the weight of the raw unprepared product, they range from 4 to 10 percent for cabbage, to 20 to 30 percent for sweetpotatoes.

Dried vegetables are bulky. The idea of compressing them to save storage and shipping space was tried by all the warring nations during the Second World War. With pressures of about 650 pounds to the square inch, it is possible to produce blocks weighing 55 pounds or more per cubic foot. Except with potatoes, there is no perceptible loss in quality from the process.

PACKAGING dehydrated vegetables is more important and more difficult than you might think. The ideal container is strong enough to withstand rough handling, a quality especially important in supplying soldiers on combat duty. It should permit hermetic sealing. It should resist penetration of moisture and be capable of retaining carbon dioxide or nitrogen, when gas packing is practiced. It should remain unaffected by normal extremes of heat and cold. Obviously, too, it should be insectproof and verminproof, and impart no foreign odor or flavor to the product.

Only a metal container satisfies all these requirements. Steel is scarce in wartime, and a perfect substitute has not been found. Single-sheet materials, even when heavily waxed, break down under rough treatment. Laminations of two or more sheets are better, but a lacquered fabric built of different materials, including metal foil and asphalt, is the most satisfactory. A bag of that sort will hold a partial vacuum when properly heat-sealed. When it is encased in a stout shipping container, it will withstand a good deal of abuse. Requirements for small-package retail distribution are naturally less exacting than those for overseas shipment.

DIRECT HOUSEHOLD USE of dehydrated vegetables is confined almost entirely to dehydrated soup mixes and certain condiments, such as onion salt, garlic salt, and chili powder. Substantial quantities of dehydrated potatoes and onions are, however, being used in such manufactured foods as corned-beef hash and catsup. Dehydrated potatoes and potato flour were among the foods flown into blockaded Berlin.

Packages of dehydrated vegetables usually have directions for use printed on the labels. Theoretically, as much water should be added as was removed in dehydration, plus enough to permit cooking without scorching. Fleshy vegetables, such as beets, carrots, and potatoes, can be reconstituted by soaking in cold water for about 30 minutes and boiling until tender. Leafy vegetables, like spinach and cabbage, are usually dropped directly into the cooking water. One pound of reconstituted vegetable is derived from about 2.4 ounces of dried beets, 2.7 ounces of potatoes, 3.3 ounces of carrots, and 1.5 ounces of cabbage.

Dehydration causes a concentration of proteins, fats, carbohydrates, and minerals. A loss of vitamins—hardly significant in some cases, but rather serious in others—has been reported. Further reduction in vitamin content occurs during storage. These facts should not be urged too strongly against dehydrated vegetables, because vitamin impairment follows other methods of preservation, as well as the standard methods of transporting and handling fresh produce. Also, it is possible that with wider choice of raw material, better handling and preparation, and improved packaging and storage, both the nutritional value and palatability of dehydrated vegetables will increase.

Granted good uniform quality and long shelf life, dehydrated vegetables should prove a great deal more than a wartime expedient, and could become the basis of a stable industry of considerable importance in the economic life of the Nation.

A NEW PROCESS of vegetable preservation, dehydrofreezing, has been under study by the Department of Agriculture for some time. The method partakes of both dehydration and freezing, the object being to effect economies in packaging, storage, and transportation, without altering the essential fresh quality of the vegetable. The water content of vegetables runs from 75 to 90 percent. Advantage is taken of the fact that in dehydration the evaporation of water is at first rapid and economical. Weight reductions in vegetables up to 40 or 50 percent are easily effected. At about 30 percent weight reduction, the product is little distorted. In particular, peas dehydrofrozen under pilot-plant conditions reconstitute well and are excellent in appearance, texture, and flavor. Also, potato slices and strips dehydrofrozen when the sugar content is optimum are superior for the production of chips and french-fries.

The water content in the partly dehydrated product is still high enough to permit growth of bacteria, yeasts, and molds; therefore the vegetables must be promptly frozen and stored at −10° to 0° F., like other frozen foods.

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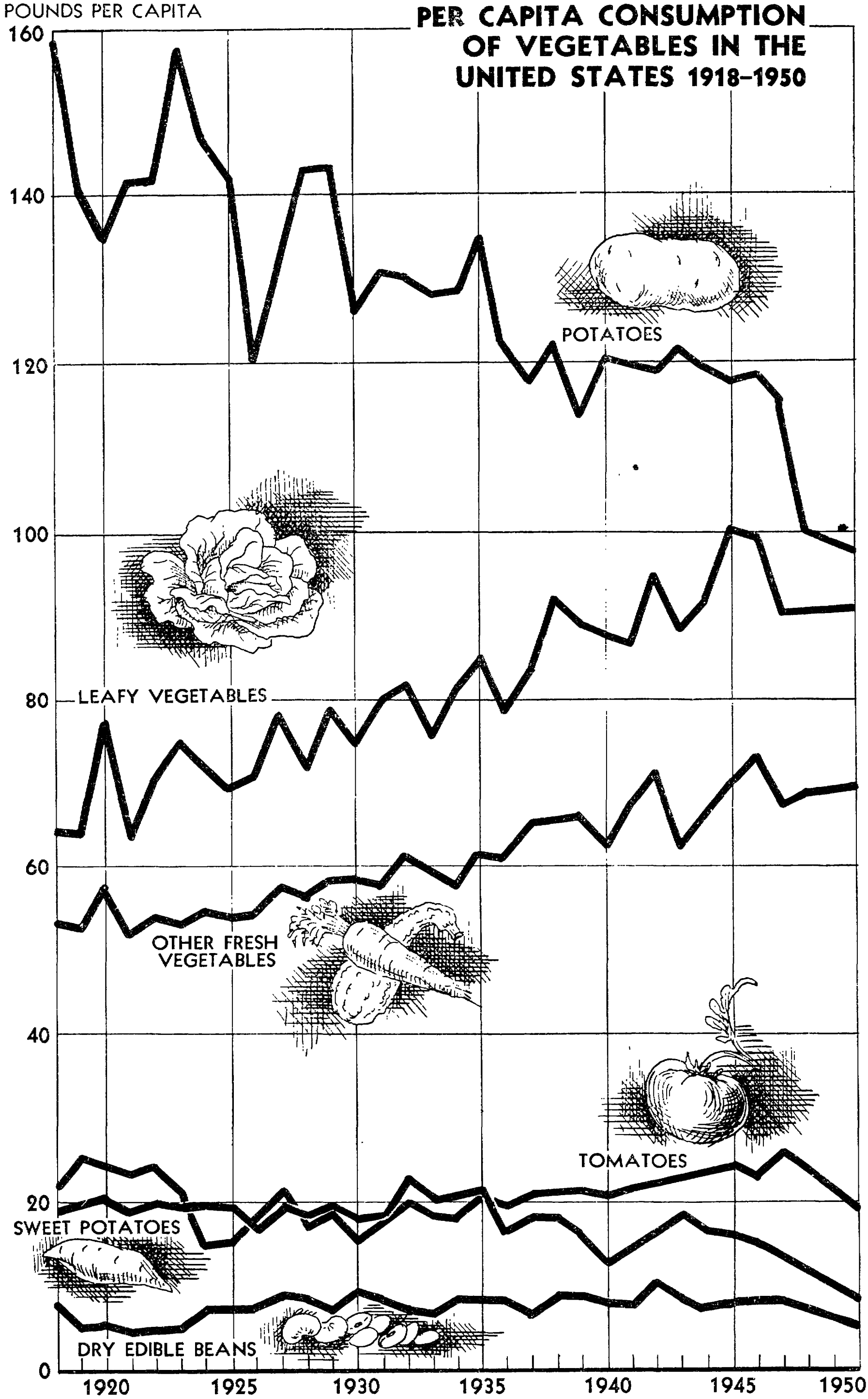
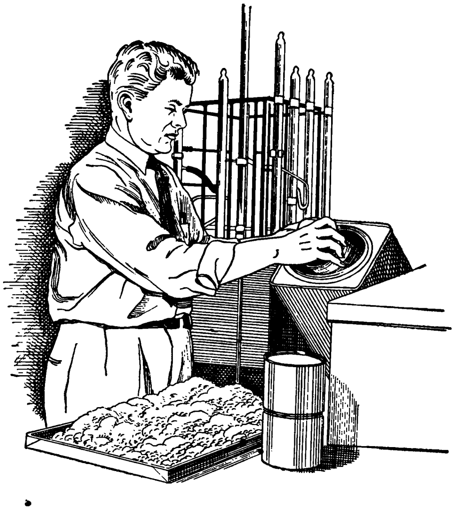
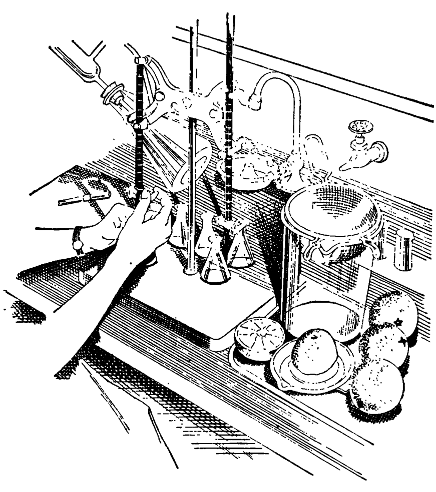
THE ARMY put lemon powder in the K-ration as a source of vitamin C. The soldier considered it a drink and did not always use it—practically never unless the water was cold. But he found other uses for it: To bleach summer uniforms, clean stoves and floors, and reduce a supposed moldy taste in bread. He used the powder as a hair rinse and, in Italy, he combined it with GI carbonate tooth powder to make biscuits.—*Paul E. Howe, Bureau of Animal Industry.*


POUNDS PER CAPITA
PER CAPITA CONSUMPTION OF VEGETABLES IN THE UNITED STATES 1918–1950
160
140
120
100
80
60
40
20
0
POTATOES
LEAFY VEGETABLES
OTHER FRESH VEGETABLES
TOMATOES
SWEET POTATOES
DRY EDIBLE BEANS
1920
1925
1930
1935
1940
1945
1950

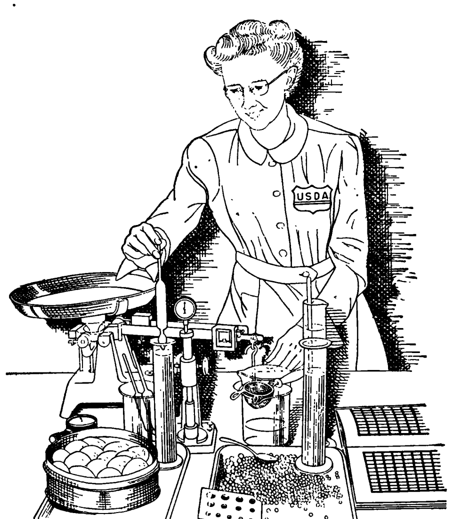


An experiment to see if calcined lime can lengthen the storage life of dehydrated potatoes.

A patron removes some of the food placed earlier in a freezer storage locker.



A food chemist determines by titration the vitamin C value of orange.



An inspector tests the quality of canned apricots and peas.