

Farmers' markets provide an array of high-quality vegetables fresh from the fields. Courtesy of Plycon Press.

# 5 Vegetables

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## Key Concepts

1. Vegetables are important in meals to provide not only an array of minerals and vitamins but also color, flavor, and textural contrasts.
2. Various parts of plants are eaten as vegetables, either raw or cooked (e.g., boiled, steamed, roasted, or fried).
3. Careful selection and handling of fresh, frozen, and canned vegetables are necessary to procure the desired quality.
4. Preparation of vegetables should be done to optimize sensory qualities (color, aroma, flavor, and texture) and to retain nutrients.

Vegetables contribute color and nutrients to meals. They contain fiber and **phytochemicals** such as beta-carotene and lycopene that may play protective roles in reducing the risk of such potential health problems as cancer and heart disease (Figure 5.1). Vegetables are not only rich sources of these important compounds, but they also contain significant amounts of other vitamins and minerals. Add to this health note the fact that vegetables generally are quite low in calories, and it is little wonder that they are popular.

Vegetables have the potential for adding wonderful colors, textures, and intriguing flavors to a meal. Imagine how drab the main course of a meal would be if the bright red of a tomato, the striking orange of carrots, the intense green of broccoli, the pearly white of cauliflower, or some other color accent were absent. Slightly crisp cooked green beans, fluffy mashed potatoes, or the crunch of a celery strip add essential textural interest to a meal. And what would many meals be without the flavor lift of an onion, sweet corn, or green pepper?

High-quality preparation of vegetables may seem to be a challenge at first, but they can be truly beautiful to look at and appealing to eat if prepared well. Unfortunately, they also can be ruined by poor cooking techniques. Mastery of vegetable cookery is an essential aspect of the study of foods. Exciting color, flavor, and textural contrast can be added to a meal when vegetables are selected and prepared with imagination and skill.

### **phytochemicals**

Substances contained in plants that provide some protection against heart disease and certain cancers.

**Figure 5.1**

Tomatoes are rich sources of nutrients (e.g., vitamin C) and lycopene, a phytochemical with potential health benefits. Courtesy of Plycon Press.



## CLASSIFICATION

Today, people still debate whether some plant foods should be classified as vegetables. The argument involves foods such as tomatoes and pumpkins that are viewed by some as fruits and by others as vegetables. The confusion can, however, be resolved in good order by using the following definition of a vegetable: a plant, usually herbaceous (with little or no woody tissue), containing an edible portion that is suitably served with the main course of a meal. Corn, beans, and most other vegetables are from plants that wither after the growing season, a characteristic common to herbaceous plants. The limited sweetness of most vegetables suits these foods to the main course rather than to dessert. Thus, this definition helps to classify tomatoes as vegetables even though they are the fruit of the plant on which they grow.

Almost all parts of plants can be used as vegetables, but specific portions of the various plants are selected for use in meals. It is on the basis of the part of the plant that is eaten that vegetables are classified. For example, although the tender green tops of onions may be used, the bulb is the main portion eaten, so onions are classified as bulbs. The roots of carrots are the portion considered to be a vegetable, while tubers, leaves and stems, fruits, and seeds of various other plants are also viewed as vegetables (Figure 5.2). Table 5.1 illustrates the classification for many of the common vegetables.

**Figure 5.2**

This market offers many examples of vegetables of all types: bulbs (onions), root (beets and carrots), tubers (potatoes), leaves/stems (lettuce), fruits (eggplant), and seeds (corn). Courtesy of Plycon Press.



**TABLE 5.1**  
**CLASSIFICATION OF VEGETABLES**

Bulb	Root	Tubers <sup>a</sup>	Leaves/Stems	Fruits	Seeds
Garlic	Beets	White potatoes	Broccoli	Tomatoes	Legumes <sup>b</sup>
Leeks	Carrots	Sweet potatoes	Brussels sprouts	Eggplant	lima beans
Onions	Radishes	Jerusalem artichoke	Celery	Peppers	kidney beans
Shallots	Parsnips	Jicama	Cabbage	Okra	red beans
	Rutabagas		Chinese cabbage	Squash, summer and winter	navy beans
	Turnips		Endive		pinto beans
	Daikon		Parsley	Cucumbers	chickpeas
	Celeriac (celery root)		Cilantro	Chinese snow peas	black-eyed peas
			Leaf lettuce	Artichokes	split peas
			Head lettuce	Green beans	black beans
			Kale	Wax beans	
			Kohlrabi		

<sup>a</sup>Enlarged, edible fleshy stems growing under the ground.

<sup>b</sup>Seeds from the Leguminosae family, a family of plant unique for the ability to fix nitrogen into the soil, thus enriching the soil.

## SURVEY OF VEGETABLES

One of the pleasures of vegetables is their great variety. With the excellent transportation and storage facilities now available for marketing vegetables, it no longer is necessary to restrict menus to corn, peas, beans, and carrots. The array in some markets may be almost puzzling; the paragraphs that follow will help to identify many different vegetables and highlight their storage and preparation.

**Anise**, also called sweet fennel, is unique among vegetables because of its flavor; in fact, it can be described as licorice-flavored celery. The bulb can be eaten raw or may be cut up and cooked by boiling, steaming, or braising. Storage following purchase should be in the hydrator drawer of the refrigerator.

**Globe (or French) artichokes**, the artichoke type found commonly in U.S. markets, are actually the flower of a thistle-like plant (Figure 5.3). The globe artichoke has an edible portion at the base of each leaf and under the choke (fuzzy portion), called the heart.

[www.friedas.com](http://www.friedas.com)

—Current information regarding a variety of unusual fruits and vegetables.

<http://www.ams.usda.gov/AMSV1.0/fv>

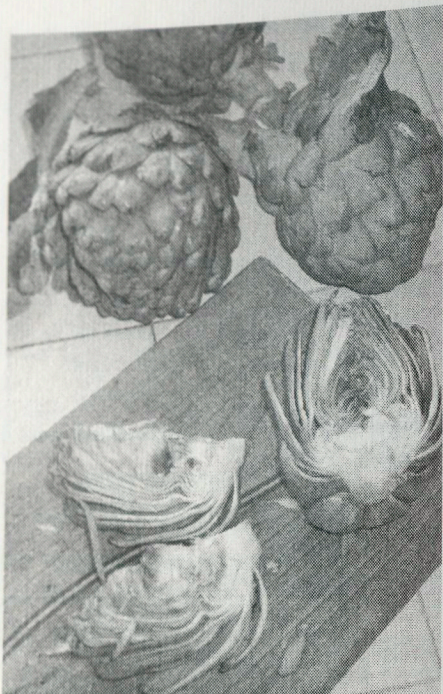
—Federal fruit and vegetable programs.



**Figure 5.3**

Globe artichokes are a type of thistle grown around the Mediterranean and also near Monterey, California, where the climate is similar.

Courtesy of Plycon Press.



**Figure 5.4**

Cross sections of artichokes reveal the edible heart, the white solid area at the base of the petals and between the purplish choke and the fibrous stem. Courtesy of Plycon Press.

[www.artichokes.com](http://www.artichokes.com)

—Information on raising, harvesting, and preparing artichokes.

[www.asparagus.org](http://www.asparagus.org)

—Website of the Michigan Asparagus Advisory Board.

These beautiful vegetables are deceptive in terms of quantity because of their limited amount of edible pulp in relation to fibrous petals and choke (Figure 5.4). However, the ceremony of dipping the base of each petal into a sauce of some type and then delicately scraping the pulp from the petal with the front teeth gives any meal a festive appeal. Globe artichokes can be stored in the refrigerator for a few days in a plastic container or in the hydrator drawer. After being boiled, steamed, or baked, globe artichokes may be served hot or cold.

**Jerusalem artichokes**, sometimes called sunchoke, are quite different and for this reason are classified as a tuber. Despite their name, Jerusalem artichokes are thought to be natives of North America. Their use ranges from raw slices in salads and garnishes to serving as a boiled or broiled alternative to potatoes.

**Asparagus**, whether green or the highly prized white, traditionally is available fresh for only a very brief period in the spring, and even then, its price is often high. For best results, storage time should be kept short, in the hydrator drawer in the refrigerator. Boiling, steaming, and stir-frying are all excellent techniques for preparing asparagus. Sometimes cooked asparagus is chilled before serving and used in salads.

**Fresh beans** often available in the market include green or snap beans, wax beans, lima beans, and fava beans (a bean similar to lima beans). Refrigerator storage should be limited to about three days, in a closed plastic bag or the hydrator drawer. Boiling, stir-frying, and steaming are suitable cookery methods.

**Dried beans** include an array of varieties: red, kidney, navy, pinto, black, pink, white, garbanzo, and lima. Unlike the other vegetables discussed here, dried beans can be stored at room temperature for several months as long as they are in their dried state. A tightly closed bag is recommended for storage in a damp climate. An extended soaking and/or cooking period rehydrates and tenderizes dried beans.

**Beets** are prized (or cursed when spilled) as a vegetable dye because of their deep red color. When harvested quite young, the greens are excellent when they are either steamed or boiled. Preparation usually involves boiling, followed by peeling and slicing. Sweet-and-sour sauces, such as the sauce used in Harvard beets, are used sometimes to heighten the flavor interest. Beet pickles are another popular means of preparing this vegetable.

**Broccoli** is a popular choice when people are seeking ways to raise the nutrient content of a meal. Not only is it nourishing, but it also is attractive on the plate, with its combination of little flowers and the stem of the plant. Optimal quality is obtained when the flowers are deep bluish-green; yellowing is an indication of aging. Boiling and steaming are the most frequent preparation methods, but sometimes broccoli is deep-fat fried or stir-fried. Prior to cooking storage needs to be in a hydrator drawer or tightly covered container to avoid moisture loss.

**Brussels sprouts**, “little cabbages,” can add the appeal of line, color, and flavor in a meal when properly prepared (Figure 5.5). Each sprout should be a tight, small head with no trace of yellowing on the green leaves. A comparatively short storage period in the hydrator drawer of the refrigerator will be possible without losing quality significantly.

**Cabbage** is a rather short word that includes an intriguing range of vegetables. The common green cabbage is known to most markets and is particularly valuable as a source of vitamin C when eaten in quantity. Heads should be firm, with a good green color and smooth leaves. A similar description can be made for red cabbage, with the exception of the color, which should be a deep purplish-red. Savoy cabbage is a close relative of green cabbage, but the leaves are characterized as being deeply crinkled. Chinese cabbage (also called Napa) is quite different in appearance, having a wide and prominent central rib in each leaf and an overall shape of an elongated head. Since all of these are susceptible to loss of moisture from their leaves and consequent loss of crispness, careful hydrator storage is necessary. These various forms of cabbage are served either raw in salads or cooked, usually by boiling.

**Carrots** have lacy tops that suggest the fact that they belong to the parsley family; other relatives of this varied group include celery and parsnips. The bright orange color and delicate flavor of high-quality carrots have made them a favorite vegetable, either raw or cooked.



**Figure 5.5**

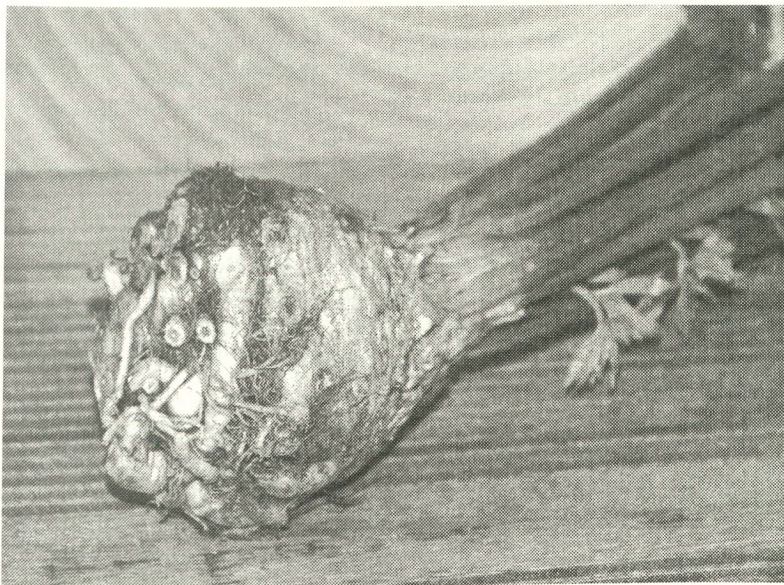
Brussels sprouts grown tightly packed on a tall stalk present a striking appearance for a cooking adventure. Courtesy of Plycon Press.

One of their virtues is their comparatively low cost and availability throughout the year. When stored without their tops, carrots can be kept in a hydrator drawer or plastic bag for many days. Carrots are remarkably versatile and can be used raw as carrot curls or sticks or shredded in a salad with raisins; boiled or steamed and served plain or with sauces; and even grated and used in carrot cake.

**Cauliflower** should be a white, compact head, free of dark blemishes or spots. Its cabbage-like flavor indicates its relationship to cabbage. Some people use small flowerets raw for dipping or in vegetable salads. In addition, the head may be cooked whole by boiling, or individual flowerets may be broken off and boiled or steamed.

**Celery** is one of the stem vegetables particularly popular in its raw form. Pascal is the variety generally preferred because of its reduced stringiness and mild flavor.

**Celeriac** is a relative of celery. However, it is the bulb-like root that is used for the vegetable (Figure 5.6). Its large cross section requires thorough cooking to tenderize it, a problem that can be minimized by cutting the root into cubes before cooking. The gnarled skin of celeriac should be removed.



**Figure 5.6**

Celeriac (celery root) is peeled and cooked before being served as a root vegetable. Courtesy of Plycon Press.



**Figure 5.7**

Daikon (the large and long white Japanese radishes seen in the back green bin toward the right of this stall in Kyoto) are also available in many American markets.

Courtesy of Plycon Press.

**Sweet corn**, quite a different product from the field corn used to feed cattle, is a highlight of summer when served boiled or steamed on the cob. Occasionally, it is roasted in a tight foil wrap. Enthusiasts often have a pot of water boiling before rushing corn from its place on the cornstalk to the pot for a brief boiling before eating. This ceremony reflects the rapid reduction in sugar content that happens after picking.

**Daikon**, also called the Japanese radish (Figure 5.7), is often available to satisfy the demand for it generated by Asians living in the United States. It may be as much as 18 inches long. Use of daikon can be similar to the use of white radishes when washed and peeled. It provides a flavor highlight and crispness of texture that is particularly appealing in raw vegetable salads.

**Eggplant**, originally found in India and China, now is a particularly popular vegetable for Middle Eastern meals. The deep purple, glossy skin of the eggplant is unique among vegetables. Size varies, but often eggplants will be as big as 6 inches in diameter. For best results, eggplant should be held only briefly in the refrigerator before cooking. Sautéed slices or baked eggplant are particularly popular ways of preparing this vegetable.

**Greens** may be either salad greens served raw or cooked greens. Although spinach is used both ways, most greens are used only as the raw or as the cooked version. Those used for cooking include kale, turnip greens, beet greens, mustard greens, and collards. During cooking, these greens will wilt drastically as water departs from the leaves, and the fragile cell walls collapse. For optimal quality, greens should be stored in

the hydrator drawer of the refrigerator for only a day or two and then should be cooked just until they are wilted.

Greens salads are extremely popular, but their quality and interest are influenced by the careful selection and proper storage of the greens. Considerable interest can be added to salads by selecting different types of lettuce to provide variety of color and texture. For instance, butterhead (Boston and Bibb) lettuces, with their moderate, slightly yellow-green color and almost oily, undulating leaves, are excellent for liners under other salads as well as for use in green salads. Bibb lettuce sometimes is known as "limestone" lettuce. Endive, a green with long, thin, curly leaves, has a scratchy texture, while escarole is somewhat less abrasive in the mouth and throat. Leaf lettuces afford yet another choice when looking for good salad greens. Some leaf lettuce is bronze or red in color. Prepackaged mixtures of salad greens featuring assorted greens such as arugula and radicchio are popular for their convenience and variety.

**Jicama** is a vegetable introduced to the United States from Mexico. Its skin must be pared before it is used—raw or boiled. Its most popular uses currently are in the raw state, as sticks for dips and as cubes in raw vegetable salads. Raw jicama often is garnished with a bit of chili powder.

**Mushrooms** are highly prized as a complement to steaks, in sauces and gravies, and as a vegetable ingredient. Commercial production of this delicacy requires careful control of humidity, temperature, and ventilation, as well as rich mulch and dark growing conditions, but the excellent financial returns have caused a healthy industry in mushroom growing. In addition to the familiar cup and button mushrooms, some markets also feature cremini, shiitake, morel, chanterelles, enoki, portabello, and oyster mushrooms (Figure 5.8). Refrigerator storage is the recommended way of storing mushrooms, but even this method should be limited to only a few days.

Some people like to go mushroom gathering in the woods, an idyllic pastime. Unfortunately, many varieties are highly toxic, a fact that has caused fatalities.

**Okra**, Creole cookery, and gumbo are inseparable. The comparatively small pods of okra contain a slippery exudate that can be minimized by drying the pods thoroughly before cutting



**Figure 5.8**  
Cremini and oyster mushrooms are among the choices available when buying mushrooms in this market. Courtesy of Plycon Press.

them. Most often, okra is used as a sliced vegetable in soups and gumbos, but it also can be dipped in batter and fried.

**Onions** and their relatives are valued for their unique flavor contributions to foods, both from the bulbs themselves and also, frequently, from the green tops. The choices range from large, dry Spanish onions to tiny scallions and chives. The globe-shaped or flat-topped dry onions are useful in heightening flavors of many different foods. Red onions, because of their attractive appearance and pleasing flavor, are useful ingredients in salads. Shallots (onion-like bulbs) are yet another possibility for flavoring. Boiling onions, small dry onions about an inch in diameter, are popular for skewering on kabobs and for the primary ingredient in creamed onions. All types of dry onions should be stored in a cool, dry place to delay root growth and possible decay.

Green onions are onions that are harvested before the bulb develops fully. Scallions, another member of this cluster of edible and flavorful group from the lily family, ordinarily are harvested when the shoots are well developed but the bulb has not formed. Chives have become a familiar sight in gourmets' kitchens where they provide an attractive touch of green and a continuing supply of flavorful shoots for garnishes. Leeks are the hardiest of the green onion-like foods. They have a somewhat flat, thick edible stalk noted for its onion flavor. For optimum quality, these various types of green onions, with the exception of chives planted in pots, need to be refrigerated in the hydrator drawer and used within a matter of days.

**Peas**, like sweet corn, are sweetest when they can go directly from the vine to the pot. Delays result in a gradual change from sugar to starch. The maturity of the pea also influences the development of starch, with mature peas being less sweet and starchier in flavor than new peas. Storage of peas should be in the pod and in the hydrator drawer of the refrigerator.

The **Chinese** or **snow pea** is a strain of pea that has been gaining rapidly in popularity recently in this country. This delicate pea is cooked and consumed pod and all, with only the tips of the pods being broken off before cooking. The bright color and crispness of the pod add both textural interest and eye appeal to many Oriental and other dishes. Another pea also eaten in its pod is the sugar pea. These are popular cooked in stir-fries or raw in salads.

Although not used in large quantities in the typical American diet, dried peas should be noted. Split peas are one type of legume that can be stored for a comparatively long period in a dry storage area. Their most popular use is in making split pea soup, usually flavored with a ham bone.

The word *pepper* seems to mean "hot" to people, yet **sweet peppers** are anything but that. Red, yellow, orange, and green sweet bell peppers are the source of pleasing color accents and

[www.onions-usa.org](http://www.onions-usa.org)

—Information on onions.

## CULTURAL ACCENT

### CHILI PEPPERS

Various hot peppers (chilies) are the hallmark of Mexican cuisine, as well as others, notably Thai and neighboring cultures. Intensity ranges from spicy to hot, depending on the variety of chilies. Some of the varieties available in the United States

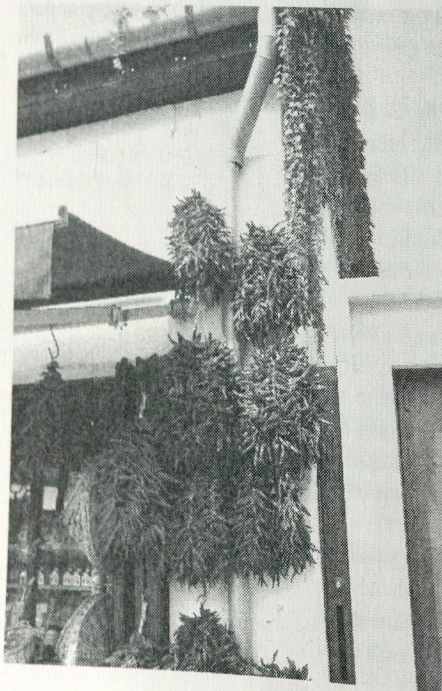
include jalapeño, serrano, Anaheim (California), and pasilla. Removal of all of the seeds in these chilies is important unless searing characteristics are desired. Sensitive people even wear rubber gloves when handling chilies to avoid skin irritations.

intriguing flavors. Sometimes the top is cut off, the seeds are removed, and then the remaining whole pepper shell is parboiled in preparation for stuffing and baking. Often, bell peppers are diced or sliced and are used raw in salads or as ingredients in casseroles.

Other types of peppers also find their way to the table in different ways. For instance, paprika (Figure 5.9), one of the most common of the spices, is prepared for market by drying and grinding paprikas (sweet red peppers).

**Potatoes** form the backbone of diets in some areas of the world. In fact, the spread of this native South American food to Europe created such shifts in diet patterns that the Irish suffered an extremely serious famine in the mid-19th century when the potato crop failed.

Potatoes occupy a unique place among vegetables because of their excellent keeping qualities when stored properly and their remarkable versatility in preparation. There even are whole cookbooks devoted to ways to prepare potatoes. Although potatoes are found in markets throughout the year all across the country, the specific varieties available in different regions vary according to the types that will grow best in the local climate. The basic types of potatoes are



**Figure 5.9**  
Paprikas, virtually the Hungarian national vegetable, are drying in the sun awaiting their chance to add a lively burst of color and flavor to a meal. Courtesy of Plycon Press.

1. Round white,
2. Russet,
3. Round red, and
4. Long white.

The storage temperature will influence the starch and sugar content of potatoes. The recommended temperature is about 60°F, or somewhat cooler than the average room. At this temperature, the sugar/starch levels in potatoes remain approximately the same as they were when the potatoes entered storage. However, when temperatures dip to around 45°F, sugar begins to accumulate, and starch levels drop; these changes are detrimental to optimal quality when cooked.

**Sweet potatoes** are available in markets throughout the year, with the choice generally being between those with a light-colored skin and a somewhat dry interior and the deeper-colored moist variety. Members of this latter variety often are called yams, even though they are not actually yams. True yams are not available in the markets in this country. Whether selecting the broad, bulky sweet potatoes with their tapered ends or "yams," the ends need to be dry and free from any hint of rot. Otherwise, they will not keep well even in cool, dry storage.

**Red radishes** are popular as a garnish or sliced in salads. The ability of the radish to fan out or to unfold when thin cuts are made in the vegetable is extremely useful when preparing garnishes to beautify a dinner plate or salad. White radishes, although lacking the bright color of the red radish, are extremely pleasing flavor accents when sliced into salads or simply eaten raw.

**Rutabagas** can be held in cool storage over the winter months. When coated with wax, this vegetable can be held for an extended period, but the wax needs to be peeled from rutabagas before they are boiled. After boiling, this yellow-fleshed vegetable often is mashed.

**Summer squash** are noted for their intriguing shapes, subtle flavors, and high water content. These squash can be kept in refrigerated storage only a few days before losing quality.

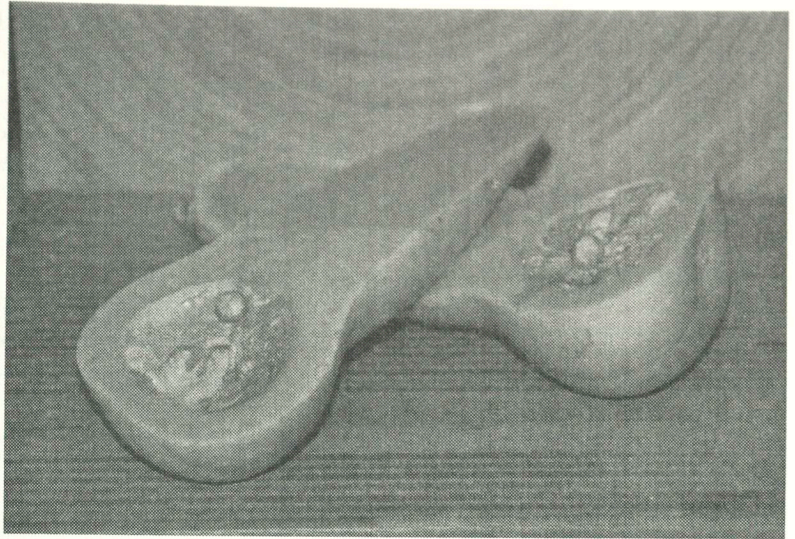
Zucchini is perhaps the best known of the summer squashes; it may be used raw in sticks for dips or in salads and also cooked in a variety of ways. Other summer squashes include yellow crookneck, pattypan or scallop, and cocozelle.

The hard-shell **winter squash**, in sharp contrast to the softer-skinned summer varieties, can be held in cool, dry storage (but not in the refrigerator) for several months. The hard shell and relatively low moisture content of winter squashes necessitate thorough cooking, often by baking, to make them highly palatable. Familiar winter squashes include Hubbard, table queen (acorn), buttercup, butternut, Turk's turban, spaghetti, and banana (Figure 5.10).

Even though they are the fruit of the plant, **tomatoes** are classified as a vegetable because they are often served in the main part of a meal. The versatility of the tomato (as a raw vegetable simply sliced as a component of vegetable salads or cooked in many ways, including in sauces and casseroles) makes this one of the most popular and widely accepted vegetables. Considerable research effort has been expended to develop tomato varieties suited for specific purposes and with the desired growing characteristics. For example, the elongated tomato was developed to fulfill the needs of commercial canners. The cherry tomato has found its niche in the hearts of salad lovers. Roma tomatoes, because of their bright red color and excellent cooking properties, have gained prominence in many recipes.

**Turnips** have gained in status with the institution of salad bars in U.S. restaurants and fast-food franchises. The turnip's white, crisp character adds interest to salads, either in grated form or in julienne strips. This vegetable is also physically strong enough to be used with dips. Of course, turnips can also be cooked. When fresh, the tops of turnips are excellent for boiling or steaming and serving as greens.

This is far from an exhaustive list of vegetables that might be available fresh, frozen, or canned in the market. The broadening interest in other cuisines doubtless will increase the availability of cilantro, bok choy, gobo, jicama, and other vegetables popular with the various ethnic groups in this country.



**Figure 5.10**

Butternut squash is a winter squash with the typical hard skin. Courtesy of Plycon Press.

### INDUSTRY INSIGHT BIOTECHNOLOGY

Biotechnology applied to developing new varieties of vegetables is an exciting and very active area of research at present. Development of plant foods with modified characteristics can be accomplished through genetic engineering and crossbreeding of carefully selected plants. By selective breeding, tomato varieties with less acid (a pH higher than the average of 4.5) were developed in the mid-1970s. Palatability and cooking characteristics were improved, but less acidic tomatoes presented a possible health risk in processed tomatoes because of the difficulty in killing *Clostridium botulinum* spores that might be present.

Another possible benefit of biotechnological research on plants may be reduced use of insecticides and pesticides. Concerns over the potential hazards created by these chemicals have sparked efforts to develop plant varieties that are resistant to insects due to the natural pesticide(s) they contain.

The possibility of creating plants that could serve as "edible vaccines" is even being explored. Among the ideas being pursued are alfalfa that can prevent cholera, a banana to prevent hepatitis B, and a potato to prevent gastroenteritis. Creation of edible vaccines is a complex process that begins by isolating the antigen from the toxin that is to be blocked. The genetic sequence of the antigen is cut out, and the antigen genes are injected into cells of the organism that causes crown gall disease. The plant being developed is infected with the crown gall disease, which transfers the altered genes into the plant.

Cells from this modified plant then are cultured to regenerate the desired plant, complete with its antigen. Consumption of such plants in adequate quantities is expected to provide immunity without the need for human inoculation. However, much remains to be learned before such a technique becomes viable as a means of preventive health care.

## ASPECTS OF PALATABILITY

Clearly, the category dubbed vegetables includes a very large range of foods, some of which are very popular and others which may only be eaten because they are "good for health." Texture (mouthfeel), color, and flavor comprise the key to acceptance. Individuals likely will have different preferences, but these characteristics play major roles in their choices.

**parenchyma cell** Type of cell comprising most of the pulp of a vegetable or fruit.

**cellulose** Complex carbohydrate made up of glucose, but not digested by people.

**pectic substances** Complex carbohydrates acting as cementing substances between cells; sequence of change during ripening is protopectin to pectin to pectic acid.

**hemicelluloses** Complex carbohydrates made up of several different sugars and sugar derivatives.

### Texture and Structure

Vegetables vary somewhat in their structure from one type to another, but generally they have an outer covering (dermal tissue), a transport system (vascular system), and pulp, which is composed primarily of **parenchyma cells**. The parenchyma cells have permeable walls to permit some substances to pass back and forth. Some rigidity is provided by the presence of **cellulose**, with additional strength being the result of **pectic substances** and **hemicelluloses** serving as connecting links between cells. These various substances are types of carbohydrates. These contribute to the texture perceived in the mouth when a vegetable is eaten.

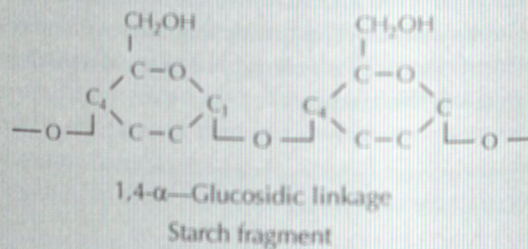
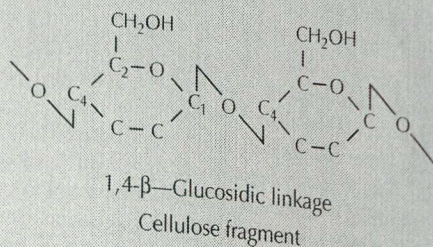
### Flavor

Flavoring substances also are vital to the appeal of vegetables. The organic acids in vegetables certainly heighten the interest of the various flavors; some sulfur-containing compounds contribute to the unique flavor overtones found in onions and members of the cabbage family. Carrots and sweet corn are among the vegetables that gain part of their popularity to the sweet taste contributed by sugar, particularly when they are barely mature. Potatoes exemplify the effect of starch on flavor.

### SCIENCE NOTE

#### STRUCTURE OF PLANT FOODS

The strong, thick nature of the dermal layer is evident when a fruits or vegetables are peeled. This protective layer has a high concentration of cellulose in the cell walls. Cellulose, like other structural carbohydrates, is not digested and absorbed for energy by people. This seems surprising when its content of only glucose units is known, for that is the same building material found in starch. However, the glucose units in cellulose are linked together differently from the linkage found in starch. The cellulose linkage is termed a 1,4- $\beta$  glucosidic linkage, whereas that in starch is a 1,4- $\alpha$  glucosidic linkage. These two types of linkages are shown below. Note that the only difference is found on the carbon labeled 1. The union on the fourth carbon of the next glucose unit is the same in both cellulose and starch.



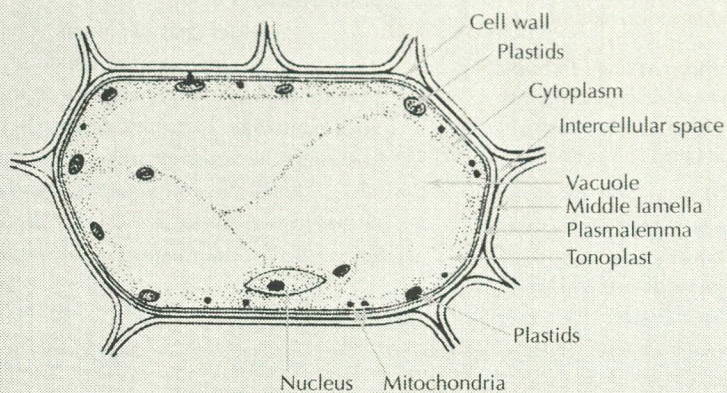
Hemicelluloses also are important components of cell walls in fruits and vegetables. These compounds are more difficult to define than cellulose because hemicelluloses contain a variety of different sugar-related products. These include derivatives of some sugars with five carbons (arabinose and xylose) as well as galactose and mannose, each of which contains six carbons. The pectic substances, discussed in detail in Chapter 19, are made up of galacturonic acid units. These units are derivatives of galactose and undergo chemical changes during ripening of fruits. Unlike hemicelluloses, pectic substances are found between cells, where they act as substances to cement cells together rather than as parts of the cell wall.

Parenchyma cells constitute the bulk of the edible portion of fruits and vegetables. Their structure, therefore,

is of special interest. Within the parenchyma cell, as can be seen in Figure 5.11, there are special structures, the **plastids**, within the **cytoplasm**. The various types of plastids perform specific, unique functions and provide diverse characteristics to specific vegetables. For instance, in green vegetables chlorophyll is formed in a special plastid called a **chloroplast**. Chloroplasts are in the cytoplasm layer just inside the cell. The orange pigments in vegetables are found in other plastids called **chromoplasts**, which also are in the cytoplasm just next to the cell wall. Starch is found in still other plastids called **leucoplasts**.

A large portion of each of the parenchyma cells is occupied by the **vacuole**. The vacuole is of particular interest because this is the region where the fluid of the cell is concentrated and where such important flavor constituents as sugars, acids, and salts are found. This is also the location of the flavonoid (white or bluish to reddish-purple) pigments. When a vegetable is

cut or peeled, many parenchyma cells are opened, allowing considerable loss of pigments and other compounds found in the vacuole.



**Figure 5.11**  
Diagram of a parenchyma cell. Courtesy of Plycon Press.

## Color

The eye has a tremendous influence over the acceptance of vegetables, and color is a key aspect of their visual appeal. There are three principal pigment categories (Table 5.2), with each of these categories having subgroups within them. **Chlorophylls**, the predominant pigments in green vegetables, are formed in chloroplasts (a type of plastid in parenchyma cells).

**TABLE 5.2**  
**COMMON VEGETABLE PIGMENTS**

Pigment	Color	Vegetable
<i>Chlorophylls</i>		
Chlorophyll a	Intense blue-green	Broccoli, lettuce, spinach, peas, green beans
Chlorophyll b	Yellow-green	
Pheophytin a	Pale green-gray	Green vegetables cooked more than 7 minutes
Pheophytin b	Olive green	
<i>Carotenoids</i>		
<i>Carotenes</i>		
Alpha-carotene	Yellow-orange	Winter squash, carrots, sweet potatoes, rutabagas
Beta-carotene	Red-orange	
Lycopene	Red	Tomatoes, watermelon
<i>Xanthophylls</i>		
Cryptoxanthin	Yellow	Sweet corn
Lutein	Orange	Spinach
<i>Flavonoids</i>		
Anthocyanins	Red, purple, blue	Red cabbage
Anthoxanthins	White	Cauliflower, white onions, turnips

**cytoplasm** Viscous layer just inside the cell wall of the parenchyma cell; contains plastids.

**chloroplasts** Plastids containing chlorophyll in parenchyma cells.

**chromoplasts** Plastids containing carotenoids (orange pigments) in parenchyma cells.

**leucoplasts** Plastids serving as the site for formation and storage of starch in parenchyma cells.

**vacuole** Largest region of the parenchyma cell; the portion encircled by the cytoplasm.

**chlorophylls** Green, magnesium-containing pigments formed in chloroplasts in fruits and vegetables.

**flavonoids** Class of pigments contributing white and red to blue colors in fruits and vegetables; two main divisions are anthoxanthins and anthocyanins.

**anthoxanthins** Group of flavonoids providing the white or creamy colors in fruits and vegetables.

**anthocyanins** Group of flavonoids providing the reddish to bluish hues of fruits and vegetables.

The orange-colored vegetables, such as sweet potatoes, carrots, and rutabagas, contain carotenes. This pigment group not only provides the attractive color of these vegetables but several of the carotenoid pigments also are nutritionally important as precursors of vitamin A. Beta-carotene is a particularly important form from the perspective of nutrition.

Vegetables that are white, blue, purple, and purplish-red contain the third group of pigments, the **flavonoids**, which are in the vacuole of parenchyma cells. Some flavonoids provide the white pigment, as seen in cauliflower. This flavonoid belongs to a group called the **anthoxanthins**. Dramatic deep reds, purples, and blues are contributed by the flavonoid group known as the **anthocyanins**.

This discussion is something of an oversimplification, for a blend of pigments commonly occurs in vegetables, with one of the pigments predominating over the others. This blending is the reason for the range of colors observed.

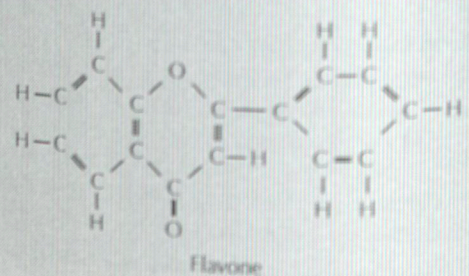
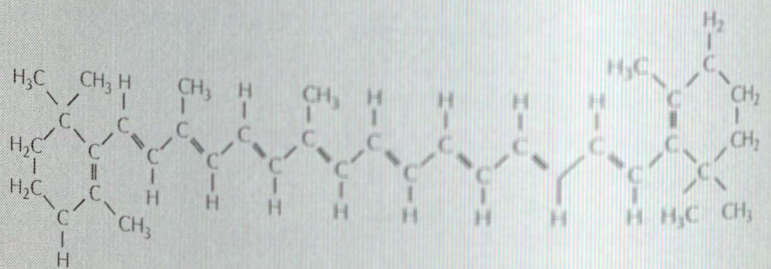
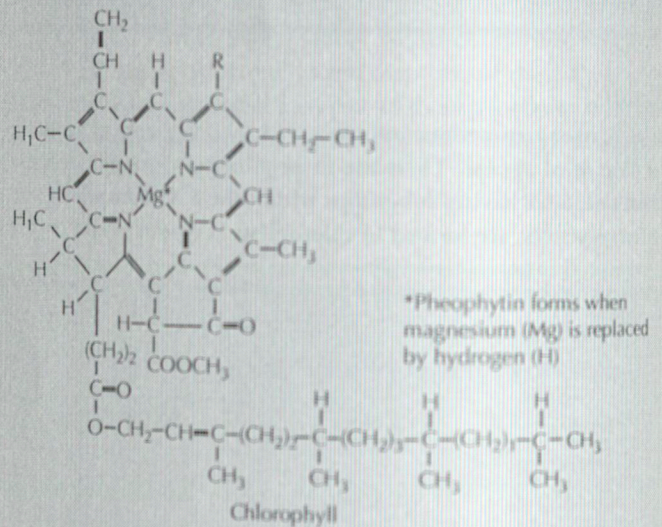
### SCIENCE NOTE PIGMENTS

Chlorophyll pigments (chlorophyll a and chlorophyll b) are susceptible to changes in their chemical structure during cooking. In the raw vegetable, these two structures differ only in the functional group attached to one of the rings in the structure. Actually, the structure of chlorophyll resembles that of heme (in hemoglobin), except that the metal complexed in chlorophyll is magnesium rather than the iron atom found in heme. In chlorophyll a, a methyl group ( $-\text{CH}_3$ ) is the functional group, resulting in the fairly intense blue-green pigment color seen in the blue-green buds on broccoli. The aldehyde ( $-\text{CHO}$ ) group in chlorophyll b imparts a rather yellow-green hue to green vegetables.

When chlorophyll-containing vegetables are cooked for at least five minutes, magnesium ions are released from some of the molecules of chlorophyll and are replaced by hydrogen. This reaction results in the formation of pheophytin a from chlorophyll a or pheophytin b from chlorophyll b. Pheophytin a causes the color to be a greenish-gray; pheophytin b is a distinctive olive drab. The combination of these two types of pheophytin yields the familiar, and rather dull, olive-green color characteristic of canned green vegetables.

The carotenoid pigments are highly unsaturated, as can be seen in the accompanying structure. These conjugated (alternating double and single bonds) double bonds account for the bright pigments of the carotenoid compounds.

Beta-carotene is but one example of the carotenes, all of which contribute color to vegetables. When this particular carotenoid ( $\beta$ -carotene) is split in the body, it yields vitamin A. The structures of the various carotenes are quite similar, varying only slightly in one of the rings at the end of the carbon chain. Lycopene (the red pigment in tomatoes) has no rings. The carotenes are quite stable pigments.

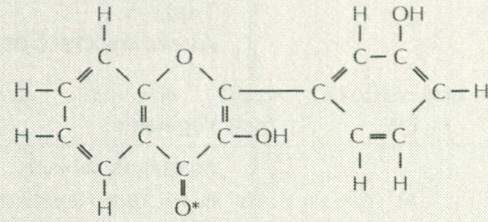


Xanthophylls are carotenoid pigments that are very similar to the carotenes, the exception being that xanthophylls have some oxygen (in the form of —OH or hydroxyl groups), while the carotenes lack this element. Examples of xanthophylls are the cryptoxanthin in corn and lutein, an orange compound in spinach (but masked by chlorophyll).

Unlike the chlorophylls and carotenoids, which are contained in plastids, the flavonoids are in the vacuole of parenchyma cells, which causes these pigments to be released into the cooking water when vegetables containing them are cut or peeled. The various flavonoids are derivatives of the parent compound, flavone. Anthoxanthins are the white or colorless pigments in vegetables, such as cauliflower. The three-carbon unit in the middle of the structure of anthoxanthins includes a carbonyl (C=O); the reddish, purple, or blue colors of anthocyanins are the result of a somewhat different structure, for they lack this carbonyl as shown in the structure.

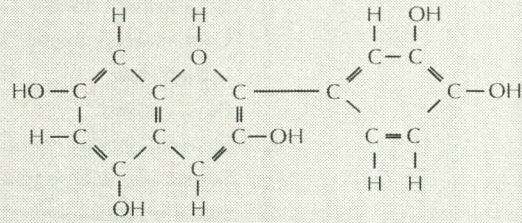
Shifts in the pigment color of the anthocyanins occur as a result of the number of hydroxyl (—OH) groups on the molecule. An increase in hydroxyl groups shifts the pigment from a reddish color toward a more bluish hue. The color shifts toward red in acid and toward blue in alkaline media, paralleling the change of color observed with litmus paper.

Metal ions (notably iron, tin, and aluminum) complex with flavonoids if they come in contact. These complexes



Flavonol (an *anthoxanthin*)

\*Carbonyl of anthoxanthins is replaced with hydrogen in anthocyanins.



Cyanidin (an *anthocyanin*)

result in unattractive hues of blue, ranging from slate blue to a greenish-blue. Such colors are not appealing in foods and should be avoided by removing metal sources of contamination.

## NUTRIENT CONTENT

For optimal health, five or more servings of fruits and vegetables are recommended. Their relatively large amounts of vitamins, minerals, and phytochemicals (Figure 5.12) are available with limited calories because of their minimal fat and large amount of water, which is particularly good news for people attempting to limit their caloric intake. In fact, green beans, cabbage, broccoli, asparagus, and many other vegetables are more than 90 percent water. Few vegetables other than legumes have less than 80 percent water.

<http://www.fruitsandveggiesmatter.gov/>

—General nutrition information on vegetables.



**Figure 5.12**

Vitamins, minerals, and phytochemicals (including some carotenoids and flavonoids) are available in abundance in fresh produce.

Courtesy of Plycon Press.

**TABLE 5.3**  
**APPROXIMATE COMPOSITION OF SELECTED VEGETABLES (1 CUP)**

Vegetable	Calories	Protein (g)	Fat (g)	Total Carbohydrate (g)	Water (%)
Asparagus, cooked	40	4	Trace	8	92
Beans, green (cooked)	44	2	Trace	10	89
Beets, cooked	74	3	Trace	17	87
Broccoli, cooked	54	4	1	17	91
Brussels sprouts, cooked	56	4	1	11	87
Cabbage, raw	22	1	Trace	10	92
Cauliflower, cooked	28	2	1	5	93
Corn, sweet, cooked	143	5	2	31	79
Lettuce, raw	8	1	Trace	11	96
Peas, cooked	134	5	Trace	25	89
Spinach, cooked	43	5	Trace	7	91
Squash, summer, cooked	36	2	1	8	94
Sweet potatoes, baked	180	4	Trace	41	72
Tomatoes, raw	32	2	Trace	7	94

Source: Compiled from Nutritive values of the edible part of foods. *Home and Garden Bulletin No. 72*. U.S. Dept. Agriculture. Washington, DC, 2002 and U.S. Department of Agriculture, Agricultural Research Service. 2010. USDA National Nutrient Database for Standard Reference, Release 23. Nutrient Data Laboratory Home Page.

Carbohydrate content varies, in both form and amount. Some of the sugar that may be present in some immature vegetables will gradually change to starch as they mature. Starch levels in white potatoes are around 15 percent and 25 percent for sweet potatoes, while cooked legumes average around 20 percent starch. In contrast, the carbohydrate level in cabbage is only about 5 percent (Table 5.3), and that is largely sugar rather than starch. The carbohydrate levels of most vegetables range between these figures, but tend toward 10 percent or less.

In addition to starch and sugars, which are digestible carbohydrates, vegetables gain much of their structure from indigestible pectic substances, hemicelluloses, and cellulose, all of which have been described briefly. The most durable of the structural components actually is not a carbohydrate; it is a woody substance called lignin and is used in the body only as roughage.

Protein and fat levels generally are very low in vegetables, thus partly accounting for the low energy value of most vegetables. The exceptions to this statement are the legumes, which are very useful sources of incomplete protein at a comparatively low cost. The protein content of cooked legumes averages approximately 8 percent—well below the protein content of meats, but much higher than the content of other vegetables and fruits. This amount of protein influences the cookery techniques needed for optimal quality.

Minerals and vitamins are found in widely varying amounts (Table 5.4) in the different vegetables, with some vegetables being notable in their content of specific nutrients. For example, the provitamin A content of dark green, leafy vegetables and orange vegetables is noteworthy, accounting for the recommendation of one of these vegetables at least every other day to ensure sufficient vitamin A is in the diet. Thiamin is relatively high in legumes, while folacin is found in excellent amounts in the leafy vegetables, and vitamin C plus other B vitamins are in other vegetables. Calcium and magnesium are found in useful amounts, too.

<http://www.ars.usda.gov/ba/bhnrc/ndl>

—USDA nutrient database.

[www.nal.usda.gov/fnic/foodcomp/Data/HG72/hg72\\_2002.pdf](http://www.nal.usda.gov/fnic/foodcomp/Data/HG72/hg72_2002.pdf)

—Home and Garden Bulletin 72 on nutritive content.

<http://www.nal.usda.gov/fnic/foodcomp/search/>

—Access to entries for nutritional composition of specific foods in USDA database.

**TABLE 5.4**  
**VITAMIN AND MINERAL CONTENT OF SELECTED VEGETABLES (1 CUP)**

Vegetable	Calcium (mg)	Iron (mg)	Vitamin A (IU)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)	Ascorbic Acid (mg)
Asparagus,							
cooked	42	1.6	970	0.18	0.25	1.9	14
canned	39	4.4	1,285	0.15	0.24	2.3	45
Beans, lima, cooked	37	2.3	323	0.13	0.10	1.8	22
Beans, green, cooked	55	1.6	833	0.09	0.12	0.8	12
Beans, wax							
cooked	58	1.6	101	0.09	0.12	0.8	12
canned	35	1.2	142	0.02	0.08	0.3	6
Beets, cooked	27	1.3	60	0.05	0.07	0.6	6
Beet greens, cooked	164	2.7	7,344	0.17	0.42	0.7	36
Broccoli, cooked	62	1.0	2,414	0.09	0.18	0.9	101
Brussels sprouts, cooked	56	1.9	1,122	0.17	0.12	0.9	97
Cabbage							
raw	37	0.4	93	0.04	0.03	0.2	32
cooked	47	0.3	198	0.09	0.08	0.4	30
Carrots, cooked	48	1.0	38,304	0.05	0.09	0.8	4
Cauliflower, cooked	20	0.4	27	0.05	0.06	0.5	55
Corn, sweet, cooked	4	0.5	392	0.17	0.06	1.2	8
Lettuce, raw (1 head)	110	2.7	1,779	0.25	0.16	1.0	21
Peas, cooked	67	3.2	282	0.20	0.12	0.9	72
Potato, baked	8	0.5	0	0.22	0.07	3.3	26
Spinach, cooked	245	6.4	14,742	0.17	0.42	0.9	38
Squash, cooked							
summer	49	0.6	517	0.08	0.07	0.8	10
winter	46	1.4	10,701	0.12	0.09	1.1	12
Tomatoes (1 raw)	9	0.8	1,499	0.11	0.09	1.1	34

Source: Compiled from Nutritive values of the edible part of foods. *Home and Garden Bulletin No. 72*. U.S. Dept. Agriculture. Washington, DC, 2002 and U.S. Department of Agriculture, Agricultural Research Service. 2010. USDA National Nutrient Database for Standard Reference, Release 23. Nutrient Data Laboratory Home Page.

## HARVESTING AND MARKETING

The high quality of vegetables in the food supply today is something that is expected. Modern farming techniques, including use of fertilizers and pesticides, are used to produce crops that are high both in quantity and quality. Attention also is directed to avoiding contamination of field crops due to fecal matter from wild animals, runoff from livestock in neighboring fields, or farmworkers.

The need for care and attention continues into harvesting and marketing operations to help retain maximum nutrient content and palatability. From the moment vegetables are harvested, proper temperature and moisture controls are necessary, for metabolic processes continue in the harvested food. Control of these chemical changes is essential to the retention of vitamins and to overall palatability of produce.

When fresh vegetables are crated, the temperature in the crates slowly begins to rise, even though they generally have an open design. This is the consequence of the respiration that is

continuing after harvest. For instance, the temperature in a crate of spinach has been measured to rise as high as 100°F, causing a soft rot to develop rapidly. Although leafy greens have a faster respiration rate than do other types of vegetables, increasing temperatures in crates of all types of vegetables still reduce quality. Vegetables can be packed loosely in crates, preferably along with some crushed ice, to reduce this problem.

The next step is rapid transport to the processing plant if vegetables are to be canned or frozen. The shorter the time and the better the temperature is controlled between harvesting and processing, the higher the nutrient value and the palatability of the processed vegetables.

If vegetables are to enter the retail market as fresh produce, proper temperature control must be maintained from harvest until they are cooked and consumed in the home. Ordinarily, they are loaded efficiently into refrigerated trucks or refrigerated railroad cars for transport to wholesale and, ultimately, retail markets. These special trucks or railroad cars work in opposite fashion at different seasons of the year, chilling the vegetables in the summer and keeping them from freezing with the assistance of heaters in the winter.

By paying careful attention to the circulation of air, maintenance of a desirable level of humidity, and control of temperature during transport in refrigerated cars, vegetables can be shipped clear across the country and arrive on the opposite coast in excellent condition. In fact, when vegetables shipped in refrigerated storage across the continent are compared with those grown locally and marketed without chilling, the refrigerated and transported produce may be of higher quality than that from local fields.

Local marketing arrangements are important if the consumer is to be able to purchase high-quality produce (Figure 5.13). Refrigerated transport from wholesale markets or warehouses to retail outlets is essential. Within the market, the retailer must have adequate refrigerated storage to maintain quality of produce awaiting display for purchase. Retail markets doing a high volume of business have the advantage of rapid turnover of produce, which is important in maintaining quality and nutritive value.

**Market orders**, established as a result of the Agricultural Marketing Agreement Act of 1937, are an important part of the marketing procedures. This legislation enables the U.S. Department of Agriculture to draw up and enforce marketing agreements via boards to regulate quality, quantity, standardization of packs, research and development projects, specification of unfair trade practices, required filing of selling prices, and collection of marketing information for the producers of the commodity specific to the marketing order. Such boards have had considerable impact over the years in influencing the development of markets for their products and promoting improvements intended to benefit producers and consumers alike.

**market order** Regulations for the marketing of specific food products under the guidance of a board authorized by the U.S. Department of Agriculture.

**Figure 5.13** Shoppers sometimes buy their fresh produce at farmers' markets featuring locally grown vegetables and fruits. Courtesy of Plycon Press.



## SELECTION

Selection of specific vegetables for a meal begins with the decision to buy them fresh, frozen, canned, or, in some cases, dried. Individual preference may influence this decision, but price and availability also play key roles in the choice. When a vegetable is in season, the quality is high and the price usually will be competitively low, making purchase of the fresh form often the best choice. However, the convenience of preparing frozen or canned vegetables may motivate people to select one of these forms even when the fresh food is comparatively inexpensive and of high quality.

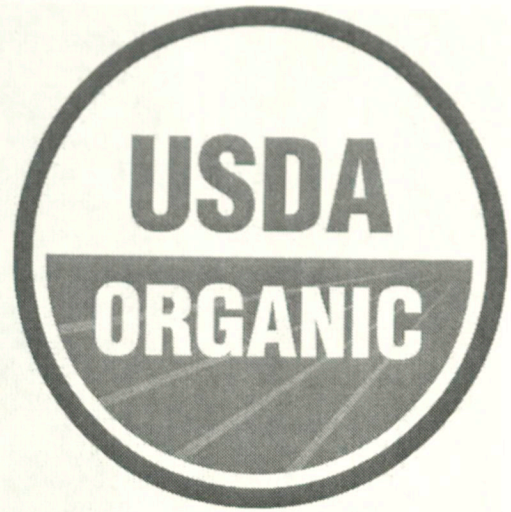
### Fresh Vegetables

The eye is an excellent guide to selecting fresh produce, although wholesalers may use grading as an aid at that point in the marketing process. The quality of fresh vegetables is influenced by the season of the year and the handling during the marketing process, with the peak harvest period ordinarily providing a particular vegetable of the highest quality.

Grade standards have been established for many vegetables under the authority of the Agricultural Marketing Act of 1946. This optional grading, under the Agricultural Marketing Service of the U.S. Department of Agriculture, is useful in the wholesale phase of marketing. However, it is not ordinarily visible to consumers directly. Typically two grade designations are used for a particular type of vegetable, although four grade designations can theoretically be used.

Today consumers may find some produce labeled with an **organic seal** (Figure 5.14). The Agricultural Marketing Service of the U.S. Department of Agriculture is responsible for administering the Organic Food Production Act of 1990 and for use of the USDA Organic seal. This seal means that the produce has been raised and marketed without pesticides, petroleum- or sewage sludge-based fertilizers, bioengineering, or ionizing radiation. However, the nutritive value of such produce is comparable to other produce raised according to standard farming practices.

Consumers usually rely on their own knowledge and experience in selecting fresh vegetables to meet their own personal standards. Such characteristics as crispness, color, and freedom from blemishes are characteristics that frequently can be used by consumers in making wise selections in the produce department. Some suggested guides for selected fresh vegetables are presented in Table 5.5.



**Figure 5.14**  
USDA's Organic Seal can only be used when produce is grown according to legal specifications. Courtesy of U.S. Department of Agriculture.

**organic seal** Seal used to designate food that meets the standards required by the National Organic Program.

<http://www.ams.usda.gov/AMSV1.0/standards>

—Federal produce grading standards.

<http://www.ams.usda.gov/AMSV1.0/NOP>

—Overview of National Organic Program.

<http://www.nal.usda.gov/afsic/pubs/ofp/ofp.shtml>

—Overview of requirements for organic production.

[www.earthboundfarm.com](http://www.earthboundfarm.com)

—Organic farming information.

**TABLE 5.5**  
**GUIDE TO SELECTION OF FRESH VEGETABLES**

Vegetable	Criteria
Artichoke	Plump, firm, heavy in comparison with size; green petals with absence of brown discoloration
Asparagus	Good green color extending down much of stalk; closed and compact tips; crisp and tender stalk
Beans (green and wax)	Bright color for variety; pods firm and crisp rather than flabby
Beets	Fresh-looking tops if still attached; surface that is smooth and deep red, firm and round with slim taproot
Broccoli	Dark green to bluish bud clusters with no trace of yellow; smooth stalks of moderate size with no traces of spoilage
Brussels sprouts	Fresh green color void of yellow leaves; tight outer leaves free of injury; tight heads
Cabbage	Firm head; fresh color in outer leaves, crisp leaves
Carrots	Crisp rather than flabby; good orange color free from sunburned green at top

(Continued)

TABLE 5.5 (Continued)

Vegetable	Criteria
Cauliflower	Uniform creamy white color with no trace of dark discoloration; solid and compact head; fresh leaves, if attached
Celery	Crisp stalks with a solid feel; glossy surface on stalk; crisp leaves; no discoloration on inside surface of large outer stalks
Corn	Ear well covered with plump young kernels; fresh husks that are green and unwilted; silks free of decay
Cucumbers	Firm, moderate size; green color all over
Eggplant	Smooth and firm with deep purple skin free of blemishes
Greens	Crisp appearance with good green color typical of the type of green; free from rust and other blemishes; no wilted or decaying areas
Lettuce	Crisp quality to leaves, with butter lettuces being somewhat less crisp, but still succulent; free of decay; good color for the variety
Mushrooms	Caps closed around the stem; surface of cap light-colored and gills (if showing under cap) should be light rather than dark; smooth and firm cap with no suggestion of drying out
Okra	Pods tender enough to bend under some pressure; less than 4 1/2 inches long; fresh green color; no blemishes
Onions, dry	Firm and dry with small necks; no decay
Onions, green	Crisp, bright green tops; free from decay
Parsnips	Smooth and firm; small to medium size; free from blemishes
Peas	Crisp pods with fresh green color; pods full but not bulging
Peppers	Firm, deep color; no trace of flabbiness or decay
Potatoes	Firm; free from sunburned green areas; no decay; skin intact and free from blemishes
Radishes	Medium size; firm and plump; fresh red color
Squash	Well developed with no soft areas, firm; summer squash has glossy and tender skin; winter squash has tough, hard skin
Sweet potatoes	Firm, no signs of decay at ends; good color
Tomatoes	Smooth; good color for stage of ripeness; firm if not fully ripe; free from blemishes
Turnips and rutabagas	Firm and smooth; free of blemishes

**waxy potatoes** Potatoes with a high content of sugar and low amount of starch; best suited for boiling and other preparations where shape is important.

**non-waxy potatoes** Potatoes with a low sugar content and high starch level; best suited for baking, mashing, and frying.

Wise selection depends not only on quality of the item selected but also sometimes on the variety. For instance, a choice might need to be made between buying large beefsteak tomatoes or cherry tomatoes for making a salad. Onions are yet another type of vegetable requiring some decision between varieties. When a recipe calls for pea pods, the variety to choose is the Chinese or snow pea, with its tender, flat pods. Regular garden peas have a pod that is too tough to provide the delicate crispness desired.

Selection of the variety of potatoes to buy should be based on the intended preparation, because cooking characteristics vary. Some potatoes, termed **waxy potatoes**, are relatively high in sugar and low in starch. The opposite type, **non-waxy (mealy)**, have high starch content and are low in sugar. Waxy potatoes have a low specific gravity, which causes them to float in water (Figure 5.15). Conversely, **non-waxy potatoes** have a high specific gravity; they will sink to the bottom of a solution containing 11 parts of water to 1 part salt.

Non-waxy potatoes will tend to slough off and to lose their shape during boiling, while waxy potatoes hold their shape well during boiling (Figure 5.16). This is not surprising, for the high starch content of the non-waxy potatoes means that there will be considerable swelling

of the cells when non-waxy ones are boiled due to gelatinization or swelling of the starch in these potatoes. These characteristics make non-waxy potatoes excellent for mashing and baking. In contrast, waxy potatoes, with their low starch and comparatively high sugar content, retain their shape, making them well suited to preparations such as potato salad, where shape of the pieces is important.

Fried potatoes, particularly French fries, are a popular way of preparing potatoes. Here again, the type of potato selected will influence the quality of the finished product. As predicted, waxy potatoes (such as the Red Pontiac) will not perform well when fried, because the high sugar content causes them to brown quite quickly or even to burn before the interior of the piece is cooked. Non-waxy potatoes, however, with their low sugar content, brown rather slowly, thus allowing time for the heat to cook the interior of the piece before the exterior becomes too dark. The familiar example of non-waxy potatoes is the Russet Burbank. Its long, flat shape is excellent for making the long slices desired in French fries.

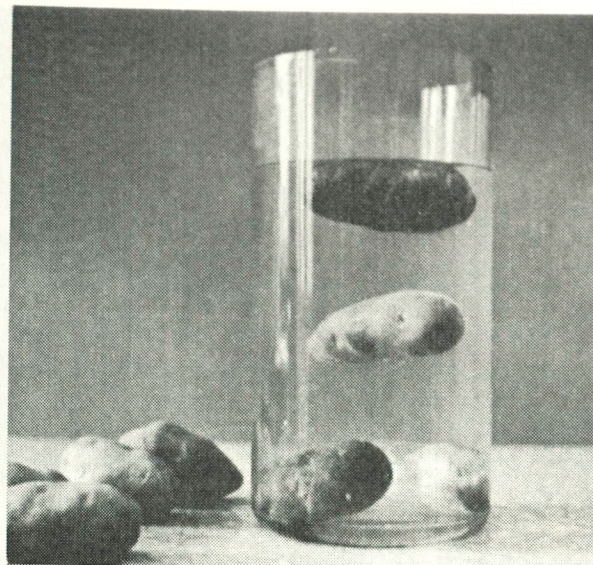
It is desirable to buy the right variety of potato for the intended use, but people who use potatoes infrequently may find the purchase of a single type is appropriate. In such instances, an all-purpose potato, such as the White Rose, may be selected. The products prepared may not be quite as good as they would be if the correct type of potato had been used, yet the quality is satisfactory for any type of preparation (boiling, mashing, or even frying). Although the White Rose often will not make mashed potatoes as light and fluffy as those from Russet Burbank, the White Rose is comparatively excellent when contrasted with the rather dark, somewhat gummy character of mashed potatoes made with Red Pontiac.

### Canned and Frozen Vegetables

Canned vegetables are a mainstay in the menu plans of some people. They have the advantages of being convenient to store and quick and easy to serve because they are cooked fully during canning. Since canned vegetables can be stored for many months at room temperature, they can be bought when on sale and held for later use without a significant loss in quality. No special equipment is needed to prepare commercially canned vegetables. In fact, salads often include canned vegetables that have simply been drained before being incorporated into the salad. Of course, canned vegetables can be used in many different recipes, even ones involving complex preparation steps.

One limitation of canned vegetables is the soft texture due to the rigorous heat treatment involved in safe processing of canned vegetables. The other limitation in canned vegetables is the color of green vegetables. Again, the intense and extended heat treatment required to prevent the possibility of botulism in canned vegetables always changes the bright color of fresh green vegetables into the familiar olive drab observed in canned green beans and spinach.

Frozen vegetables have gained an important segment of the vegetable market as a result of some creative marketing as well as inherently pleasing quality. The bright green color of frozen peas and beans is a real plus for these and other frozen green vegetables. Although frozen vegetables do require a bit of cooking before they are ready to serve, the time actually is very short, particularly when the vegetables are being heated in a microwave oven. This gives them a real advantage over fresh vegetables, which require some time to prepare for cooking and then a cooking period



**Figure 5.15**

Potatoes with low specific gravity float in 1:11 salt water brine and retain shape well when boiled, which are characteristics of waxy potatoes. "Sinkers" are non-waxy potatoes that slough off when boiled.

Courtesy of Plycon Press.



**Figure 5.16**

Waxy potatoes (left) have low specific gravity and hold shape when boiled; as specific gravity rises (toward right) potatoes are non-waxy and slough off. Courtesy of Plycon Press.

usually at least six minutes long. To enhance sales, manufacturers have created some unusual vegetable combinations, several with sauces to add a gourmet touch to the frozen food section. Although comparatively expensive, these frozen vegetable products have been well accepted.

A disadvantage of frozen vegetables is the requirement for freezer space. The freezer compartment in most refrigerators is adequate to accommodate the amount of frozen vegetables many families might wish to store for a week or longer. People who have a freezer can purchase frozen vegetables when special sales occur and store them for use perhaps as long as six months later.

Grading standards for quality have been established by the U.S. Department of Agriculture, the same agency that is responsible for monitoring enforcement of these regulations. The three grades for canned and frozen vegetables are U.S. Grade A or Fancy, U.S. Grade B or Extra Standard, and U.S. Grade C or Standard. To use these federal grades, packers must have a federal inspector from the U.S. Department of Agriculture present constantly. These inspectors monitor to be sure that the grade specifications are being satisfied. For U.S. Grade A, vegetables must be of top quality and have the appropriate color, have a high degree of tenderness, and be free of blemishes. U.S. Grade B is characterized as being slightly more mature than U.S. Grade A and less carefully selected for color and tenderness. Vegetables in U.S. Grade C are lacking in uniformity and have poorer color and flavor. This lowest grade is perfectly adequate for use in casseroles and soups and can save consumers money.

Packers are not required to use the federal grades. They can use their own grade designations or even designate their grades as *Grade A or Fancy* if they choose. Unless the product is designated as *U.S. Grade A, B, or C*, a federal inspector is not required to supervise the grading process. Consumers often use the brand name as the guide to quality rather than reading the grade designation. By noting quality and uniformity available in different brands, it is possible to make purchasing decisions that integrate quality and price to meet specific needs.

The suggested serving size for cooked vegetables is half a cup. To ensure that enough vegetable is being purchased to provide the appropriate number of servings, it is helpful to have a guide to estimated yields of fresh, frozen, and canned vegetables. The number of servings for common market units of vegetables is provided in Table 5.6.

**TABLE 5.6**  
**ESTIMATED SERVINGS OF FRESH, FROZEN, AND CANNED VEGETABLES**

Vegetable	Estimated Servings from		
	Fresh (1 lb)	Frozen (10 oz)	Canned (1 lb)
Asparagus	4	2 1/2	2-3
Beans, green or wax	5	3-4	3-4
Beans, lima	2 (in pods)	3-4	3-4
Beets	4	—	3-4
Broccoli	3-4	3	—
Brussels sprouts	5	3-4	—
Cabbage	4	3-4	—
Carrots	4	3-4	—
Cauliflower	4	3-4	3-4
Corn	3	3	—
Peas	1 per ear	3-4	3-4
Potatoes	2 (in pods)	3-4	3-4
Spinach	3-4	3-4	3-4
Tomatoes	4	2-3	2-3
	4	—	4

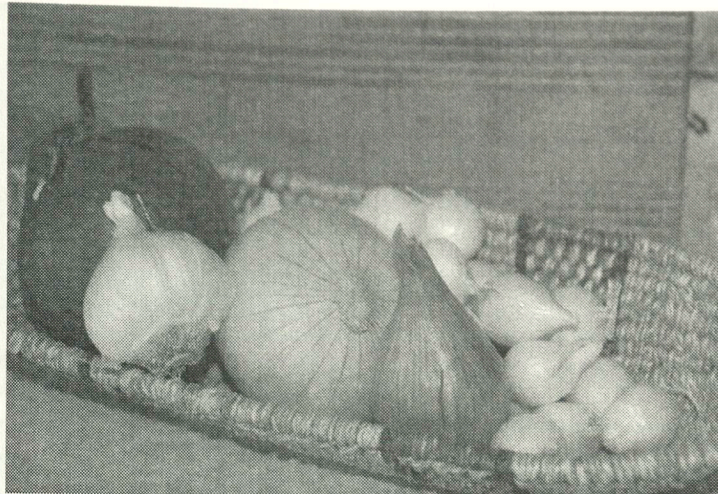
Source: Adapted from *Handbook of Food Preparation*, American Home Economics Association, Washington, DC, 8th ed., 1980; Peterkin, B., and C. Cromwell, *Money's worth in foods*, Home and Garden Bulletin No. 183, Ag. Res. Serv., USDA, Washington, DC, 1977; Thompson, E. R. *How to buy canned and frozen vegetables*, Consumer Marketing Service Bulletin, No. 167, Washington, DC, 1969.

## STORAGE

Fresh vegetables, with a few exceptions, should be stored in the refrigerator. Since refrigerator space often is limited, trimming of the tops of radishes and carrots, as well as the removal of leaves around a head of cauliflower and other inedible portions, may be done before storing produce. The cool air of the refrigerator will slow respiration and help to delay deteriorative changes, but the dryness of the air causes serious loss of moisture unless storage is in the closed hydrator drawers or in sealed plastic bags.

Although all vegetables rely on their moisture content for part of their crisp texture, moisture is particularly important for succulents, such as the various greens. The combination of the cool air (which will be saturated with only limited loss of moisture from the leaves) and the small amount of air surrounding greens in the hydrator drawer or plastic bag is the best possible way to help keep the cells in the leaves of the greens filled with their normal amount of water. Many other fresh vegetables, such as sweet corn, broccoli, and peas, also will maintain quality best by storage in the hydrator drawers.

The chief exceptions to the rule of storing fresh vegetables in the refrigerator hydrator drawers are potatoes, winter squash, Spanish and other dry onions, dry legumes, and other dried foods. All of these types of vegetables should be stored in a dark, dry, and somewhat cool place with some air circulation (Figure 5.17). As mentioned earlier, the temperature control for potatoes is of particular importance because of the potential for shifts in the type of carbohydrate in the stored potatoes. About 60°F (15.6°C) is considered optimal. Low temperatures cause an accumulation of sugar, and warmer temperatures raise the level of starch.



**Figure 5.17**

Red onions, garlic, Spanish onions, shallots, and boiling onions (left to right) are best stored in a cool, dark, and dry place. Courtesy of Plycon Press.

## VEGETABLES IN MENU PLANNING

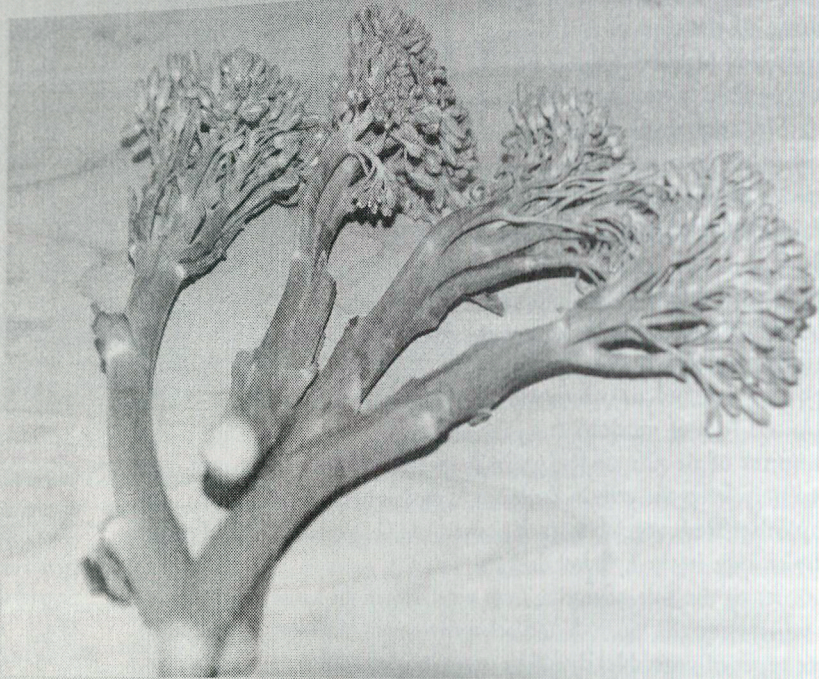
Vegetables have the potential for being the highlight of the meal when they are chosen carefully and prepared with skill. The attractive colors, distinctive shapes, and assorted flavors can be utilized to add just the right touch to a menu that might otherwise be a bit dull. Selection of the vegetable and the way it will be prepared should be based on color, texture, shape, and flavor of the vegetable in relation to the other foods being served. For instance, confetti corn (sweet corn with diced green pepper and pimiento) adds color and flavor excitement to a meal of white fish and rice pilaf. The bright color and delicate flavor of a broiled tomato accents a dinner featuring baked halibut. Mashed potatoes provide a pleasing textural contrast when served with slightly crisp, buttered, boiled carrots as the vegetables in a meal. Some vegetables can be cut into different shapes to give the desired line to a plate. For instance, carrots can be cut into slices or into matchsticks or even left whole, depending upon the other foods being included in the meal.

### INGREDIENT HIGHLIGHT BROCCOLINI

The focus on eating more vegetables and fruits is stimulating research to develop vegetables that will capture the attention of the dining public. Broccolini (also called asparation) is a hybrid of broccoli and Chinese kale that was created by Sakata Seed Co. (Figure 5.18). Sometimes this vegetable is simply named baby broccoli.

Broccolini is a rather delicate vegetable to grow. Extremes in temperature can seriously affect the crop; irrigation also requires careful regulation. With proper controls, harvesting can be done throughout the year. However, this is a vegetable that is expensive to produce because it is fairly labor intensive; this helps to explain its comparatively high cost in markets.

(Continued)

*(Continued)***Figure 5.18**

Broccolini (a hybrid of broccoli and Chinese kale) sometimes is called asparation because its flavor is reminiscent of asparagus. Courtesy of Plycon Press.

The slim stalks of broccolini are topped by quite delicate flowerets resembling broccoli. These tender stalks help to make broccolini popular. Tenderizing happens simply by blanching the vegetable in boiling water for

a minute or two, which serves also to develop a bright green color. The flavor has overtones of asparagus, which helps to explain why this vegetable sometimes is called asparation.

## FACTORS IN VEGETABLE COOKERY

### Nutrient Retention

Vegetables have a well-deserved reputation as being good sources of nutrients, but the truth is that the way in which vegetables are prepared can have a definite influence on their actual nutritive value. Even more important than the nutrient content in a vegetable is its palatability and general appeal. A vegetable can be a good source of nutrients, but they will not be available to the body if the vegetable is not eaten. Preparation for maximum palatability is clearly an important factor in the nutrient contribution of vegetables.

Efficient transport of vegetables through the marketing process to the table is essential to maintaining maximum vitamin content. They are at risk during the marketing period. Vitamins A and C (ascorbic acid) undergo oxidative losses most easily. Keeping cut surfaces to a minimum during preparation reduces oxidation and maximizes the levels of both vitamins.

The length of time vegetables are cooked will influence nutrient retention, and so will the method used in cooking. Stir-frying is a method that helps to conserve nutrients because it is rapid and is done with little or no added water. The iron content of green beans is increased very slightly if they are stir-fried in a stainless steel pan.

Due to their solubility in water, the B vitamins and vitamin C are lost to an extent when vegetables are boiled; these losses are accelerated if the water is alkaline. However, their loss is minimized if the cooking water is boiling when vegetables are added because the cooking time is reduced. The sudden, intense heat halts enzyme action and expels some oxygen, which

**TABLE 5.7**  
**PROPERTIES OF VITAMINS IMPORTANT IN FOOD PREPARATION**

Vitamin	Solubility in Water	Sensitivity to			
		Oxygen	Light	Heat in Presence of	
				Acid	Alkali
Vitamin A	No	Sensitive	Sensitive	Stable	Stable
Thiamin	Yes	Stable	Stable	Sensitive	Sensitive
Riboflavin	Yes	Stable	Sensitive	Stable	Sensitive
Niacin	Yes	Stable	Stable	Stable	Stable
Ascorbic acid	Yes	Sensitive	Sensitive	Sensitive	Sensitive
Vitamin D	No	Stable	Stable	Stable	Stable

intensifies the color. Soda should not be added to the cooking water because this is particularly destructive to thiamin, a B vitamin (Table 5.7).

Microwave cookery is one technique for helping to keep vitamin losses to a minimum. The extremely small amount of water used is helpful in retaining the water-soluble vitamins. Additionally, the cooking time is relatively short in microwave cookery. Stir-frying is another technique involving almost no water. Despite the numerous cut surfaces that promote vitamin losses, this method conserves vitamins because of the very short cooking time required to tenderize the thin slices. Steaming is another method effective in conserving nutrients. A pressure saucepan provides yet another alternative for cooking vegetables. This causes some increase in vitamin loss despite the short cooking time because the cooking temperature is higher than that of boiling water.

### Texture

Denaturation of protein, gelatinization of starch, and softening of the cellulose and other structural elements are changes taking place when vegetables are cooked. These physical changes result in distinct changes in texture, with the final effect being determined by how long the vegetable is cooked. The increasing tenderness that occurs during cooking is due primarily to softening of cellulose and conversion of some of the cementing pectic substances into more soluble pectic compounds. When these changes have proceeded to suit individual taste, the palatability of some vegetables is enhanced.

The acidity or alkalinity (pH) of the cooking water will have a definite influence on the softening occurring during boiling of a vegetable. The texture quickly becomes mushy and the shape blurs if soda is added to make the water alkaline. This change is detrimental to palatability (as well as being harmful to thiamin retention). Ordinarily, soda is not added when cooking vegetables because of the detrimental effects. However, the softening of dried beans can be speeded significantly by adding a maximum of 1/8 teaspoon of soda per cup of beans; even this small amount causes the beans to be slightly lower in thiamin than they would be if no alkali were added to the soaking and/or cooking water.

If lemon juice or other acid is added to the water used for boiling a vegetable, the effect on texture will be just the opposite of the effect of alkali. In fact, the vegetable will be extremely resistant to softening over an extended boiling period if water is acidified. This effect is particularly important to remember, for some vegetable recipes involve the use of acid. For example, in the preparation of Harvard beets, first the beets are boiled in water to soften them. When tender, the sliced beets are combined with a vinegar (acidic) sauce and heated to serving temperature. Unless the beets are tender before they are combined with the sauce, the slices will be too crisp to enjoy. Similarly when lemon butter sauce is to be combined with boiled carrots or other boiled vegetable, the vegetable must be cooked until the desired degree of tenderness is achieved before the acidic lemon juice is added.

Calcium ions are often found in hard water, and these ions can combine with pectic substances to form insoluble salts in the vegetables. The apparent result is a hard vegetable that is extremely resistant to softening during cooking. This is a particular problem when dried beans are being cooked. However, food processors use this ion to advantage when processing tomatoes. By the addition of a calcium salt (usually calcium chloride), tomatoes can be kept in their original round form instead of becoming mushy and indistinct.

Molasses is an acidic food ingredient that has a fair amount of calcium ions. When baked beans are being prepared with molasses in the sauce, it is imperative that the beans be softened to the desired degree of tenderness before the flavorful, molasses-containing sauce is added and baked with the beans. If the sauce is added too soon, the beans will not become tender.

### Color

The problem in vegetable preparation is to optimize color by proper cooking techniques, being sure that the cooking medium and the cooking time are controlled to give the desired results. The specific techniques that are appropriate differ with the pigments predominating in the various vegetables.

Pigments sometimes change color or hue when a vegetable is cooked, and the results range from pleasing to distinctly unpalatable. Because of this potential for detrimental changes, pigments require special consideration when planning cooking methods. Initially, the original color intensifies when vegetables are plunged into boiling water. This drastic change in temperature apparently causes expulsion of the small amount of air between the cells, making pigments (particularly chlorophyll) appear even brighter than before heating. This abrupt start to heating vegetables has the added advantage of keeping cooking times as short as possible, which helps to avoid converting chlorophyll to pheophytin and also aids in retaining nutrients.

The acidity or alkalinity of the water in which vegetables are being boiled will modify the colors of all pigments except the carotenoids. Vegetables containing chlorophyll will gradually take on an olive-drab color while they are cooking if the water is acidic (or if the cooking period exceeds about five to seven minutes). However, a slightly alkaline medium promotes retention of chlorophyll, as pointed out in Table 5.8.

Flavonoids, both anthoxanthins and anthocyanins, retain a desirable color in a slightly acidic medium, while alkali will cause poor color. For instance, the white of cauliflower in a barely acidic medium is considered desirable, but yellowish cauliflower, the result of alkali, is not acceptable. The color change from the rather pinkish-red seen in red cabbage cooked in a mild acid to the bluish color of a barely alkaline medium can cause complete rejection of that vegetable simply because of the change in the anthocyanin pigment with increasing alkalinity.

Vegetable cells naturally contain some mild organic acids, but these acids may be released into the cooking medium, causing pigment changes to begin to develop. In the case of chlorophyll, the change will be toward an olive green, a transition that should be avoided if possible. If green

**TABLE 5.8**  
**COLOR REACTIONS OF VEGETABLE PIGMENTS**

Pigment	Example	Color in Acid	Color in Alkali	Color Reaction to Metals
Chlorophyll	Broccoli	Olive green <sup>a</sup>	Bright green <sup>b</sup>	Copper, iron: bright green
Carotenoids	Carrots	Orange	Orange	
Flavonoids				
Anthoxanthins	Cauliflower	Colorless, white	Yellow	Aluminum: yellow
Anthocyanins	Red cabbage	Red	Blue to green	Iron: brown
				Iron: blue
				Tin: purple

<sup>a</sup>Pheophytin.

<sup>b</sup>Chlorophyllin.

vegetables are boiled in an uncovered pan, the volatile organic acids will escape from the cooking medium, thus maintaining the water close to neutral. The desired chlorophyll pigment will be maintained by keeping the lid on only until the water returns to boiling after the vegetable has been added and keeping the cooking time short.

The technique for boiling the flavonoid-containing vegetables is the reverse of that for those containing chlorophyll. Both the anthocyanin and anthoxanthin pigments are considered to be more desirable in an acidic than in an alkaline medium. Thus, using a lid on the pan retains the volatile organic acids and protects the pigments.

The pH of the water when boiling vegetables pigmented with carotenoids has little effect on their color. From the perspective of color, there is no compelling reason either for using or not using a lid on carotenoid-pigmented vegetables.

## Flavor

Although color will have a very strong influence on the acceptance of vegetables, other sensory qualities of vegetables also play a role. Flavor and the related characteristic, aroma, are key aspects of palatability. The aroma of onions cooking may be tempting to many, but the strong odor of cabbage boiling may completely repel others. Aromas are important because they contribute to the perceived flavor of a food, too. Vegetables with a strong aroma will also have a strong flavor and may be rejected on that basis.

To help promote a desirable flavor, it is advisable to cover a pan when a mild-flavored vegetable is being prepared. Conversely, do not use a cover when a strong-flavored vegetable is being boiled so that the volatile flavoring compounds can escape from the product. Remember, any odor escaping into the air is simply that much less odorant remaining to strengthen the flavor of the finished product.

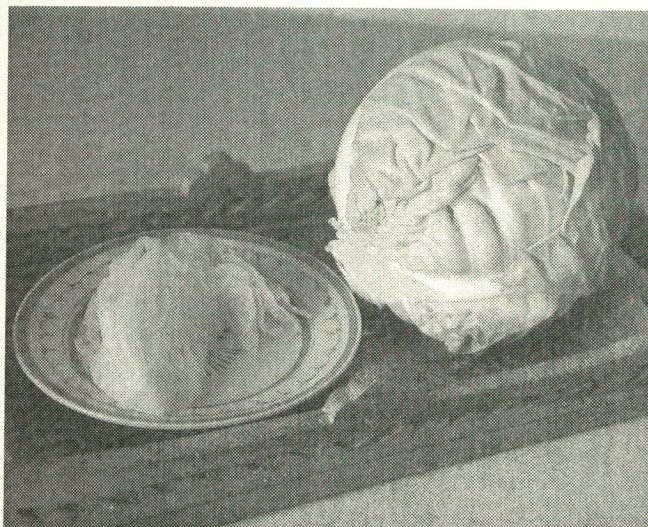
Anyone who has ever sampled the cooking water from boiled cabbage is well aware of the solubility of some of the flavoring components. By using enough water to cover strong-flavored vegetables with an excess of about 1/4 inch of water, the flavoring components will be diluted by the leaching action of the cooking medium. This small excess will help to weaken the strong flavors of the various members of the cabbage family, thus promoting palatability. When mild-flavored vegetables are being prepared, however, using just enough water to barely boil over the vegetable will assure uniform boiling of the vegetable with a minimum influence on losing flavoring compounds into the cooking water.

The length of cooking time has a distinct influence on the flavors of certain key vegetables. The onion family, with its intense, sulfur-containing flavoring components, will grow increasingly mild with continued heating. This is because some of the key flavoring compounds (including propionaldehyde, hydrogen sulfide, and sulfur dioxide) are volatile and lost from the vegetable. While a certain reduction in quantity of these intense substances is helpful, excessive loss leads to uninteresting flavors. The desired compromise can be achieved by cooking onions for a moderate length of time without a cover.

In contrast to onions, the cabbage-like vegetables develop intense flavors with extended cooking. Raw cabbage contains **sinigrin**, a glycoside found in various members of this family (Figure 5.19). In the presence of water and heat, sinigrin is converted to allyl isothiocyanate and ultimately to hydrogen sulfide, a strong and unpleasant-smelling compound. The longer the cooking time, the greater is the production of hydrogen sulfide. By keeping cooking time short for members of the cabbage family, palatability will be increased significantly.

For optimum flavor of cooked vegetables, you will need to decide (1) whether to use a lid or not, (2) how much water is needed, and (3) how long the cooking period should be. Appropriate decisions with regard to these three variables will yield significant dividends in the preparation of highly pleasing cooked vegetables.

**sinigrin** Compound in the cabbage family that ultimately is converted to hydrogen sulfide, causing an unpleasant flavor.



**Figure 5.19**

Raw cabbage (right) contains sinigrin, a glycoside that is converted to hydrogen sulfide when cabbage is boiled (left).

Courtesy of Plycon Press.

## PREPARATION PROCEDURES FOR FRESH VEGETABLES

### Preliminary Steps

For all fresh vegetables, careful washing is essential. Many vegetables are cleansed well by washing them directly under a stream of cold, running water, using a vegetable brush or plastic scouring pad for scrubbing potatoes or other vegetables with stubborn dirt clinging to them. The quickest and most efficient way of cleaning mud from the veins and convolutions of greens is to fill a clean sink with cold water and then slosh the leaves up and down vigorously to remove the dirt. Drain the water from the sink, being sure to rinse the dirty sediment down the drain. Then refill the sink with fresh, cold water. Repeat the vigorous sloshing action and draining until the water remains clean and sediment no longer collects in the bottom of the sink as the rinse water is drained.

Following washing, careful inspection of fresh produce to remove all blemishes provides an important quality control check. At this point, any necessary trimming, paring, and cutting should be done judiciously. For example, corn on the cob is prepared by removing the husks and also the fine corn silks caught in the rows between kernels. Similarly, green beans are trimmed at both ends to eliminate the very tough cellulosic areas sealing off the ends of the pods. Practically all fresh vegetables will need some judicious trimming to eliminate woody stalks, heavy, tough leaves, or other features that are not appropriate for human consumption.

Not all vegetables require extensive trimming prior to cooking. For instance, cabbage wedges should be cut so that enough of the core remains with each piece to ensure that the wedge will remain intact during boiling. Beets are left whole, with the root still attached and at least an inch of the stem remaining. These precautions help to avoid damaging any of the cells holding the anthocyanin pigments.

Paring can be done to remove the skins of potatoes, carrots, and a few other vegetables. Use of a vegetable peeler helps to keep trimming losses to a minimum, although a paring knife also is a convenient way of removing skins. To reduce oxidative losses of vitamins and also to avoid possible discoloration, paring should be done right before cooking the vegetable.

Discoloration in some potatoes is caused by enzyme action causing formation of a pigment called melanin from the amino acid tyrosine. This color change progresses through a brownish pink finally to a gray color. If potatoes have to stand after paring, discoloration can be minimized by placing them in a bowl of water to cover the entire surface and prevent oxygen from reaching the potatoes.

Many vegetables are cut into various shapes and pieces prior to being cooked. This permits them to enhance the line and design of the menu. Cooking time is also reduced.

### Boiling

Probably the most common way of preparing cooked vegetables is by boiling them. Most fresh vegetables can be tenderized by boiling in water, with or without a lid, depending on color and flavor considerations. In preparation for boiling vegetables, enough water should be brought to boil in a covered pan to barely cover the vegetable (or to exceed this depth by about 1/4 inch for strong-flavored vegetables). The cleaned and cut or whole fresh vegetables then are added to the boiling water, with the lid being replaced or removed, depending upon the specific vegetable. Boiling is continued just until the vegetables can be cut conveniently with a fork, but are not mushy. Guidelines for boiling selected vegetables appear in Table 5.9.

### Steaming

Steaming requires a rack to hold vegetables in the steam above the water boiling in a pan. Many variations of steamers and steamer baskets are on the market today. Steamed vegetables generally retain their water-soluble nutrients because they are not directly in water. The time required for steaming is longer than the time for boiling if home-style steamers are used. Commercially, pressurized steamers are fairly common. The elevated temperature of steam under pressure makes it possible to steam vegetables to the desired stage of doneness more quickly than boiling.

**TABLE 5.9**  
**SUGGESTED TECHNIQUES FOR BOILING SELECTED FRESH VEGETABLES**

Vegetable	Use of Cover	Reason to Cover or Uncover	Amount of Water	Size of Piece	Boiling Time (min) <sup>a</sup>
Artichoke, globe	Covered <sup>b</sup>	Steam needed	3/4 in.	Whole	35–45
Asparagus	Uncovered	Green color	Small <sup>c</sup>	Stalks	4–7
Beans, green	Uncovered	Green color	Small	Whole	5–7
Beets	Covered	Mild flavor	Small	Whole	30
Broccoli	Uncovered	Green color, strong flavor	— <sup>d</sup>	Split stalk	4–6
Cabbage, green	Uncovered	Green color, strong flavor	Large <sup>e</sup>	Wedge	4–6
Cabbage, red	Uncovered	Strong flavor	Large	Wedge	4–6
Carrots	Covered	Mild flavor	Small	Small, whole	5–8
Cauliflower	Uncovered	Strong flavor	Large	Whole flower flowerets	12–15 6–8
Corn	Covered	Mild flavor	Small	Kernels	4–6
Corn on the cob	Covered	Mild flavor	To cover	Whole	4–7
Onions	Uncovered	Strong flavor	Large	Whole	12–17
Parsnips	Uncovered	Strong flavor	Large	Whole	20–40
Peas	Uncovered	Green color	Small	Whole	5–7
Potatoes	Covered	Mild flavor	Small	Whole	15–20
Spinach	Covered to wilt, then uncovered	Green color	Clings to leaves	Leaves	3–5
Sweet potatoes	Covered	Mild flavor	Small	Whole	15–20
Tomatoes	Covered	Mild flavor	None	Whole	7–15

<sup>a</sup>Variation in cooking times depends on size and maturity of vegetables, as well as personal preference.

<sup>b</sup>Chlorophyll turns olive green with or without a cover because of the long cooking time needed for artichokes, so cover is used to trap steam in the pan to aid in retaining the flavor.

<sup>c</sup>Just enough water is used to bubble to the top of the vegetable when the water is boiling gently.

<sup>d</sup>Water to within 1/4 in. of flowers if broccoli is standing upright in water.

<sup>e</sup>Enough water is used to provide an extra 1/4 in. of water over the vegetable.

Some green vegetables may be less palatable when steamed than when boiled because steaming requires a cover, which may result in an olive green color. Strong flavors may be intensified by steaming because the lid traps volatile flavoring components; in addition, there is limited loss of soluble substances into the steam, as contrasted with the probable escape of these flavors into the water when vegetables are boiled.

Mild-flavored, sweet vegetables are well suited to steaming, which develops a tender, yet slightly crisp texture while retaining a desirable flavor. Table 5.10 outlines some appropriate preparation techniques for many vegetables.

### Simmering

The high protein content and low moisture level in dried legumes necessitate special preparation techniques for these nutritious vegetables. Rehydration is necessary, and this is a fairly slow process compared with the preparation of fresh vegetables. To promote the rehydration and softening of legumes, a soaking period (use of 1/8 tsp soda being optional) is the first preparation step. Either an overnight soaking period or a two-minute boiling period followed by an hour of soaking in the same water can be used equally well to shorten the simmering time needed to tenderize the beans. The exceptions to this soaking period are lentils and split peas, for they will become tender when simply simmered for about an hour or less.

**TABLE 5.10**  
**SUGGESTED METHODS FOR PREPARING VARIOUS VEGETABLES**

Vegetable	Boiled	Steamed	Broiled	Baked	Fried	Stir-fried
Artichoke, globe	X	X				
Asparagus	X	X				X
Beans, string	X	X				X
Beans, dried lima		Simmered		X		
Beans, fresh lima	X	X				
Beets	X	X		X		
Broccoli	X	X			X	X
Brussels sprouts	X	X				
Cabbage, green	X	X				X
Cabbage, red	X	X				X
Carrots	X	X		X		X
Cauliflower	X	X			X	X
Celery	X					X
Corn	X	X		X		
Eggplant				X	X	
Mushrooms			X		X	X
Okra	X				X	
Onions	X	X	X	X	X	X
Parsnips	X	X		X	X	
Peas	X	X				
Potatoes	X	X		X	X	
Spinach	X	X				X
Squash, acorn				X		
Squash, summer	X	X			X	X
Sweet potatoes	X	X		X	X	
Tomatoes	X	X	X	X	X	
Zucchini	X	X			X	X

Ordinarily legumes are simmered in the water used to soak them so that the water-soluble B vitamins leaching into the soaking water will be retained with the cooked beans. The recommended amount of water for soaking is a maximum of three cups per cup of dried beans. The anticipated final yield of cooked beans from a cup of the original beans is about two to three cups after the simmering period of 90 minutes or more. At this point, the starch in the legumes will have gelatinized, causing the beans to swell significantly. The comparatively mild heat treatment will denature the protein, tenderize the cellulose and pectic substances, and eliminate possible toxic substances, as well as deactivate a trypsin inhibitor. The net result of these changes is that simmered legumes are palatable and comparatively inexpensive sources of protein that can be utilized fairly well by the body, particularly when cereals (rice, for example) or nuts are served with them.

If pectic substances in legumes are precipitated by calcium, tenderizing is difficult. Usually, the phytic acid found in legumes is able to bind calcium ions to prevent combination with pectic substances and formation of insoluble pectinates. The difficulty in softening legumes is compounded if molasses is added before adequate softness has been achieved by simmering. This problem is the result of the action between the calcium ions and acid in the molasses. Hard water causes a similar problem due to calcium salts. When preparing baked beans, the beans need to be tender before the molasses-containing sauce is added. Acids, such as tomatoes, also

should not be added before legumes are softened by simmering because of the retarding effect that all acids will have on the softening of the pectic substances and cellulose.

### Broiling

Broiling is a direct heat method of preparing tender vegetables quickly. Tomatoes (cut in half) and stuffed mushroom caps are two vegetables that can be broiled successfully. A few other vegetables, such as boiling onions, are excellent when broiled if they have been parboiled first. Parboiling almost to the point of tenderness prior to broiling ensures that the center of the vegetable will be appropriately tender by the time the exterior becomes a pleasing, golden brown color.

### Baking or Oven Roasting

Baking and oven roasting are essentially the same dry heat method of heating food. However, the usual preparation for baking is slightly different from oven roasting. Baked potatoes have long been practically a national institution, but other vegetables, for instance winter squash and eggplant, also are suitable for baking because their skins protect them from drying excessively while baking. Preparation is simple—scrub thoroughly and bake until tender. Roasting ears of corn are also well suited to baking. Many other vegetables, with the exception of green vegetables, can be baked satisfactorily if they are placed in a covered casserole to help keep them moist.

Temperatures for baking vegetables may range anywhere from 300° to 425°F (149°C to 218°C), depending upon the other items that may be in the oven at the same time. Energy conservation suggests that baking vegetables when some other menu item also is being baked is good use of resources. Toaster ovens are useful for baking vegetables when they are the only item to be baked.

Oven-roasted vegetable medleys are colorful and healthy menu items. Sweet peppers of various colors, small new potatoes, carrots, eggplant slices, or other vegetables cut into smaller ( $\approx 1$  in.) pieces are suitable for roasting. Parboiling of whole onions or other large pieces may be done to shorten the roasting time. After they have been brushed or sprayed with olive or other oil and any desired seasonings, the vegetables are roasted at 400°F (204°C) or hotter and are stirred occasionally while roasting about an hour or until tender. If necessary, vegetables can be removed from the pan as they become tender and are pleasingly browned.

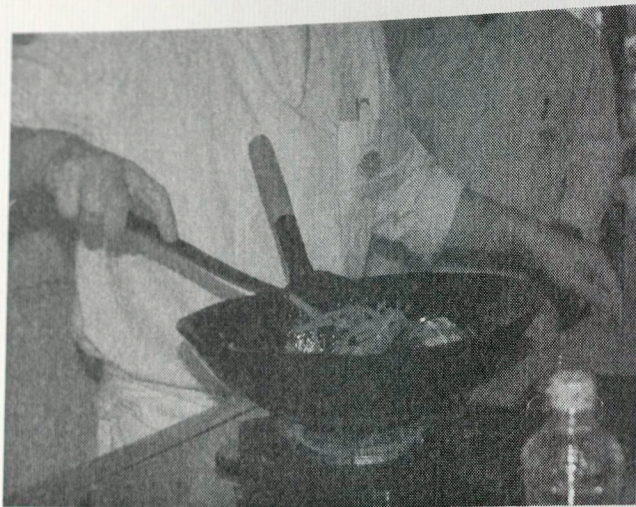
### Frying

French-fried potatoes and onion rings are popular menu items despite the advice that Americans should eat less fat. The techniques used in frying vegetables can be geared toward keeping the fat level of such items as low as possible when they are being prepared. The fat for deep-fat frying should be at about 375°F (190.5°C) before the vegetables are placed in the fat. This temperature is hot enough for rather fast cooking of the vegetable, but not so hot that the vegetable burns on the exterior before it is soft in the center. With cooler temperatures, the vegetable will absorb increasing amounts of oil as the cooking time is extended.

By placing small amounts of raw vegetable into the frying oil, the temperature of the fat will drop only slightly from the desired frying heat. Careful draining of the fried food and blotting on paper towels before serving are also important ways of helping to keep the fat content of deep-fat fried foods comparatively low.

Vegetables to be fried sometimes are dipped in a batter prior to frying, and sometimes they are blotted rather dry with paper towels and then dropped carefully into the hot fat. French-fried potatoes are always fried without batter, while dipping in batter before frying enhances onion rings and such familiar Japanese tempura morsels as sliced sweet potatoes, carrots, and green beans.

Shallow-fat frying of vegetables is done to a limited extent. Potatoes often are prepared in this way, with cottage fries and hash browns being two of the very popular recipes. Since the fat level is too shallow to check with a thermometer, the rule is to keep the fat from getting so hot that it smokes.



**Figure 5.20**

Green beans and bean sprouts are the first of the ingredients being stir-fried in a Thai recipe. Courtesy of Plycon Press.

**wok** Metallic, bowl-shaped pan developed in Asia for stir-frying.

## Stir-Frying or Panning

Stir-frying or panning, utilizing either a **wok** or a frying pan, is a method of vegetable cookery borrowed from Oriental cuisines (Figure 5.20). A wok relies on intense heat at the bottom of the bowl to cook thin slices of the vegetable very quickly in a small amount of oil. As soon as the vegetable slices brown slightly, they are pushed up the side, where heat conduction will keep finished portions warm while other slices are being fried in the bottom.

One of the delights of stir-frying is that vegetables, despite their thin slices, maintain just a suggestion of crispness. Another plus for this method of vegetable cookery is its speed. This not only saves preparation time but also helps to retain nutrients. The combination of the very short preparation time and the limited contact with water results in good retention of vitamin C and

other water-soluble nutrients in spite of the large surface area exposed by the thin slices. Other advantages of stir-frying are the fresh and vibrant green color maintained in chlorophyll-containing vegetables and the fresh flavors.

Although many vegetables will become sufficiently tender just with the heating that occurs while the slices are being browned slightly, some require additional time to achieve the desired texture. With extended frying in the intense heat of the wok, thick pieces may become too dark or even burn before the slices are done and the texture is sufficiently tender. In preparing vegetables that tenderize slowly, stir-frying is initiated as usual (i.e., with a small amount of salad oil, butter, or margarine in the bottom of the wok). However, the wok may be covered with a lid whenever stirring is not being done, and just a little water added to form steam to help tenderize the slices.

## Other Techniques

**Microwaving** Microwave ovens offer yet another means of preparing vegetables comparatively quickly. One of the advantages of a microwave oven is the rapid cooking that can happen if only small quantities are being prepared. Although cookery methods in the microwave oven frequently include adding a small amount of liquid and covering the vegetable with a paper towel or other suitable protection to trap moisture, the retention of the water-soluble vitamins (even the elusive vitamin C and the B vitamins) is good.

The texture of fresh vegetables that have been prepared in a microwave oven is often a bit more tenacious and chewy than is true of similar vegetables that have been boiled. Some people find that this texture is undesirable. Others find the excellent color and flavor provide sufficient compensation. Microwaving results in uneven cooking of various parts of the vegetable. This can be offset to a degree by rotating or stirring once or twice during the cooking period if the vegetables are in slices or pieces. Even then, the loss of water from parenchyma cells will be greater in these vegetables than in boiled counterparts; this loss explains, in part, the difference in texture resulting from these two cookery methods.

**Pressure Cooking** Some time can be saved in cooking some vegetables by using a pressure saucepan, but the greatest savings are gained with vegetables requiring 20 minutes or more to become appropriately tender. The use of a pressure saucepan is particularly helpful at high altitudes where reduced temperature of boiling water at atmospheric pressure causes considerable delay in tenderizing vegetables.

A small amount of water is placed in a pressure saucepan along with the washed and trimmed vegetables. The cover is secured, and the pan is heated, keeping the **petcock** open. When steam begins to come continuously through the open petcock, the pressure gauge (15 pounds) is put in position and full heat is continued until the gauge begins to jiggle. This indicates the correct pressure has been reached, and the timing of the cooking begins. The heat is adjusted lower until the gauge jiggles about three times per minute. Since the pressure is creating

**petcock** Small opening in the cover of a pressure saucepan to let steam escape and on which the pressure gauge is placed.

### JUDGING POINTS COOKED FRESH VEGETABLES

- Attractively cut
- Pleasing, bright color
- Texture tender enough to be cut, but not soft (puréed or mashed should be very soft)
- Flavor delicate, yet characteristic of the vegetable

a very high temperature, timing must be done carefully, for an error of 30 seconds can cause a significant variation from the desired result in tenderizing the vegetable.

As soon as the desired time has elapsed, the pressure saucepan is removed from the heat and is held under cool running water briefly to reduce the pressure inside before the pressure gauge is removed and the lid opened. Strong-flavored and green vegetables are suited less well to pressure saucepan cookery than are other vegetables, but many can be cooked successfully this way.

## PREPARING CANNED AND FROZEN VEGETABLES

### Canned Vegetables

Preparation of vegetables canned commercially is as simple as opening the can and heating them to serving temperature in their own juice, or draining and using them cold in salads. The canning process has cooked the vegetables completely. Reheating vegetables in a microwave oven is done in a glass dish, with only enough of the liquid added to provide the juice desired in serving (often only the liquid clinging to the vegetable as it is spooned from the can). No cover is required for this brief period of microwaving unless a sauce, such as that on creamed corn, is being heated with the vegetable.

Home-canned vegetables present the potential hazard of being a source of the toxin produced by *C. botulinum*. Since this toxin can be fatal in even extremely small amounts, home-canned vegetables should be boiled actively for at least 15 minutes before they are even tasted. To use home-canned vegetables without following this precaution is to take a risk that could result in death (Chapter 19). The sole exception to the rule of boiling for 15 minutes is tomatoes, for they are usually acidic enough that they do not favor growth of *C. botulinum* spores.

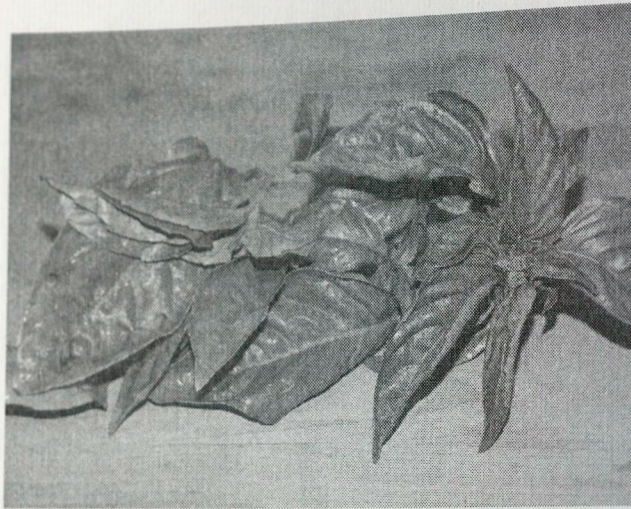
### Frozen Vegetables

Frozen vegetables have been **blanched** before freezing to inactivate enzymes that might cause oxidative changes during frozen storage. This brief cooking period is enough to begin to soften the cell walls and shorten the subsequent cooking period required when the frozen vegetable ultimately is cooked. Usually, the block of frozen vegetable is placed in a small amount of boiling water (ordinarily about half a cup of water for a 10-ounce portion of vegetable) and is boiled just until the vegetable is tender. Some frozen vegetables are packaged in bags designed to remain sealed until after cooking. These should be prepared according to the directions on the package.

A lid can be used to help trap the steam for melting the upper portion of the frozen block. Even green vegetables can be cooked from their frozen state to their serving temperature with the pan covered because the oxidative enzymes that promote pheophytin formation have been inactivated by the prior blanching period. In addition, the very short boiling period is unlikely to result in pheophytin being formed from chlorophyll.

Microwaving works particularly well for preparing frozen vegetables. As the frozen block softens during the heating process, the vegetables should be stirred to promote even heating. The texture of frozen vegetables heated in a microwave oven is close to those that are boiled, because the changes in the cell walls resulting from the blanching period and the formation of ice crystals during freezing usually result in adequate tenderizing, even with a fairly brief cooking period in the microwave oven.

**blanching** Boiling or steaming for a brief period to inactivate enzymes prior to freezing.



**Figure 5.21**

Basil is an herb that can be used as a flavoring or a garnish to add interest to vegetables. Courtesy of Plycon Press.

is essential if a sauce is going to be added or if the vegetable will be served directly on the main dinner plate. Herbs may be stirred into the drained vegetable, along with the margarine or butter, before serving. A squeeze of lemon juice stirred into the vegetable is another way of adding a subtle flavor accent.

## ADDING INTEREST

Even when vegetables have been prepared perfectly, they may seem monotonous if only a narrow range of vegetables is prepared, particularly if only one or two preparation techniques are being used. The use of sauces, seasonings, and spices can add considerable appeal to the vegetables in meals. Sauces that are appropriate for vegetables include lemon butter, hollandaise, béchamel, and mornay, as well as sweet-sour sauces. Imaginative use of herbs is another way of accenting vegetables. Basil (Figure 5.21), dill, marjoram, mint, oregano, chopped parsley, chopped chives, rosemary, sage, savory, tarragon (very sparingly), and thyme are some of the popular herbs for vegetables.

Attractive and appetizing service of vegetables is important to acceptance. Careful draining before serving

## SUMMARY

Vegetables often are classified according to the part of the plant that is used as food, the resulting classifications being bulbs, roots, tubers, leaves and stems, fruits, and seeds. Vegetables have an outer covering, a vascular transport system, and pulp, which is composed mostly of parenchyma cells. The structural components of vegetables are primarily cellulose, hemicelluloses, and the pectic substances. Within the parenchyma cells, starch is formed and stored in the plastids called leucoplasts, carotenoid pigments in the chromoplasts, chlorophylls in the chloroplasts, and flavonoid pigments, plus sugars, acids, and salts, in the large portion of the cell, called the vacuole.

Vegetables are valuable sources of nutrients when they are prepared and served in tempting ways. Among the nutrients contained in vegetables are many of the vitamins (particularly provitamin A in the dark green, leafy, and yellow vegetables) and minerals. A few are also excellent sources of starch. An important contribution of vegetables in the diet is their fiber, which is useful in promoting intestinal motility.

Throughout the year, a wide range of fresh vegetables can be obtained in large supermarkets. Many of these should be stored in the refrigerator, carefully wrapped to protect against moisture loss in the home. A few, potatoes being a notable example, should be stored about 10°F (6°C) below room temperature to promote optimum quality retention. At 60°F (15.6°C), starch content of non-waxy potatoes remains high, thus promoting their excellent performance for mashing, baking, and frying. Waxy potatoes held at this temperature will retain adequate amounts of sugar, yet starch content will be controlled to enable them to be used for their best preparation modes, for boiling and in salads and casseroles.

Considerable nutrients and palatability can be lost if care is not exercised in the handling of vegetables from the farm

to the market and, ultimately, the family table. Temperature control is vital to nutrient retention and the avoidance of spoilage. Control of the moisture level in the surrounding environment during storage also is important. The eye can be a good guide to the selection of vegetables of high quality and nutrient value.

Cookery techniques should be designed to optimize color, flavor, total palatability, and nutrient content. This is a large order, but appropriate decisions regarding the amount of water to use in boiling, the use of a lid, and length of cooking can be made. Green vegetables will retain their chlorophyll rather than form pheophytin if the cooking time is kept short and a lid is not used. A tiny bit of acid helps to retain the desired color in the flavonoids (anthoxanthins and anthocyanins), but adding much acid will cause vegetables to remain hard. Using a lid on a boiling vegetable helps to hold in the natural organic acids. A minimum amount of water to just boil over a fresh vegetable and the use of a lid will promote optimum flavor in a mild-flavored vegetable, whereas uncovering a strong-flavored vegetable like cabbage helps to increase palatability by weakening the flavor. If either color or flavor is improved without the lid, the cover should be left off for maximum palatability.

In addition to boiling, vegetables can be prepared by steaming. Legumes are simmered because they take a long time to soften. Broiling, baking, frying, and stir-frying are other techniques suited to preparing some vegetables. Microwave cookery of vegetables, particularly of canned and frozen vegetables, is yet another quick technique. A pressure saucepan is a time saver in cooking vegetables that require at least 20 minutes to soften appropriately; it is of particular merit when cooking vegetables in the mountains.

## STUDY QUESTIONS

1. Compare the cost and palatability of the following vegetables in their fresh, frozen, and canned forms: corn, peas, string beans, carrots, and potatoes. Which products represent (a) the most economical choices and (b) the greatest palatability?
2. Make a list of the various gourmet vegetables in the frozen food section. What types of sauces or special ingredients are incorporated in these items? How does the cost compare with the cost of the plain frozen vegetables?
3. What are some vegetables that are examples of each of the pigment categories? What color changes may be anticipated in each in the presence of acids and alkalis? How can cooking technique influence the color of cooked vegetables?
4. Describe the techniques involved in cooking vegetables by each of the following methods: boiling, steaming, broiling, baking, frying, stir-frying, microwaving, and pressure cooking. Name at least one vegetable suitable for each method.
5. Explain the use of a lid and the amount of water to be used in boiling each of the following fresh vegetables: corn, broccoli, onions, red cabbage, Brussels sprouts, spinach, cauliflower, beets, carrots. Explain why you chose each.

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