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vegetable processing

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Vegetable

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vegetable processing, preparation of **vegetables** for use by humans as **food**.

Vegetables consist of a large group of plants consumed as food. Perishable when fresh but able to be preserved by a number of processing methods, they are excellent sources of certain minerals and vitamins and are often the main source of **dietary fibre**. The consumption of vegetables has increased significantly as consumers have become more health-conscious. Owing to the perishable nature of the fresh produce, **international trade** in vegetables is mostly confined to the processed forms.



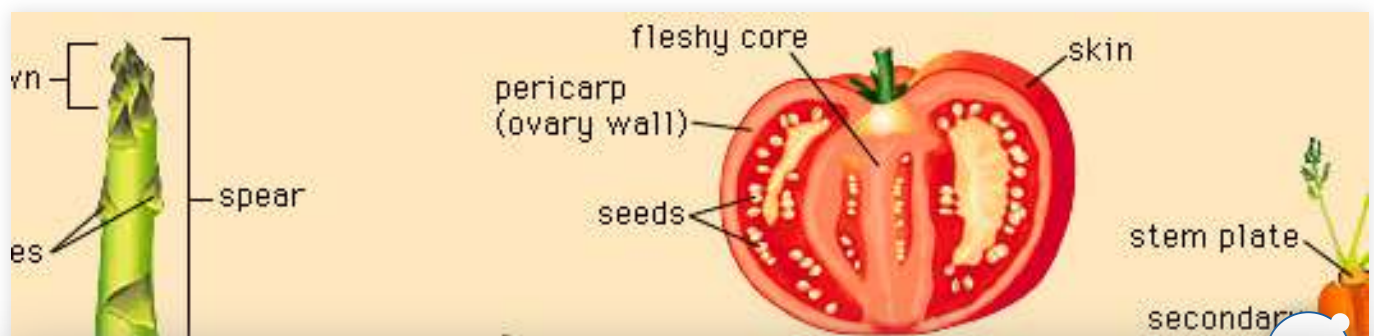
BRITANNICA QUIZ

A Few Facts About Food Processing Quiz

How much do you know about where your food comes from? What about the science behind food processing? Test your knowledge of what you eat in this quiz.

Structure and composition

Vegetables can be classified by edible parts into **root** (e.g., potatoes and carrots), **stem** (asparagus and celery), **leaf** (lettuce and spinach), immature flower bud (broccoli and brussels sprouts), and fruit (tomatoes and cucumbers). The four basic types are illustrated in **Figure 1**.





vegetable structures

Structures of four representative vegetables.

Image: Encyclopædia Britannica, Inc.

Aging and spoilage

Depending on the class of [vegetable](#), there are differences in the structure, size, shape, and rigidity of the individual cells. The fresh market shelf life and processing requirements are also very different. Vegetable cells, as [plant cells](#), have rigid cell walls and are glued together by various polysaccharides such as cellulose, hemicellulose, and pectin. Once vegetables are harvested from the fields, the cells, now deprived of nutrient supplies normally obtained from soils and the air, go into senescence, or [aging](#). The most noticeable structural change in senescent vegetables is softening, or loss of texture. Softening is caused by natural enzymatic reactions that degrade the [plant cell](#) walls. A large group of [enzymes](#) is involved in the senescence stage, including cellulase, pectinase, hemicellulase, proteinase, and others. After these enzymes break open the cells, chemical oxidation reactions take place and the vegetables develop off-flavours and loss of nutritional value. Broken cells are also much more easily subject to microbial attacks, which quickly lead to [spoilage](#). In addition, even though the vegetables may be packaged or bagged, the plant cells continue to respire, or break down carbohydrates for energy needs. [Respiration](#) leads to loss of quality, so that eventually the products are unsuitable for human consumption.

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Nutritional value

The four quality factors of vegetables are colour, texture, flavour, and nutritive values.

Fresh vegetables are purchased on the basis of colour and texture, but repeated purchases

thiamine, niacin, folic acid). The nutrient composition of selected vegetables is shown in the Table.

Nutrient composition of selected vegetables and vegetable products (per 100 g)*

vegetable or vegetable product	energy (kcal)	water (g)	carbohydrate (g)	vitamin C (mg)	thiamin (mg)	riboflavin (mg)	niacin (mg)	vitamin A (IU)
asparagus, canned	14	94.63	2.25	16.4	0.054	0.089	0.851	474
asparagus, raw	23	92.40	4.54	13.2	0.140	0.128	1.170	583
cabbage, raw	25	92.15	5.43	32.2	0.050	0.040	0.300	133
carrots, raw	43	87.79	10.14	9.3	0.097	0.059	0.928	28,129
Chinese cabbage, raw	13	95.32	2.18	45.0	0.040	0.070	0.500	3,000
corn, sweet, raw	86	75.96	19.02	6.8	0.200	0.060	1.700	281
corn on the cob, frozen	98	71.79	23.50	7.2	0.103	0.088	1.681	246
lettuce, iceberg, raw	13	95.89	2.09	3.9	0.046	0.030	0.187	330
peas, green, frozen	77	79.93	13.70	18.0	0.258	0.100	1.707	727
peas, green, raw	81	78.86	14.46	40.0	0.266	0.132	2.090	640
potato chips	536	1.90	52.90	31.1	1.167	0.197	3.827	0
potatoes, mashed, dry flakes	354	6.51	81.21	83.6	1.031	0.110	6.146	0
potatoes, raw	79	78.96	17.98	19.7	0.088	0.035	1.484	0
tomato juice, canned	17	93.90	4.23	18.3	0.047	0.031	0.673	556

*Values shown are approximations; actual nutrient composition can vary greatly depending on such factors as growing conditions, harvest, and storage.

Source: U.S. Department of Agriculture, Composition of Foods, Agriculture Handbook no. 8–11.

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Certain vegetables contribute **lipids** to the diet, mostly in the form of unsaturated oils. Roots and legumes can be important contributors of dietary **proteins**—especially in developing countries, where animal proteins are scarce. One potential nutritional problem of obtaining proteins from a single vegetable source is the low concentration of essential **amino acids** in vegetables. Twenty common amino acids are considered to be building blocks of proteins for the body. Of these 20, the body cannot synthesize 8; these 8 must be obtained from foods. Most vegetable proteins are low in one of the eight essential amino acids; for example, corn is low in lysine, and soybeans are low in methionine. However, if proteins are obtained from a proper mixture of vegetables, there will not be a nutritional problem.

It is a common misconception that fresh vegetables are always superior in nutritional value to processed vegetables. Several investigations have shown frozen or canned vegetables can actually have higher nutritional value than fresh products. Fresh vegetables are subject to quality and vitamin losses during transportation and storage, whereas processing before these losses occur can yield a nutritionally superior product. Research has shown that a major cause of nutrient loss in vegetables is in the draining of cooking or processing liquids.

Fresh and minimally processed vegetables

Harvesting and storing

Most leafy vegetables that do not require harvesting by mechanical device are cooled immediately after harvest to remove field heat, sorted to remove debris, washed to remove dirt, and bundled or packed for shipping and retail. In most cases vegetables are bundled as whole plants, since cutting will injure the cells and liberate ethylene, which promotes senescence and shortens shelf life. Low-temperature storage is essential in the handling

countries where refrigeration is not available, postharvest losses of fresh vegetables can be as much as half the total harvest.

For **roots** and **legumes**, the harvesting of which is normally done by machines, some sorting and grading are performed either in the field or at collection stations. Bulk handling of these vegetables is common, and few additional steps of preparation are performed before distribution. For vegetables that need to be stored for long periods of time, treatments to avoid microbial spoilage, insects, and small-animal invasion may be necessary. For some vegetables such as cucumbers, a washing and waxing step may be taken to improve the shelf life and the attractiveness of the produce.

Packaging

Provided in response to demands for convenient foods, minimally processed fresh produce has gained popularity in the marketplace. These vegetables go through additional preparation steps of washing, sorting, grading, cutting, and packaging into retail-size containers. In order to extend the shelf life of these products, vacuum packing and **modified-atmosphere** (MA) packaging are practiced. In most cases air is replaced by an atmosphere high in **carbon dioxide** and low in oxygen. This modified atmosphere can slow the respiration rate and therefore the senescence of cut vegetables. The most common products in American and European markets are various types of cut lettuces with shredded carrots, cabbages, and other vegetables. Modern packaging techniques employing “clean room” concepts make it possible for such **vegetable** products as salad mix and stir-fry mix to have shelf lives approaching those of the whole plants. The products can be shipped by refrigerated containers to overseas locations and still have a shelf life long enough to reach consumers.

Minimally processed vegetables normally do not contain any preservatives and have not gone through any heat or chemical treatment. The disadvantage of these products is that refrigeration storage is essential, limiting its practice to developed countries.

Processing of vegetables

Because of the varied growing and harvesting seasons of different vegetables at different locations, the availability of fresh vegetables differs greatly in different parts of the world. Processing can transform vegetables from perishable produce into stable foods with long shelf lives and thereby aid in the global transportation and distribution of many varieties of vegetables. The goal of processing is to deter microbial spoilage and natural physiological deterioration of the plant cells. Generally, the techniques include [blanching](#), dehydrating, canning, [freezing](#), fermenting and pickling, and irradiating.

Blanching

After vegetables have been washed clean, they must undergo blanching (heating) in hot water at 88 °C (190 °F) for two to five minutes or with steam in a conveyor at 100 °C (212 °F) for one-half to one minute. Blanching inactivates natural enzymes that would cause discoloration and off-flavours and aromas. It also serves to reduce the number of microorganisms and to render vegetables limp for easy packing into containers. For some vegetables, such as spinach, snap beans, and collards, the blanching step also serves to remove harsh flavours.

After blanching the vegetables must go through rapid cooling in either cold water or cold air for better quality retention. The vegetables are then ready for the various food-processing methods described below.

Dehydration

Drying is probably the oldest method of preserving foods. The removal of water from

water is a reduction in volume and weight, which aids in storage and transportation of the dried products. Modern drying techniques are very sophisticated. Many machines are available to perform tunnel drying, vacuum drying, drum drying, spray drying, and [freeze-drying](#). Although freeze-drying produces a [food](#) of outstanding quality, the cost is high, and it has not been used widely in vegetable products.

One of the most familiar dehydrated products is instant potatoes. Almost all the mashed potato dishes served in restaurants and institutions are rehydrated instant potatoes. In restaurants and institutions dehydrated potato granules are used, while dehydrated flakes are preferred for home cooking. Potato granules have high bulk density and are easy to handle in large quantity. However, they produce mashed potatoes with a pasty texture—an effect caused by the rupture of cells during processing, so that starch is released from the cells. Mashed potatoes made from flakes, on the other hand, have a mealy texture comparable to that of freshly prepared mashed potatoes. The major difference in the processing of these two dehydrated products is in the drying steps. For granules, air-lift drying is used to bring the product to 10–13 percent moisture. After screening to proper granule size, the product is dried to 6 percent moisture in a fluidized-bed drier. In the making of flakes, a steam-heated drum drier is used to bring a flattened sheet of potato solids to final moisture content before it is broken into a suitable size for packaging. Although a considerable quantity of the potato cells are ruptured during the breaking of the dried sheet, the reconstituted product has an acceptably mealy texture because the potatoes are subjected to a precooking and cooling treatment as well as the addition of a monoglyceride emulsifier.

A small amount of [sulfite](#) may be used in producing certain dried vegetables. The sulfite serves as an [antimicrobial agent](#), aids in [heat transfer](#), and (in the case of potatoes) acts as a blanching agent. A small percentage of the consumer population is allergic to sulfite. Although the rehydrated product contains little or no sulfite, consumer concerns are forcing the industry to search for economically [feasible](#) sulfite replacements.

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and put through severe **heat treatment** to ensure the destruction of bacteria spores. The containers are sealed while hot so as to create a vacuum inside when they are cooled to room temperature. Properly processed canned vegetables can be stored at room temperature for years. Minor defects of the process, however, will result in **bulged** cans after long periods of storage. For safety reasons, the contents of these cans should not be consumed. Although in most cases bulged cans are caused by the formation of gas from chemical reactions between the metal cans and their acidic contents, there is a remote possibility that inadequate heat processing did not destroy all bacteria spores. And, even though most heat-resistant spores are nonpathogenic, spores of *Clostridium botulinum* can survive underprocessing and produce deadly toxins that cause botulism.



home canning

Preserved vegetables and fruits processed through home canning.

Image: Library of Congress, Washington, D.C. (Digital File Number: LC-DIG-fsac-1a35476)

Unfortunately, because of the severe heat treatment, some canned vegetables can have inferior quality and less nutritive value than fresh and frozen products. The nutrient most susceptible to destruction in canning is **vitamin C**.



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For high-quality products, **aseptic canning** is practiced. Also known as high-temperature–short-time (**HTST**) processing, aseptic canning is a process whereby presterilized containers are filled with a sterilized and cooled product and sealed in a sterile atmosphere with a sterile cover. The process avoids the slow heat penetration inherent in the traditional in-container heating process, thus creating products of superior quality.

The canning process can be illustrated by the example of **green beans** (*Phaseolus vulgaris* L.). After arrival at the processing plant, the beans are conveyed to size graders. Graders consist of revolving cylinders with slots of various diameters through which the beans fall onto conveyers. The conveyers carry them to snipping machines, where their tips and

marketed as French-cut beans. Both the small whole and cut beans are blanched for $1\frac{1}{2}$ to 2 minutes in 82 °C (150 °F) water and mechanically packed in cans. The cans are then filled with hot water and dry salt or with brine, steam-exhausted for approximately five minutes, and sealed while hot or with steam flow. Depending on the size of the can, they are heat-processed for various periods of time—from 12 minutes at 120 °C (250 °F) to 36 minutes at 115 °C (240 °F). The cans are cooled to room temperature, labeled, and packaged for storage or immediate distribution.

Freezing

Frozen foods have outstanding quality and nutritive value. Indeed, some frozen vegetables, such as green peas and sweet corn, may be superior in flavour to fresh produce. The high quality of frozen foods is mainly due to the development of a [technology](#) known as the individually quick-frozen (IQF) method. IQF is a method that does not allow large ice crystals to form in [vegetable](#) cells. Also, since each piece is individually frozen, particles do not cohere, and the final product is not frozen into a solid block. Various freezing techniques are commonly used in the preservation of vegetables. These include blast freezing, plate freezing, belt-tunnel freezing, fluidized-bed freezing, cryogenic freezing, and dehydrofreezing. The choice of method depends on the quality of end product desired, the kind of vegetable to be frozen, capital limitations, and whether or not the products are to be stored as bulk or as individual retail packages.

Most vegetables frozen commercially are intended for direct consumer use or for further processing into soups, prepared meals, or specialty items. Advances in packaging materials and techniques have led to bulk frozen products being stored in large retortable pouches. Many restaurants and institutions prefer bulk frozen soups packaged in these pouches because of their quality and convenience.

One of the most important vegetable crops preserved by freezing is [sweet corn](#) (*Zea mays* L.). Both corn on the cob and cut corn are frozen. Sweet corn must be harvested while still young and tender and while the kernels are full of “milk.” After the ears are mechanically harvested, they are promptly hauled to the processing plant, where they are automatically dehusked and desilked. Probably more than any other vegetable, sweet corn loses its quality rapidly after harvest. Frozen corn maintains high quality by being processed w

minutes and then promptly cooled. However, even an 11-minute blanch in steam does not completely inactivate all the enzymes in the cob portion. It is believed that the off-flavour frequently found in home-frozen corn on the cob comes from off-flavours produced in the cob that migrate out to the kernels. **Blanched** and cooled corn is quickly frozen by the fluidized-bed freezing process before packing. Blanched whole-kernel corn is produced either by blanching the corn on the cob before cutting; by partially blanching on the cob to set the milk, then cutting and blanching again; or by cutting before blanching. The “split” method of blanching twice produces the highest-quality product. After the corn is cut, impurities such as husk, silk, and imperfect kernels must be removed by either brine flotation or froth washing. In both methods the sound corn stays at the bottom while the impurities float off the tank. Whole-kernel corn can be frozen quickly using the individually quick-frozen method. Frozen corn can be packaged into polyethylene bags or cardboard cartons and labeled for retail, or it can be bulk-stored for further processing into components of value-added products such as frozen dinners.

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