7 Vegetables and Fruits

Introduction

Vegetables are the edible portion of plants eaten with (or as) the main course. They are in salads and soups. Vegetables may be processed into beverages or vegetable starches, eaten fresh or lightly processed, dried, pickled, or frozen. They impart their own characteristic flavor, color, and texture to diets, and undergo changes during storage and cooking. Ranked next to the cereal crops wheat, rice, and corn, potatoes are the most prolific vegetable crop grown for human consumption.

Fruits are defined in more than one way. *Botanically*, fruits are the mature ovaries of plants with their seeds. Therefore this definition includes all grains, legumes, nuts and seeds, and common "vegetable-fruits" such as cucumbers, olives, peppers, and tomatoes. When defined and considered in a *culinary role*, fruit is the fleshy part of a plant, usually eaten alone or served as a dessert. Fruits are high in organic acids and sugar—higher than vegetables.

The nutritive value of vitamins, minerals, fiber, and other compounds contained in fruits and vegetables is extremely important to the diet. Additional dietary and medicinal benefits of fruits and vegetables are being discovered. "Vary your veggies" and "focus on fruits" is the USDA advice in selecting vegetables and fruits as part of a healthy diet. Also given as USDA advice is "make half your plate fruits and vegetables."

Structure and Composition of Cell Tissue

The structure and composition of vegetables and fruits show that they contain both *simple* and *complex* cells. The *simple* cells are similar to one another in function and structure and include *dermal* tissue and *parenchyma* tissue. Dermal tissue is the single-layer *outside* surface of leaves, young stems, roots, and flowers, while ***parenchyma tissue*** (*see below*) makes up the majority of the plant, and is where basic molecular activity such as the synthesis and storage of carbohydrate by sunlight (photosynthesis) occurs.

Complex tissue includes the vascular, collenchyma, and sclerenchyma supporting tissue. Major vascular tissue consists of the xylem and phloem; *xylem* conducts water from the roots to the leaves, and *phloem* conducts nutrients from the leaves to the roots. These tissues may be located in the center of the vegetable, for example, as is seen in carrots.

A plant is composed *primarily* of simple *parenchyma* tissue (Fig. 7.1). Each cell is bounded by a cell wall produced internally by

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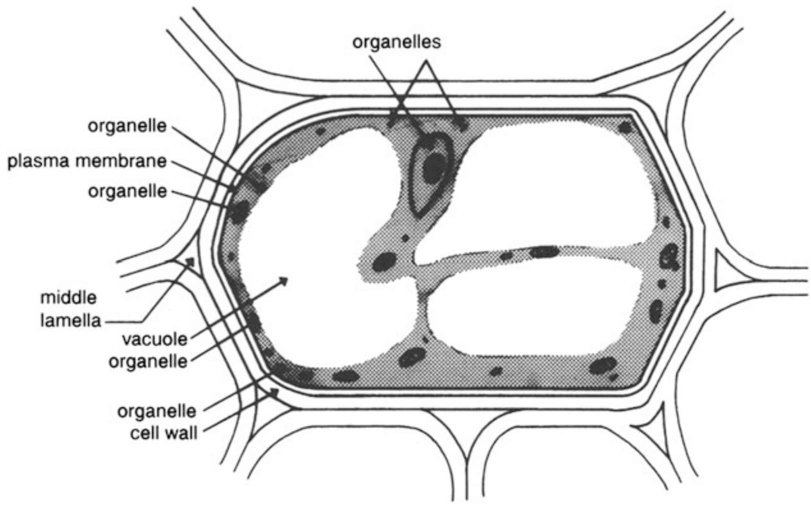


Fig. 7.1 Components of a parenchyma cell (*Source*: Division of Nutritional Sciences, New York State College of Human Ecology)

the protoplast. The wall serves to support and protect cell contents and their retention, influx, or release. When the wall is *firm*, the original shape and texture of the cell are maintained. However, when the wall is *destroyed* (by cutting, dehydration, or cooking), it breaks and spills its contents into the surrounding environment. Thus, water, sugars, or water-soluble vitamins of a cell may be lost.

The *primary* cell wall is made of ***cellulose***, hemicellulose, and pectic substances including pectin. Older, more mature plants may also have a *secondary* cell wall composed of *lignin* (see "Chemical Composition of Plant Material" section), in addition to the primary cell wall.

Inside the parenchyma cell wall is the protoplast, composed of three parts—*plasma membrane*, *cytoplasm*, *and organelles*. The *plasma membrane* surrounds the functional cell, while the ***cytoplasm*** of the protoplast includes all of the cell contents inside the membrane, yet outside the nucleus. The *organelles* include nucleus, mitochondria, ribosomes, and plastids. It is the plastids that contain fat-soluble material such as fat-soluble vitamins, and fat-soluble pigments including chlorophyll and carotenoids (each is discussed in a subsequent section of this chapter.)

Outside the cell wall, *between* adjacent cells, is the ***middle lamella***. This is the "cementing" material between adjacent cells and it contains pectic substances, magnesium and calcium, water, and air spaces.

Each parenchyma cell contains an inside cavity known as a ***vacuole***. It may be *large* in size, holding plentiful amounts of water, and comprising the major portion of parenchyma cells, or it may be *small* in size. In an intact, *un*cooked cell, vacuoles hold sufficient water and provide a desirable *crisp* texture to the cell. The opposite effect is noted in *wilted* or cooked cells.

The ***cell sap*** of the vacuole contains the water-soluble materials including vitamins B and C, sugars, inorganic salts, organic acids, sulfur compounds, and the water-soluble pigments. These cell sap components may escape into the surrounding soaking/rehydrating/cooking water.

Chemical Composition of Plant Material

Carbohydrate

Carbohydrate constitutes the *largest* percentage of the dry weight of plant material. It is the basic molecule formed during *photosynthesis* when water (H_2O) and carbon dioxide (CO_2) combine to yield carbohydrate (CHO) and oxygen (O_2).

Carbohydrate is present in both the simple and complex forms. For example, *simple* carbohydrates are the *mono*saccharides—including *glucose* and *fructose*; and *di*saccharides, such as *sucrose*, that may increase during the fruit ripening process. *Complex* carbohydrates or *poly*saccharides are synthesized from simple carbohydrates and include *cellulose* and *starch*.

Various complex carbohydrates and the effect of heat on those carbohydrates are discussed in the following (see also Chap. 3)

Starch is the storage component of carbohydrate located in roots, tubers, stems, and seeds of plants. When subjected to heat and water, starch absorbs water and gelatinizes (Chap. 4). Vegetables vary in their starch content. Some vegetables such as potatoes are starchy, some moderate, and others such as parsley are less starchy. Starch is digestible as the bonds between the glucose units are $\alpha-1,4$.

Cellulose is water-insoluble fiber that provides *structure* to plant cell walls. The molecular bonds between glucose units are β-1,4; therefore, cellulose remains *in*digestible to humans, although it may be softened in cooking.

Hemicellulose fiber provides structure in cell walls, and the majority is *in*soluble. It is softened when heated in an alkaline environment, such as, if baking soda is added to cooking water for the purpose of green color retention.

Pectic substances (Chap. 5) are the firm, intercellular "cement" between cell walls, the gel-forming polysaccharide of plant tissue, and are hydrolyzed by cooking. Large *in*soluble forms of pectin become *soluble* pectin with ripening of the plant material.

In addition to carbohydrates, there is a noncarbohydrate fiber material present in the complex vascular and supporting tissue. It is ***lignin*** and is found in older vegetables. Lignin remains unchanged by heat and may exhibit an unacceptable "woody" texture.

Protein

Protein makes up less than 1 % of the composition of a *fruit*, and protein *is low* in most *vegetables*. Protein is most prevalent in legumes—peas and beans—yet, even then, it is an *incomplete* protein as it lacks the essential amino acid, methionine.

Protein that is present as enzymes may be extracted from plants and used in other foods. Examples include the proteolytic enzymes that contribute the beneficial tenderizing effects to meats such as *papain* (derived from papaya), *ficin* (obtained from figs), and *bromelain* (extracted from pineapple).

Fat

Fat composes approximately 5 % of the dry weight of roots, stems, and leaves of vegetables. It makes up less than 1 % of the dry weight of a fruit, except for fruits such as avocados and olives that contain 16 % and 14 % fat, respectively. Fat is instrumental in development during the early growth of a plant.

Vitamins

The vitamins present in vegetables and fruit are primarily *carotene* (a vitamin A precursor) and *vitamin C*. *Beta-carotene*, is present in dark orange fruits, vegetables, and as an underlying pigment in green vegetables. Vitamin B_1 (thiamin) is also present. Fruits supply more than 90 % of the water-soluble vitamin C and a major percentage of the fat soluble vitamin A in a diet.

Water-soluble vitamin losses may occur upon soaking when vitamins leach out, and also in heating. Losses occur primarily in heating. In addition to soaking and heating, enzymatic action may negatively affect the nutritive quality of fruits and vegetables. Specifically, the enzymes, ascorbic acid oxidase and thiaminase, can cause nutritional changes in vitamins C and B_1, respectively, during storage. Therefore, retention of these vitamins is controlled by deactivating the enzymes in blanching prior to freezing.

CULINARY ALERT! It is interesting to note that vitamins A and C, so plentiful in fruits and vegetables, are both listed on Nutrient Facts labels as vitamins that Americans lack, therefore increase consumption of fruits and vegetables.

Minerals

Minerals are more prolific in vegetables than in fruits and are notably calcium, magnesium, and iron. Calcium ions are *added* to some canned vegetables in order to promote firmness and lessen softening of pectic substances. Yet, since the oxalic acid in spinach and the phytates in peas *bind calcium*, decreasing its bioavailability, calcium is *not* added to these canned vegetables.

Water

Water is found *in* and *between* plant cell walls. Some of its functions in the plant are to transport nutrients, to promote chemical reactions, and to provide plants with a crisp texture if cell membranes are intact.

Water constitutes a small percentage (10 %) of seeds and is a substantially larger percent of leaves. It makes up 80–90 % of a plant, as is evidenced by the drastic size reduction of a measure of vegetables that is subject to dehydration.

CULINARY ALERT! Think about how the volume of plant material changes significantly when a food dehydrator is used to remove water from food.

Phytochemicals (More in Appendices)

Phytochemicals are plant chemicals. They are non-nutrient materials that may be especially significant in preventing disease and controlling cancer. These chemicals are the focus of much research concerning their importance to human health.

The list is long of the many examples of such plant chemicals. It includes the beta-carotene of carotenoid pigments, the flavonoid group of pigments, as well as the sulfur-containing allyl sulfide and sulforaphane. Additionally, dithiolthiones, indoles, and isothiocyanates in cruciferous ("cross-shaped blossom," cabbage family) vegetables, isoflavones, phytosterols, protease inhibitors, saponins in legumes, and limonene and the phenols of citrus fruit are among the plant chemicals that may be effective in disease prevention.

Turgor Pressure

A plant's ***turgor pressure*** is the pressure that water-filled vacuoles exert on the cytoplasm and the partially elastic cell wall. A raw product still attached to the plant prior to harvesting is generally crisp because the vegetable or fruit contains a large percentage of water, which provides turgidity to the plant. As previously mentioned, the structure of plant material is, to a large degree, dependent on the water content of the parenchyma cell.

Shortly after the fruit or vegetable is "picked" from the plant, water is lost to the air (evaporation) due to air flow with its evaporation, or due to low humidity storage. As a result, there is a loss of turgor pressure. The product becomes limp, wilted, and dehydrated. If the parenchyma cell is still *intact* (*not cooked* or otherwise destroyed), water may reenter the cell, and turgor of this wilted, limp product may be restored. Soaking is an example of rehydration.

CULINARY ALERT! It is possible to rehydrate or recrisp by storage in high humidity (refrigerator's hydrator box or crisper) or by minimal soaking in warm, 70–90 °F (21–32 °C), water.

Subsequent to soaking, when plant pores open and take up water, the plant pores then re-close, and hold the absorbed water for approximately 6 h if the plant is refrigerated (Produce Marketing Association, Newark, DE). Soaking raw plant material may be discouraged though, as water-soluble nutrients and pigments may, by purely physical means, escape into the soaked water. [To rehydrate lettuce, it is suggested that it should not be soaked, except rather, placed in only 2 in. or so of warm water (Produce Marketing Association, Newark, DE).] Sprays of dips to make the produce waterproof may also be employed.

Once the parenchyma cell is subjected to cooking, *osmosis* ceases and *diffusion* occurs, which changes the texture, flavor, and shape of fruits. ***Osmosis*** represents water movement across a semipermeable membrane. ***Diffusion*** signifies water *and solute* movement across a *permeable* membrane.

Pigments and Effects of Additional Substances

Plant pigments enhance the aesthetic value of fruits and vegetables for humans, as well as attract insects and birds, which fosters pollination. These pigments are subject to change with ripening and processing of the raw vegetables or fruits. The four pigments found in plants are *chlorophyll*, the green pigment; *carotenoids*, a yellow, red, or orange pigment; and the flavonoids, both *anthocyanin*, the red, blue, or purple pigment, and *anthoxanthin*, the white pigment. "… a variety of different colors of non-starchy vegetables and fruits, including red, green, yellow, white, purple and orange, as well as tomato-based products and allium vegetables, such as garlic, are recommended daily." (Food Product Design 2012)

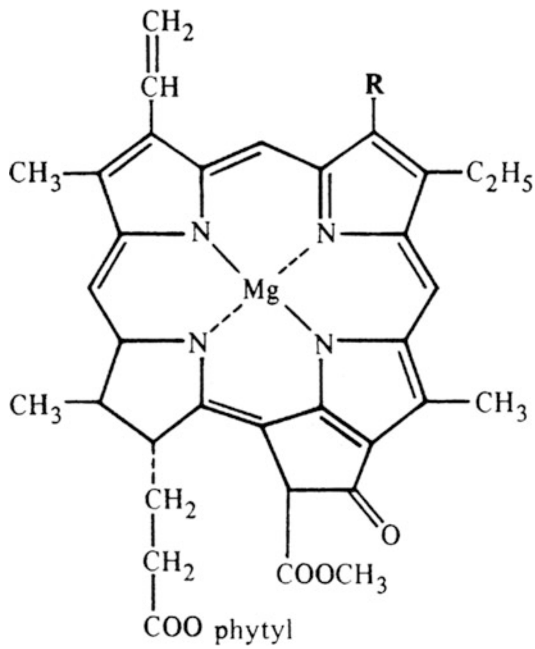


Fig. 7.2 Chlorophyll

High-performance liquid chromatography (HPLC) is generally used for plant pigment analysis. A discussion of the major pigments and a description of how they may change appears in the following material.

Chlorophyll

Chlorophyll is perhaps the most well-recognized plant pigment. It is the green pigment found in the cell chloroplast, and it is responsible for photosynthesis (i.e., converting sunlight to chemical energy). It is *fat-soluble* and may appear in vegetable cooking water if the water also contains fat.

Chlorophyll is structurally a porphyrin ring containing magnesium at the center of a ring of four pyrrole groups (Fig. 7.2). Phytol alcohol is esterified to one of the pyrrole groups, and it confers solubility to fat and fat solvents. Methyl alcohol is attached to another pyrrole group.

If the magnesium in chlorophyll is *displaced* from its central position on the porphyrin ring, an *irreversible* pigment change occurs. A number of factors cause this pigment color change, including prolonged storage, the heat of *cooking*, changes in *hydrogen ion* concentration (pH), and the presence of the minerals, zinc and copper. These factors are responsible for producing a drab, olive-green colored pigment in the *cooked* product. In a *raw* form the cell membrane does not allow H to contact/change a pigment.

Initially, as green vegetables are *heated*, air is removed from *in* and *between* the cell, and a *bright green* color becomes apparent. Then internal organic acids are released and hydrogen displaces magnesium, producing pheophytins. Either magnesium-free *pheophytin a*, which is a gray-green pigment, or *pheophytin b*, an olive-green pigment, is formed. These changes to the chlorophyll pigment become more marked with time, so a short cooking time is recommended.

As well, cooking the product *uncovered* for the first 3 minutes allows the escape of volatile plant acids that would otherwise remain in the cooking water and react to displace magnesium. Using a cover while cooking allows less change of chlorophyll to occur. (This is not true of all vegetable pigments as seen later.)

When *heated*, green-pigmented vegetables that are *high* in acid content undergo *more* color change than green vegetables *low* in acid, and green vegetables show less color change than fruits with their *high* acid. Even *raw* green vegetables, such as *raw* broccoli, change color to the underlying yellowish color as the chlorophyll degrades.

CULINARY ALERT! Pigments may change from the natural color due to extended heating and release of the plant's *internal* organic acids; therefore, minimum cooking is preferred. In addition to the internal organic acids, an *external* acid environment (i.e., acid added to cooking water) causes the natural green color to change into olive-green pheophytin.

The preceding discussion has been on the effect of *acids* on pigment color. As opposed to an acid environment, an *alkaline* environment also affects the green pigment. As the professional or home chef knows, the addition of the alkaline material, sodium bicarbonate (baking soda), produces and maintains a desirable green color. The soda reacts with chlorophyll, displacing the phytyl and methyl groups on the molecule, and the green pigment forms a bright-green, water-soluble chlorophyllin.

Nonetheless, although producing a desirable *appearance* with pH change of added soda, the benefit is accompanied by an unacceptable 1. *loss of texture*, due to softening of hemicellulose. Sodium bicarbonate also 2. *destroys ascorbic acid* (*vitamin C*) and *thiamin* (*vitamin* B_1). Therefore, due to these texture and nutrient losses the addition of this alkali substance is *not* recommended.

CULINARY ALERT! Sodium bicarbonate (baking soda) has a positive effect on color. However, it negatively affects texture and nutritive value.

In food preparation, the minerals, copper and zinc, may be released in the process of cutting or chopping. Also, some knives, copper bowls, or colanders may produce *un*desirable color changes in chlorophyll by displacing magnesium.

Regardless of the manner in which chlorophyll is changed, when the chlorophyll is destroyed, a second underlying carotenoid pigment may become apparent. Carotenoids are discussed below.

Carotenoids

The ***carotenoids*** are red, orange, and yellow *fat-soluble* pigments in fruits and vegetables, including *carotenes* (the hydrocarbon classification) and *xanthophylls* (the oxygenated class). They are found in chloroplasts along with chlorophyll, where the green pigment dominates, and also in chromoplasts without chlorophyll. The carotenoid pigment is seen especially in flowers, fruits, including tomatoes, peppers, and citrus fruits, as

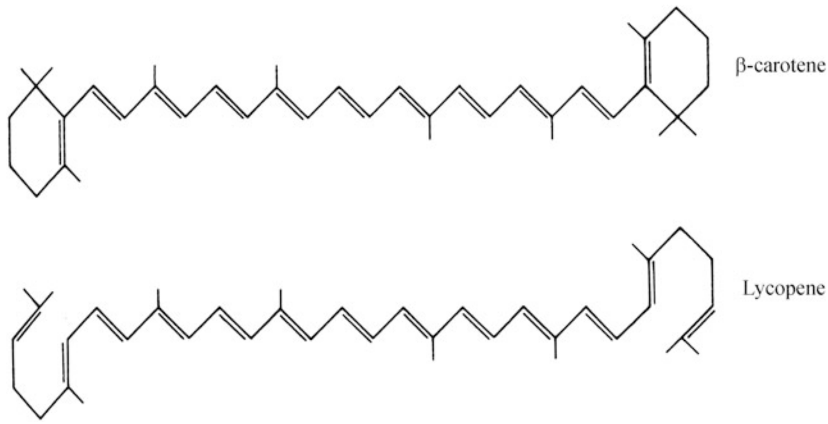


Fig. 7.3 Beta-carotene, lycopene

well as roots, including carrots and sweet potatoes.

Carotenes are unsaturated hydrocarbons containing many carbon atoms. The conjugated double bonds (i.e., double bonds alternating with single bonds) are responsible for the color; the greater the number of conjugated double bonds, the deeper the color. For example,

- *Beta*-carotene is naturally orange in color and contains a six-membered ring at each end of the chain (Fig. 7.3) In comparison to beta-carotene:
  - *Alpha*-carotene has one *less* conjugated double bond and is *paler* in color.
  - *Lycopene*, found in tomatoes and watermelon, has the *deepest red-orange color* because it has two *more* double bonds than beta-carotene, and it has two open rings (Fig. 7.3) at each end of the chain.

There exist hundreds of types of carotenes—40 or more carotenoids are known to be precursors of vitamin A. The most well-known carotene is the aforementioned beta-carotene, cleaved by an enzyme in the intestinal mucosa to yield vitamin A.

Xanthophylls are the yellow-orange colored derivatives of carotenes containing carbon, hydrogen, and oxygen. Xanthophylls include lutein and zeaxanthin.

Autumn leaves show evidence of destruction of the green chlorophyll pigment, as the carotenes, and "autumn xanthophylls" that existed along with the chlorophyll become visible. Corn contains the xanthophyll *cryptoxanthin*, and green leaves contain *lutein*. Paprika also contains xanthophyll pigment.

The carotenoid pigment may undergo autoxidation due to the large number of double bonds. This oxidation may result in "off-flavor" and color loss, yielding unsatisfactory products. Antioxidants such as butylated hydroxy anisole (BHA), butylated hydroxy toluene (BHT), or tertiary butylated hydroxy quinone (TBHQ) are frequently added to a wide variety of foods containing fruits and vegetables, herbs, or spices to prevent this detrimental oxidation.

> The FDA does not allow health claims for spices. However supportive research into the health benefits of spices fits nicely into two consumer trends: movement toward natural remedies and a growing appetite for spicy foods. (Hazen 2012)

Whereas *oxidation* causes development of a *lighter-color* cooked vegetable, *caramelization* of plant sugar may result in a *darker-color* cooked vegetable. It is recommended that carotene-pigmented vegetables should be either covered during cooking, or cooked quickly, as in stir-frying. Since the pigment is fat soluble, table fat such as butter or margarine should be minimized or omitted in cooking as the pigment may become paler.

The length of cooking time does *not* negatively affect carotenoid pigments as much as it does for chlorophyll, and changes are *not* as noticeable. However, upon *heating*, and in the presence of *acid*, some molecular isomerization occurs. Specifically, in carotenoids, the predominant *trans* molecular form, naturally present in plants, is changed to *cis* configuration in a matter of a few minutes, and the pigment becomes less bright. Unlike the case with chlorophyll pigments, *alkali* environments do *not* produce a color change.

Carotenes provide color in food. Food technologists have developed annatto, carrot, paprika, and tomato *extracts* to provide color in foods. (Pinkish-white flowers of the annatto plant with their small reddish-orange seeds inside offer dye used to color foods such as cheddar cheese.)

In addition to the plant pigments, added herbs and spices also provide carotene coloring and flavor. Albeit in *small* amounts in foods, they contribute to vitamin A values that appear on nutrition labels. They supply advantageous nutrients such as beta-carotene. This addition offers the same nutrients as a diet of yellow, green, and leafy vegetables, although in significantly lesser amounts.

Carotene from vegetables or fruits may prevent oxidation of body tissues, and development of *cancer*, although much remains unknown about possible benefits of *supplements* of this biologically active component of plant material. The Academy of Food and Nutrition advocates *foods* in the diet as the best source of good nutrition (see "Nutritive Value of Vegetables and Fruits" section rather than supplements).

CULINARY ALERT! Cooking change is minimal for carotenoids.

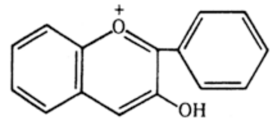


Fig. 7.4 Anthocyanin

Another group of pigmented compounds consisting of anthocyanins and anthoxanthins are the flavonoids.

Anthocyanin

Anthocyanin (Fig. 7.4) is the red, blue-red, blue, or purple pigment in fruits and vegetables such as blueberries, cherries, raspberries, red cabbage, red plums, and rhubarb (not beets; see "Betalaines" section). The *skins* of radishes, red apples, red potatoes, grapes, and eggplant also contain anthocyanin pigment. It is prevalent in buds and young shoots, and is an underlying pigment of chlorophyll, that becomes apparent as a purplish pigment in autumn leaves when chlorophyll decomposes.

Anthocyanins contain a *positively charged oxygen* in the central group of the molecule and belong to the flavonoid group of chemicals. Thus they are distinguished from the orange-red found in carotenoids. These pigments are *water-soluble* and are found in the cell sap of plants. They may be released into the cooking water with soaking or prolonged heat exposure.

In the following is a discussion regarding anthocyanin and pH.

pH and color: Care must be taken when working with the anthocyanin pigments. Mixed fruit juices for a punch drink or fruits incorporated into baked goods with alkaline leavens may produce undesirable color. Either the addition of *alkali* or an alkaline cooking medium produces unwelcome violet-blue or turquoise color.

In an *acidic* environment, the anthocyanin pigment exhibits a more characteristic

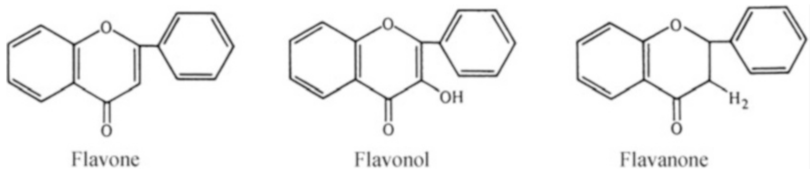


Fig. 7.5 Anthoxanthin

red color. A tart, acidic apple is often added to red cabbage while cooking in order to produce a more appealing finished product.

pH and texture: Textural characteristics are *also* affected by pH. If acids such as lemon juice or vinegar are added to fruits and vegetables (anthocyanin pigment) for better color, it should be *after* desired softening has occurred because acid prevents softening (see “Cooking Effect” section).

Recall the *negative* changes to the chlorophyll pigments when it is cooked *covered*, and still *retaining* plant acids. The opposite is true of anthocyanin pigmented vegetables. In fact, cooking the anthocyanin-pigmented vegetable *with* a cover is recommended for better color retention since *plant acids* are then *retained* yielding acidic cooking water. If fruits containing anthocyanins are added to batters and dough, such as in the preparation of blueberry muffins, *acidic* buttermilk is also incorporated to assist in preserving color. Color changes that occur in cooking are reversible.

Metals, such as iron from non-stainless-steel preparation tools, also change pigments. Metals can change the natural purplish pigment to a blue-green color. Therefore, food products containing the anthocyanin pigment are often canned in lacquer-coated (enamel-lined) metal cans to prevent the product acid from interacting with the can metal and causing undesirable color changes.

CULINARY ALERT! Anthocyanin color is subject to reversible changes in cooking.

Anthoxanthin

A fourth major pigment, ***anthoxanthin*** pigment (Fig. 7.5) is also a flavonoid, and is similar to anthocyanin, yet it exists in a *less* oxidized state, as the oxygen on the central group is *uncharged*. (Recall: anthocyanins contain a *positively charged oxygen*.) Anthoxanthins are white, or pale yellowish, *water-soluble* pigments found in a plant’s cell sap. This classification represents flavone, flavonol, flavanone, and flavanol pigments, and includes fruits such as apples, or vegetables such as cauliflower, onions, and potatoes.

A *short* cooking time is desired for the anthoxanthin pigment. Otherwise, with *prolonged* heat, the pigment turns into an undesirable brownish gray color. For example, white, anthoxanthin potatoes, with their low organic acid content, may become unfavorably dark colored after prolonged cooking due to formation of an iron–chlorogenic acid complex. Some anthoxanthins may *change* to anthocyanins and exhibit a pinkish tinge if vegetables are overcooked.

In *acid* environments, anthoxanthin becomes lighter. (Therefore, in household use, cooking in an acid environment, incorporating one teaspoon of cream of tartar per quart of water may be useful in lightening the color.) If cooking water is *alkaline* or contains traces of iron salts, the result may be a *yellow* or *brown* discoloration of white cooked vegetables. Cooking in aluminum cookware also causes the same negative discoloration.

CULINARY ALERT! Short cooking of the anthoxanthin pigment is advised. It remains whiter in acid.

Betalaines

Betalaines are a minor group of pigments that contain a nitrogen group in the molecular structure. They are similar to, yet *not* categorized as anthocyanins or anthoxanthins. These pigments differ in color.

For example,

- Betacyanines are **red-colored** like anthocyanins at a pH of 4–7
- Betaxanthines are **yellow-colored** like anthoxanthins at a pH above 10
- Betalaine below a pH of 4 is **violet-colored**

A lacquered can (as with anthocyanins) is used in order to prevent color changes that may result from metals in the can reacting with the betalaine pigment.

Tannins

Tannins (tannic acid) are polyphenolic compounds that add both color and astringent flavor to foods. They may be responsible for the *unwanted* brown discoloration of fruits and vegetables, as well as for the *desirable* changes that provide tea leaves with their characteristic color. They range in color from pale yellow to light brown, and due to their acidic nature, they tend to cause the mouth to pucker. (Astringents shrink mucous membranes, extract water, and dry up secretions.)

The term tannin represents a broad group of compounds found in plants—normally in bark, fruit, leaves, and roots. Tannins, such as the brownish pigment found in tea leaves may be used as the brown colored dye in dyeing fabrics or tanning leather. Food tannins found in wines, and teas, contain antioxidant properties correlated with good health. Tannins precipitate proteins causing them to become a solid and "*settle*" out to the lower edge of a solute phase (however, proteins will *float* if they are less dense than the solvent).

Flavor Compounds

The flavor of cooked vegetables is greatly influenced by the presence of sulfur both *allium* and *brassica* compounds, although aldehydes, ketones, organic compounds, and alcohols are contributors to the flavor profile. Some of the favorable sulfur compounds, including allyl sulfides may increase excretion of carcinogens from the body, according to the American Cancer Society (ACS).

Allium

Vegetables of the genus ***allium*** include chives, garlic, leeks, onions, and shallots, each different members of the *lily* family. Onions, for example, contain strong sulfur compounds, and exhibit enzyme activity when cut, causing the eyes to tear (lachrymatory effect). Similarly, garlic undergoes an enzymatic change to sulfur compounds, precursor (+)-*S-allyl-*L*-cysteine sulfoxide*, producing the identifiable garlic odor.

While these flavor compounds in plants are *water soluble*, they may be lost from the vegetable to the water, then volatized as steam during cooking. It follows then, that if a *mild* flavor is desired in cooked onions, a *large* amount of boiling water and cooking *uncovered* for a long time period is recommended. In that manner, sulfur flavor compounds are degraded and vaporized. Inversely, a *sweeter*, *more concentrated* flavor is produced if *less* water and a *cover* is used. The most *intense* flavor results from cooking in fat where flavor is simply *not* lost.

CULINARY ALERT! Allium: is mild if vegetable is cooked in a large amount of water, uncovered. A concentrated, stronger flavor is apparent if less water, and covered cooking is chosen. Intensity is greatest when cooking in oil.

Brassica

Vegetables of the genus ***Brassica*** include broccoli, Brussels sprouts, cabbage, cauliflower, kale, kohlrabi, mustard greens, rutabaga, and turnips. They are of the *mustard* family and are known as *cruciferous* vegetables that have a cross-shaped blossom on the young, growing plant. As opposed to allium, the *naturally mild* flavor of the *raw* vegetables with brassica *becomes quite strong* and objectionable with prolonged *cooking* as hydrogen sulfide is produced.

That is why, for optimal flavor of *brassica* flavored vegetables, a *small* amount of briskly boiling cooking water and *short* cooking is advised. Also, in order to allow the volatile organic acids to escape, it is recommended that the vegetables should be *uncovered* at the beginning of the cooking process. Then they may be *covered* to keep the cooking time short.

Several vegetables of the Brassica genus, such as cabbage, contain a sulfur compound known as *sinigrin*. Sinigrin may interact with an enzyme, myrosinase released from the cut or bruised cell and produce potent mustard oil. *The* (+)-*S-methyl-L-cysteine sulfoxide* compound may convert to the more desirable dimethyl disulphide.

CULINARY ALERT! Brassica: cooking in a small amount of water, for a short time, with a cover, prevents development of an unacceptable strong flavor.

Organic Acids

Organic acids give the tart, sour taste of fruits, and they include some of the following acids—citric acid, malic acid, or tartaric acid. *Vegetables* contain a greater variety of organic acids, yet maintain a less acidic pH level than fruits.

Concentrates, Extracts, Oils, Spices, and Herbs

Concentrates, extracts, oils, spices, and herbs incorporate flavor into food as it is processed. These may be used as an alternative to fresh, frozen, or dehydrated vegetables in a product formulation and they provide products with a pure, consistent quality of flavor when they are added. *Concentrates* impart the vegetable's characteristic flavor. *Natural plant extracts* may be used to yield the flavors and aroma of fresh herbs and spices. *Essential oils* are also removed from a plant and concentrated to produce flavoring oils. These may be the replacement for some spices and herbs.

Although there may not be a clear-cut distinction between an herb and spice, a herb is generally from the *herbaceous* part of plants. According to the American Spice Trade Association (ASTA), a spice is "any dried plant product used primarily for seasoning purposes." Spices may come from fruits, flowers, roots, or seeds, as well as from shrubs and vines. They enhance color, flavor, palatability, and they exhibit antimicrobial properties (Sherman & Flaxman 2001). (The Food and Drug Administration (FDA) does not include dehydrated vegetables in its definition of spices, but rather they are "flavors.")

An immense amount of folklore goes along with herbs and spices, which may be used for medicinal as well as culinary purposes. While *traditional medicine* in practice for centuries, includes the use of herbs and spices, such traditional medicine may be combined in practice *today* with *Western or modern medicine*. In fact, the *National Center for Complementary and Alternative Medicine*, established by the *National Institutes of Health*, has as its mission to seek out effective and alternative medical treatment, to evaluate the outcomes, and report findings to the public!

Vegetable Classifications

Vegetable classifications demonstrate the parts of the plant eaten as food. This varies throughout the world. The eight common parts, beginning with underground parts of the plant and progressing to those parts growing above ground, are as follows:

- **Roots**—underground; beet, carrot, jicama, parsnips, radish, rutabaga, sweet potato, turnip, yam ("Sweet potatoes" are a yellow to orange color flesh, either dry or moist. In the USA, they may be known as "yams," and both names are stated on a label. The non-orange, true "yam" is yellow, white, or purple-pigmented flesh root vegetables)
- **Tubers**—underground; enlarged fleshy stem; starch storage area after leaves manufacture carbohydrates; buds or eyes form new plants; Irish potato, Jerusalem artichoke
- **Bulbs**—stems with an underground bulb of food reserve; garlic bulb, leeks, onions, shallots, spring onions (green onions or scallions do not possess a real bulb)
- **Stems**—a plant's vascular system, nutrient pathway; a lot of cellulose; asparagus, celery, kohlrabi, rhubarb
- **Leaves**—the manufacturing organ for carbohydrate that is then stored elsewhere in the plant; Brussels sprouts, cabbage, lettuce, parsley, spinach; also seaweed and "greens" such as beet, collards, kale, and mustard greens
- **Flowers**—clusters on the stem; artichoke, broccoli, cauliflower
- **Fruits**—the mature ovaries with seeds, generally sweet, and fleshy; apple, banana, berry, and orange; although including vegetable-fruits, such as avocado, cucumber, eggplant, okra, olive, pepper, pumpkin, snap beans, squashes, and tomato that are not sweet, and seeds
- **Seeds**—in fruit of a plant; may be in pods; includes legumes such as dried beans, peas, and peanuts, and, in the USA, sweet corn (although it is a grain, not vegetable); may be sprouted

Harvesting and Postharvest Changes

Harvesting and postharvest processing *schedules* and *procedures* should be strictly followed to ensure fruits and vegetables with the highest possible quality. Crops are harvested at *different* stages of maturity prior to storage, and they are likely to be larger and less tender with age. It may be ideal to harvest *less mature* fruits and vegetables, *or* to allow them to "ripen on the vine."

Another ideal practice is that of *cooling* fresh produce *in the field*, and then canning *close* to the field, prior to transport. This practice minimizes negative changes in quality.

After harvest, fruits and vegetables continue to undergo respiration, the metabolic process of taking in oxygen (O_2) and giving off carbon dioxide (CO_2), moisture, and heat. The maximum rate of respiration occurs just before full ripening. *Climacteric* fruits, such as the apple, apricot, avocado, banana, peach, pear, plum, and tomato ripen *after* harvesting. Tropical fruits such as the papaya and mango are also climacteric, as is the avocado.

On the other hand, *non-climacteric fruits*, such as the cherry, citrus fruit, grapes, melon, pineapple, and strawberry ripen *prior* to harvest.

- Climacteric—ripens AFTER harvesting

- Non-climacteric—ripens BEFORE harvesting

Natural postharvest sunlight, artificial, or fluorescent light exposure may form a green chlorophyll pigment and *solanine* (bitter, and toxic at high levels) in some vegetables such as onions or potatoes. Green colored spots may appear just below the skin, and if small, these small amounts may easily be cut away.

Proper packaging for shipping is significant. Storage conditions that retain plant's moisture or heat reduce negative changes in the fruit or vegetable, such as undesirable mold or rot.

Ripening

Evidence of ripening can be *seen* and felt to the touch in a physical evaluation. For example, changes from the green color (due to chlorophyll degradation) allow more carotenoid pigment to be visible in the fruit as it ripens. Flavor changes are noted with an *increase* in the sugar and *decrease* in the acid content.

Between the produce maturity and ripening, there is a lot of unseen enzymatic activity. Although ripening may be *unseen*, there is internal hormonal and enzyme activity prior to change in the physical appearance.

A *noticeable* ripening change that occurs is due to the production of odorless and colorless ethylene gas. For example, the emission of this gas generates a softening of the plant cell wall. *Ethylene gas* is a naturally occurring hydrocarbon produced by some vegetables and fruits, especially apples, bananas, citrus fruit, melon, and tomatoes. In particular, lettuce and leafy vegetables as well as any bruised fruits are especially susceptible to undesirable respiration due to the presence of ethylene gas. Storage conditions should *separate* ethylene producers from other fruits that do not require ripening. ("*One bad apple spoils the whole bunch*!")

In addition to *natural* ethylene gas, there is also *artificially* produced ethylene gas, made by the burning of hydrocarbons. Food distributors may introduce measured doses of ethylene gas into a closed food chamber for the purpose of ripening unripened fruits before they are sold to retailers. The effectiveness of ethylene in achieving faster and more uniform ripening is dependent on the pulp temperature and stage of maturity of the fruit, and the relative humidity of the ripening room (SYSCO Foods).

CULINARY ALERT! A technique for ripening fruit at home is to place unripened fruit in a closed paper bag, which then traps ethylene gas and speed up desirable ripening.

There is some control for the unwanted effects of natural ethylene gas, which may overripen the fruit and result in poor quality. Specifically, *gibberellic acid* may be added as a control to the external storage environment of fruits and vegetables. A preharvest application of this plant growth regulator delays ripening, and retains firmness in a fruit, both of which are important considerations in postharvest handling, storage, and transportation.

In the process of *senescence* (overripening), the intracellular protopectin develops into water-soluble pectin. *Overripe* fruits and vegetables become soft or mushy as the once-firm cells separate from one another. To control unwanted ripening and extend shelf life, edible waxes and other treatments, including irradiation treatment, may be applied to fruits and vegetables. The enzymes, sucrose synthetase and pectinase, are used in measuring maturity of *some* potatoes and fruits.

Refrigeration may reduce adverse chemical reactions. As well, manipulation of CO_2 and O_2 through controlled atmosphere storage (CA), controlled atmosphere packaging (CAP), and modified atmosphere packaging (MAP) offers control of ripening (Chap. 19).

Enzymatic Oxidative Browning

Enzymatic oxidative browning (***EOB***) occurs when the plant's phenolic compounds react with enzymes in the presence of oxygen. When bruised or cut during preparation, discoloration of *some* fruits or vegetables may occur. For example, when some varieties of apples, apricots, bananas, cherries, peaches, pears, eggplant, or potatoes are bruised or cut, the product *enzymes* are exposed to *oxygen* in the atmosphere, and the produce is subject to undesirable *browning or EOB*.

Control measures to prevent EOB may not be easy. For example, there may be more than one substrate existing in a fruit or vegetable, also, oxygen may come from intercellular spaces, not solely surface air, and then the responsible enzyme must be denatured. Damaging enzymes spread in storage, and as mentioned earlier, it is true that "one bad apple spoils the whole bunch!"

One effective control of browning is to avoid contact between the substrate and oxygen. In order to achieve this, food may be covered with a *sugar syrup* in order to block oxygen, or it may be covered with a film wrap that limits oxygen permeability. *Another* control is the application of a commercially prepared *citric acid powder* or *ascorbic acid* to the cut fruit surface. Lemon juice in a ratio of 3:1 with water may be applied to the surface of the fruit, according to the Produce Marketing Association. In this manner, the vitamin C juice is oxidized *instead* of the pigment, and the acidic pH inhibits enzymatic action.

Pineapple juice, because of its sulfhydryl groups (–SH) acts as an antioxidant, and is an *additional*, effective means of protection against browning. (As with lemon juice, the Produce Marketing Association recommends dipping cut fruits in pineapple juice [3:1 ratio, pineapple juice to water] for controlling EOB.) Sulfur compounds in the juice interfere with the darkening of various foods, such as cut fruit, cut lettuce leaves, and white wine. However, due to health concerns of a small percentage of the population allergic to sulfites, the use of sulfiting agents to prevent browning is restricted in raw products. Other available agents may be used.

Home gardeners usually blanch fruits or vegetables prior to freezing. *Blanching* destroys the polyphenol oxidase enzyme and enables the product to withstand many months of freezer storage *without* degradation. Blanching entails the placement of (usually) cut-up fruit or vegetable pieces in boiling water for a precise period of time prior to freezing. The exact length of time depends on the volume and texture of the product.

CULINARY ALERT! To control browning, avoid contact between the substrate and oxygen—cover susceptible fruit with a sugar syrup or film wrap. Cover or immerse cut fruit in lemon juice, orange juice, pineapple juice, or a commercial treatment to control browning.

Cooking Effect

Cooking has many effects on food—its water retention, color, texture, flavor, and nutritive value to name a few of the effects. When short cooking periods and cooking methods such as steaming are selected, the effect is minimal loss of both flavor and nutritive value. Also, steaming retains the natural color as it does not allow contact between released internal acids and the food.

Vegetables and fruits may be consumed raw, without cooking, or are made ready for consumption by methods such as baking, boiling, frying, pressure-cooking, sautéing, steaming, stir-frying, and so forth. Cooking introduces appearance and texture changes, as well as flavor and nutritive value changes, as shown in the following.

Water Retention/Turgor

Water retention and turgor are changed once a fruit or vegetable is cooked. Once cooked, the cell membranes *lose* their selective permeability, and unlike the simple movement of water/osmosis that occurs in *raw* produce, the *cooked* cell membranes allow the additional movement of sugars and some nutrients as well as water. *Diffusion* occurs as substances move from an area of higher concentration to an area of lower concentration and the plant cell loses its form, water, and turgor.

Color

The natural color of *raw* fruits and vegetables varies, and the color of *cooked* fruits and vegetables is influenced by a number of factors as previously discussed in this chapter. These factors include the natural plant pigment and pH, age, duration of cooking, use of a pan lid, cooking method employed, and surrounding environment. *Blanching* serves to inactivate enzymes and expel intercellular air that may negatively affect color.

Cooking in aluminum or cast-iron cookware may *negatively discolor* cooked products, therefore, instead, the use of stainless steel may be recommended for cooking vegetables or fruits. Another color change accompanies the use of sodium bicarbonate, which yields a *brighter green* color. However, as earlier mentioned, this usage is not recommended, as vitamin and texture losses occur.

Texture

Without doubt, the *texture* of a fruit or vegetable changes upon cooking. The texture of the cooked vegetable depends on a number of factors. These factors include pH, age, duration of cooking, and water composition. For example, lengthy cooking in boiling *alkaline* water drastically softens texture as hemicelluloses break down; cellulose is softened, and pectins degrade. The addition of *acid*, such as the addition of a tomato to another vegetable recipe, yields a firm cooked vegetable because tissues do not soften, and pectin precipitates.

Helping to retain texture are calcium ions. These calcium ions are *naturally* present in hard water or may be *added* to many canned vegetables in commercial processing. For example, canning tomatoes with the addition of calcium *retains* the texture of cooked plant tissue forming insoluble salts with pectic substances. For a similar reason, brown sugar or molasses are common additives that are useful in retaining texture as well—e.g., Boston Baked Beans. Of course, the texture is also related to maturity of the plant, which may become tougher and “woody” due to the presence of lignin in older plants.

Flavor

The flavor of cooked vegetables is dependent on factors such as the classification as either *Allium* or *Brassic*a, and loss of both water-soluble organic acids and sugars from the vacuole. Additionally, recipe ingredients including sugar, fat, herbs, and spices vary the flavor of vegetables and may actually encourage a wary person to eat the vegetables!

Nutritive Value

Nutritive value is presented in much more detail *later* in this chapter. For now, discussion is limited to *cooking effect* on nutritive value. The nutritive value of cooked fruits and vegetables is influenced by factors such as nutrients naturally present in the food, the type of cooking medium, duration of cooking and added substances. Through diffusion, water-soluble *vitamins and sugars* in the cell sap are lost from parenchyma cells and may be oxidized. On the other hand, *minerals* present in plant material are inorganic substances that cannot be destroyed (although they may be discarded in fruit or vegetable trimmings).

Of nutritional benefit in cooking is a *short cooking* time in a *minimal* amount of water or *steaming* the vegetables. Yet, there are times when just the opposite, that is, *lengthy cooking*, with *plentiful* water may be desirable to achieve mild taste—foods such as mild tasting cooked onions may benefit from lengthy cooking and plentiful water.

Regarding the use of lids, it may be beneficial to cook *with a pan lid on* since it speeds up cooking and leads to the *desirable* retention of acids, flavor, or nutrients. Recall however, cooking with a *lid on* for the entire duration of cooking is *detrimental* to the green chlorophyll pigment and *Brassica* flavored vegetables as has been described.

CULINARY ALERT! Cooking produces changes in the turgor, appearance, texture, flavor, and nutritive value. Some changes are desirable, some not! Cook vegetables minimally.

Fruits—Unique Preparation and Cooking Principles

In this portion of the chapter, attention is given to some of the unique aspects of cooking and preparing *fruits*. Further discussion of "fruits" in this section may include vegetable-fruits such as avocados and peppers, yet most typically, fruit is referring to sweet, fleshy fruits containing seeds. It should be kept in mind that bananas and seedless grapes are examples of *fruits without seeds*.

To repeat a previously mentioned concept, the *botanical* definition of a fruit includes all grains, legumes (beans and peas), nuts, as well as some plant parts commonly eaten as "vegetables" (i.e., tomatoes) and thus is different from the culinary definition. According to its *culinary* role, fruit is the sweet, fleshy part of a plant, usually eaten alone or served as dessert. Grains, legumes, and nuts do not fit into this culinary definition of fruit; neither do the "vegetable-fruits" such as avocadoes, cucumbers, eggplant, okra, olives, peppers, pumpkin, snap beans, squash, and tomatoes, which are typically considered as *vegetables* in dietary regimes. The following is interesting:

> A 1893 tax dispute led to the ruling by the United States Supreme Court that a tomato was a vegetable. "Botanically, tomatoes are considered a fruit of the vine, just as are cucumbers, squashes, beans, and peas. But in common language of people, whether sellers or consumers of provisions, all these are vegetables which are grown in kitchen gardens, and which, eaten cooked or raw, are, like potatoes, carrots, parsnips, turnips, beets, cauliflower, cabbage, celery, and lettuce, usually served at dinner in, with, or after the soup, fish, or meats which constitute the principal part of the repast, and not like fruits, generally, as dessert" (United States Supreme Court) (Cunningham 2002).

Fruit Preparation

During fruit preparation, *water loss* may occur. For instance, when fresh-cut strawberries are sprinkled with sugar for added flavor, water is lost from the fruit through osmosis, and red (sweetened) liquid can be seen collecting in the bowl of strawberries. Other fruits may show the same effect or undergo *discoloration* due to EOB.

Whether prepared commercially by Industry, by a foodservice establishment or at home, cooking fruit in different manners/mediums may occur as follows:

Water: When fruits are cooked in *plain water*, water moves into the tissues (***osmosis***), and sugar, at a 12–15 % level naturally, diffuses out (***diffusion***). The fruit, including dried fruit, such as raisins, becomes plump. Pectins become soluble and diffuse into water; cells become less dense, and the product becomes tenderer. Cellulose is softened, and lignins remain unchanged. The fruit loses its shape.

Sugar addition: Sugar may be utilized in cooking. It offers flavor and some preservation. When *large* amounts of sugar (amounts greater than that found naturally in fruits) are added to the cooking water at the *beginning* of cooking, the tenderization is diminished and the *shape* will be *maintained*. This is because the water moves out, and the higher concentration of sugar outside of the piece of fruit moves in by diffusion. As well, the sugar interferes with plant pectin solubility. It also dehydrates cellulose and hemicellulose resulting in shrunken, tough walls.

Timing for the addition of sugar is significant. If sugar is added to fruit *early* in cooking, then that is desirable for berries or slices, where retaining shape is important. *Conversely*, when fruits are cooked in plain water and sugar is added *late*, after cooked fruit *loses its shape* and softens, desirable fruit sauces such as applesauce are formed.

Flavor changes: There are flavor changes that occur in a fruit preparation method such as cooking fruit. Water-soluble sugars and other small molecules, escape to the surrounding water in cooking. Consequently, the cooked fruit tastes blander, unless sugar is added during cooking.

Fruit Juices and Juice Drinks

Fruit "Juices" are 100 % fruit by definition, while "juice drinks" must only contain 10 % or more of real juice. Each may be formulated from a variety of fruits. Data on yield and amounts of produce needed to extract juice becomes important in studies on diet and disease (Newman et al. 2002). The FDA requires that commercial juices be pasteurized to control microbial growth. Treatment with ultraviolet (UV) irradiation is given in order to reduce the pathogens and other detrimental microorganisms.

Grading Vegetables and Fruits

Grading by the United States government (USDA) is a *voluntary* function of packers and processors. It is *not* an indication of safety, nutritive value, or type of packs (e.g., "packed in heavy syrup" and so forth). Wholesalers, commercial, and institutional food service, including restaurants and schools, may purchase according to grade using written specifications, although consumers may be unaware of grading.

Dried and *frozen* forms of fruits and vegetables are graded, although grading indications appear *less* commonly than on *canned* or *fresh* products that often show grade. In the highly competitive wholesale food-service market, *canned* fruits and vegetables receive US Grade A, B, or C.

US Grade A is the *highest* rating and indicates the best appearance and texture, including clarity of liquid, color, shape, size, absence of blemishes or defects, and maturity. US Grade C is the *lowest* grade. *Fresh fruits* and vegetables are rated US Fancy, US No. 1, and US No. 2.

Private labeling by some companies may have specifications that state a narrow range within a grade. Proprietary names may be assigned to various grades.

Organically Grown Vegetables and Fruits

"Organically grown" was formerly a term without a federal standard for the foods' production, handling, and processing. Finally, in February 2001, the USDA provided a federal definition for "organically grown." Rules for implementing The Organic Foods Production Act of 1990 took several years to go into effect and proposals were released for feedback several years prior to the final ruling. A tremendous amount of public input was obtained in an attempt to satisfy both the organic farmer and the consumer.

The intent of the final comprehensive Organic Foods standard was to *clarify* for the consumer. As well, it was to *ease potential confusion* in domestic and export sales, and make use of just *one* product label, eliminating the need for individual state and/or private standards. The USDA Organic Seal was also redesigned for better consumer understanding and became effective for use in August 2002.

Subsequent to legislation, foods labeled "organic" must be grown *without* the use of chemical pesticides, herbicides, or fertilizers (Wardlaw & Smith 2011) and have *verifiable records* of their system of production. Organic products must be 95 % organically produced; processed foods may be labeled "made with organic ingredients." If organic production and handling is *not* followed, yet a product *is* offered for sale as organic, a large monetary fine may be imposed.

Even though there is the *absence* of chemical pesticides, herbicides, and fertilizers used during growth, which would be desirable to some individuals, there is *no* evidence that organically grown foods are *higher* in *nutrient* content than conventionally grown foods. A poor soil may yield a lower crop, yet *not* one of lesser nutritive value (Newman et al. 2002).

While the *pesticide* residue would certainly be lowered or nonexistent, *bacterial counts* of organically grown plant material may be *higher* than conventionally grown foods. This is especially true if animal manure was used as a fertilizer, and care in washing was overlooked. Organically grown is *not* synonymous with *food safety* either, therefore, as with all produce, care must be taken to wash contaminants off all fruits and vegetables.

Of note in this discussion is the reminder that the National Organic Program (NOP) applies to *more than fruits and vegetables*. Crop standards, livestock standards, and handling standards are all addressed by the Act.

Biotechnology (More in Appendices)

Biotechnology (biotech) advocates say that biotech assists in providing a less expensive, safer, and better tasting food supply. Several years of conventional breeding techniques may be shortened by gene manipulation, possibly by half for some foods. Growers have strived to increase availability and yield of their crops, despite factors such as weather conditions in the growing region, insect infestation, and the lengthy time period of conventional breeding. It could be said that biotechnology goes back many centuries as a tool in breeding crops.

Biotech represents a combination of (a) conventional breeding, by plant breeders including selection, gene-crossing, and mutation, with (b) biotechnology, including recombinant DNA, and gene transfer. Continued collaboration between scientists using both approaches is needed in order to improve product quality and meet consumers' demands. Many consumers want to have genetically altered food products so-labeled.

The FDA ensures the safety of genetically altered foods and food ingredients in two ways, by regulating: *adulteration*, and by the *food additive* provision of the rules. These two FDA regulating methods provide the same safety standards of any other *non-bioengineered* food product.

The following is a statement by the FDA Biotechnology Coordinator regarding food biotechnology:

Food biotechnology

First, let me explain what we mean when we refer to food biotechnology or genetically engineered foods. Many of the foods that are already common in our diet are obtained from plant varieties that were developed using conventional genetic techniques of breeding and selection. Hybrid corn, nectarines (which are genetically altered peaches), and tangelos (which are a genetic hybrid of a tangerine and grapefruit) are all examples of such breeding and selection. Food products produced through modern methods of biotechnology such as recombinant DNA techniques and cell fusion are emerging from research and development into the marketplace. It is these products that many people refer to as "genetically engineered foods." The European Commission refers to these foods as Genetically Modified Organisms. The United States uses the term genetic modification to refer to all forms of breeding, both modern, i.e., genetic engineering, and conventional.

The new gene splicing techniques are being used to achieve many of the same goals and improvements that plant breeders have sought through conventional methods. Today's techniques are different from their predecessors in two significant ways. First, they can be used with greater precision and allow for more complete characterization and, therefore, greater predictability about the qualities of the new variety. These techniques give scientists the ability to isolate genes and to introduce new traits into foods without simultaneously introducing many other undesirable traits, as may occur with traditional breeding. This is an important improvement over traditional breeding.

Second, today's techniques give breeders the power to cross biological boundaries that could not be crossed by traditional breeding. For example, they enable the transfer of traits from bacteria or animals into plants.

In conducting its safety evaluations of genetically engineered foods, FDA considers not only the final product but also the techniques used to create it. Although study of the final product ultimately holds the answer to whether or not a product is safe to eat, knowing the techniques used to create the product helps in understanding what questions to ask in reviewing the product's safety. That is the way FDA regulates both traditional food products and products derived through biotechnology.

Statement of:
James H. Maryanski, Ph.D., Biotechnology Coordinator
Center for Food Safety and Applied Nutrition Food and Drug Administration

Before:
The Subcommittee on Basic Research, House Committee on Science

FDA

Providing human and environmental *safety*, as well as *high-quality* foods, is of great significance to public. The FDA requires that all bioengineered foods be labeled *if* they are significantly *different* from the original conventional food in nutritive value, or in posing food allergies.

Areas of research continue to focus on improving the areas previously mentioned. Certainly, the nutritive content of plant foods, such as improving the protein content of plants, and increasing their resistance to pests, or improving their storage is researched. In addition to providing the consumer with greater economy, convenience, and improved nutritive value, safety is a factor that is important to both the grower and consumer. *Safety* of biotechnology has been debated and discussed by the public, educators, environmentalists, and scientists. The future may hold more such debate.

Historically, the safety of the first genetically engineered food designed for human consumption was demonstrated to the FDA and approval was granted for use of the Flavr-Savr tomato (in *May 1994*). Its shelf life was 10 days longer than other tomatoes. Due to the polygalacturonase (PG) enzyme, it stayed on the vine *longer*, thus it could be vine ripened with enhanced flavor. Then, in 1996, the planting of corn, potato, soybeans, and tomato varieties developed through *biotechnology* began following FDA decisions on safety. Currently many more food varieties are being developed through advances in biotechnology.

According to the International Food Information Council (IFIC), a significant component of the US harvest is produced by biotechnology (IFIC). In 10 years, during 2005, over 1,400 biotech notifications were acknowledged, and over 500 permits were approved (USDA).

The USDA's Agricultural Research Service (ARS) along with private industry and Academic research centers maintain the goal of developing improved genetic engineering. To date, there are some food companies that have ceased using, or announced that they will not use GMO's due to negative consumer reaction. The debate continues.

1. What is Agricultural Biotechnology?

Agricultural biotechnology is a range of tools, including traditional breeding techniques, that alter living organisms, or parts of organisms, to make or modify products; improve plants or animals; or develop microorganisms for specific agricultural uses. Modern biotechnology today includes the tools of genetic engineering.

2. How is Agricultural Biotechnology being used?

Biotechnology provides farmers with tools that can make production cheaper and more manageable. . ..

Researchers are at work to produce hardier crops that will flourish in even the harshest environments and that will require less fuel, labor, fertilizer, and water, helping to decrease the pressures on land and wildlife habitats. . . .

In addition to genetically engineered crops, biotechnology has helped make other improvements in agriculture not involving plants. Examples of such advances include making antibiotic production more efficient through microbial fermentation and producing new animal vaccines through genetic engineering for diseases such as foot and mouth disease and rabies.

USDA

For a more in-depth report on biotechnology and foods, see reports by the Institute of Food Technologists.

Irradiation

Irradiation is reported elsewhere in this text and in other writings. The aim is to control pathogens. There is much information available to learn beyond the scope of material in this text. Some fresh fruits, juices, and sprouts have also been treated in this manner. Plant seeds may be irradiated to control pathogens. On the horizon are the results of further studies seeking suitable methods to control pathogens in products other than fruits and vegetables.

According to the USDA "Food irradiation is a technology for controlling spoilage and eliminating foodborne pathogens." The result is similar to pasteurization. The fundamental difference between food irradiation and pasteurization is the source of the energy used to destroy the microbes. While conventional pasteurization relies on heat, irradiation relies on the energy of ionizing radiation.

"Food irradiation is a process in which approved foods are exposed to radiant energy, including gamma rays, electron beams, and x-rays. In 1963, the Food and Drug Administration (FDA) found the irradiation of food to be safe. . . . Irradiation is not a substitute for good sanitation and process control in meat and poultry plants. It is an added layer of safety".

Radura Symbol

Vegetarian Food Choices

Vegetarian foods are chosen by a growing number of vegetarians, whether it is for religious, political, health, or other reasons. To clarify "vegetarian" is not simple, one must realize that it may indicate something different to various individuals. The meaning varies. However, true *vegans* are vegetarians who omit all animal products from their diet. If other types of vegetarian cuisines are followed, vegetarians might consume milk, or eggs, white meat, or fish. Persons adhering to consumption of minimal animal products are classified as "flexitarians."

In view of the fact that *animal* products are the only significant source of vitamin B_{12}, vegans consuming a meat-less diet may be wise to obtain reliable, vitamin B_{12} fortified foods. Vitamin B_{12} supplementation may be chosen in order to maintain the myelin sheath surrounding the nerves and prevent permanent nerve damage and paralysis. It is valuable to note that microwave heating *inactivates* vitamin B_{12} in foods (Chap. 9).

Labeling of Vegetables and Fruits

Nutrition Facts

Nutrition Facts labeling on foods in the USA must report on four items—vitamin A and C and the minerals, calcium and iron. These are identified below the solid line on all Nutrition Facts food labels. These four nutrients in particular are listed as nutrients that fall short of adequate levels for the population. Many Americans would do well to increase their intake of these two vitamins that are simultaneously so prevalent in fruits and vegetables. The label provides the consumer with information regarding the percentage of Daily Value that they are consuming in each serving. Individual fresh fruits and vegetables do not have labels, yet supermarket brochures, posters, or plastic bags relate the nutrient contribution.

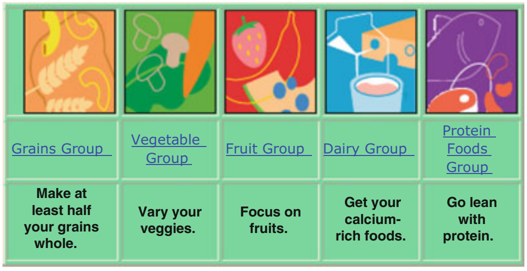
Label Terms

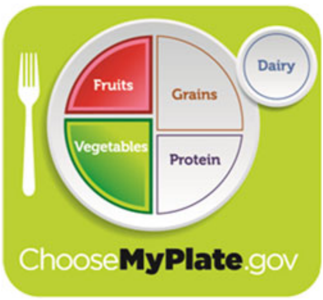
Labeling terms that apply to fruits and vegetables include the following and must appear as a product descriptor after the product name, for example, "green beans, fresh"

- A "***Fresh***" food must be a raw food, alive, and respiring. Some skin surface treatment is acceptable, such as application of wax, or pesticides. Treatment with less than 1 kGy irradiation, to inactivate pathogenic and spoilage microorganisms is allowed. (The FDA is considering use of the term "fresh" for alternative nonthermal technologies that function to protect the US food supply, and clearly convey food characteristics to consumers.)
- "Freshly prepared" is food that has not been frozen, heat processed, or preserved.
- A "Good Source of" must contain 10–19 % of the Daily Value of that nutrient per serving.
- If an item states "Fat-free," it must have less than 1/2 g of fat per serving. "Lowfat" indicates that the product must contain 3 g of fat or less per serving.
- Calorie level is important to many consumers. If an item states "Low-calorie," it must contain less than 40 cal per serving.
- "Sodium-free" signifies that a product contains less than 5 mg of sodium (Na) per serving. "Very-low-sodium" is used for a product that contains less than 35 mg of Na per serving, and "Low-sodium" is less than 140 mg Na per serving.
- "High-fiber" is 5 mg or more of fiber per serving.

The 1991 nutrition labeling produce regulations were amended by the FDA. Regulations exist for labeling nutritive value of the 20 most frequently consumed vegetables and fruits. In addition to the top 20, other vegetables and fruits *must* be labeled if nutritional claims are made. Such labeling is *voluntary* and will continue to be voluntary if there is sufficient compliance noted by the FDA.

Nutritive Value of Vegetables and Fruits

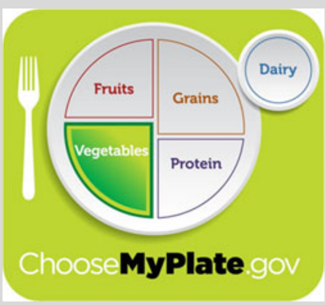




(USDA)

ChooseMyPlate.gov

http://www.choosemyplate.gov/food-groups/vegetables.html



What Foods Are in the Vegetable Group?

Any vegetable or 100 % vegetable juice counts as a member of the Vegetable Group. Vegetables may be raw or cooked; fresh, frozen, canned, or dried/dehydrated; and may be whole, cut-up, or mashed.

Vegetables are organized into five subgroups, based on their nutrient content.

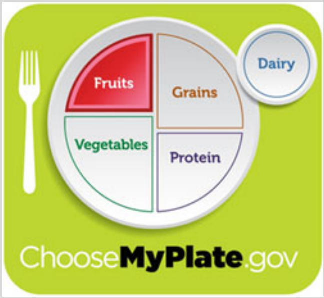
Key Consumer Message: Vary your veggies. Make half your plate fruits and vegetables.

View Vegetables Food Gallery

The *nutritional value* of vegetables and fruits is important in the diet. This text section is lengthy! Due to a worldwide supply and international purchasing potential, vegetables and fruits have year-round availability. Achieving good nutrition is enhanced by availability of the nutrients present in fruits and vegetables.

Vitamins, notably vitamins A and C, minerals (calcium and iron), and dietary fiber, are among the great benefits of a high fruit and vegetable diet, whether foods are canned, frozen, or fresh. As well, there are antioxidant properties (beta-carotene, vitamin C, and vitamin E), and anticarcinogenic properties, and fat is low for the majority of fruits and vegetables.

http://www.choosemyplate.gov/food-groups/fruits.html



Any fruit or 100 % fruit juice counts as part of the Fruit Group. Fruits may be fresh, canned, frozen, or dried, and may be whole, cut-up, or pureed. Some commonly eaten fruits are identified on the website.

Key Consumer Message: Focus on fruits. Make half your plate fruits and vegetables

View Fruits Food Gallery

Further dietary and medicinal benefits of fruits and vegetables are shown. For example, non-nutrients, such as the ***phytochemicals*** (phyto = plant) in fruits and vegetables, may function in the prevention of human disease. This further supports the idea that nutrition is obtained from food rather than isolated compounds. Isolated compounds of fruits, vegetables, and other foods that are thought to provide health and medicinal benefits to the diet are ***nutraceutical***s. The FDA has not recognized the term nutraceuticals or allowed health claims on products beyond those that are supported by the scientific community (Chap. 20, Appendix).

Additional evaluation and research is needed in order to address the many potential health benefit/disease-preventing properties of plant material. Some nutrition facts are included in Figs. 7.6 and 7.7.

Unfortunately, the USDA Department of Health and Human Services has noted: "In this land of plenty, millions of Americans aren't eating wisely. Not because they haven't had enough to eat, but because they eat too many of the wrong things or too little of the right."

According to the American Diabetic Association Exchange List, one serving of vegetables contains 25 cal and one serving of fruit contains 60 cal.

"Vary your veggies" and "focus on fruits" is the USDA advice in selecting vegetables and fruits as part of a healthy diet.

Citrus fruits contain antioxidants, vitamin C, and relatively good amounts of folic acid that has been shown to prevent reoccurrence of neural tube defect in pregnant women. The FDA allows a label claim regarding foods with dietary fiber and a reduction of cancer incidence.

Taste is the most important factor that influences food choices; positive messages about benefits of diets with plenty of fruits and vegetables help with making choices. On a regular basis, the American Public eats too little of fruits and vegetables containing nutrients, such as vitamins A and C (on all Nutrition Facts labels), or the antioxidant vitamin E, all of which have an important role in preventing or delaying major degenerative diseases of Americans.

VEGETABLES

NUTRI-FACTS

UPDATE

NUTRITION FACTS FOR RAW VEGETABLES[1]

Nutrient / % Daily Value of Nutrient

Vegetables, Serving portion (gram weight/ounce weight)	Calories	Calories From Fat	Total Fat (g/%DV)	Sodium (mg/%DV)	Potassium (mg/%DV)	Total Carbohydrate (g/%DV)	Dietary Fiber (g/%DV)	Sugars (g)	Protein (g)	Vitamin A (%DV)	Vitamin C (%DV)	Calcium (%DV)	Iron (%DV)
Asparagus, 5 spears (93 g/3.3 oz)	25	0	0/0	0/0	230/7	4/1	2/8	2	2	10	15	2	2
Bell Pepper, 1 medium (148 g/5.3 oz)	30	0	0/0	0/0	270/8	7/2	2/8	4	1	8	190	2	2
Broccoli, 1 medium stalk (148 g/5.3 oz)	45	0	0.5/1	55/2	540/15	8/3	5/20	3	5	15	220	6	6
Carrot, 7" long, 1 1/4" diameter (78 g/2.8 oz)	35	0	0/0	40/2	280/8	8/3	2/8	5	1	270	10	2	0
Cauliflower, 1/6 medium head (99 g/3.5 oz)	25	0	0/0	30/1	270/8	5/2	2/8	2	2	0	100	2	2
Celery, 2 medium stalks (110 g/3.9 oz)	20	0	0/0	100/4	350/10	5/2	2/8	0	1	2	15	4	2
Cucumber, 1/3 medium (99 g/3.5 oz)	15	0	0/0	0/0	170/5	3/1	1/4	2	1	4	10	2	2
Green (Snap) Beans, 3/4 cup cut (83 g/3.0 oz)	25	0	0/0	0/0	200/6	5/2	3/12	2	1	4	10	4	2
Green Cabbage, 1/12 medium head (84 g/3.0 oz)	25	0	0/0	20/1	190/5	5/2	2/8	3	1	0	70	4	2
Green Onion, 1/4 cup chopped (25 g/0.9 oz)	10	0	0/0	5/0	70/2	2/1	1/4	1	0	2	8	0	0
Iceberg Lettuce, 1/6 medium head (89 g/3.2 oz)	15	0	0/0	10/0	120/3	3/1	1/4	2	1	4	6	2	2
Leaf Lettuce, 1 1/2 cups shredded (85 g/3.0 oz)	15	0	0/0	30/1	230/7	4/1	2/8	2	1	40	6	4	0
Mushrooms, 5 medium (84 g/3.0 oz)	20	0	0/0	0/0	300/9	3/1	1/4	0	3	0	2	0	2
Onion, 1 medium (148 g/5.3 oz)	60	0	0/0	5/0	240/7	14/5	3/12	9	2	0	20	4	2
Potato, 1 medium (148 g/5.3 oz)	100	0	0/0	0/0	720/21	26/9	3/12	3	4	0	45	2	6
Radishes, 7 radishes (85 g/3.0 oz)	15	0	0/0	25/1	230/7	3/1	0/0	2	1	0	30	2	0
Summer Squash, 1/2 medium (98 g/3.5 oz)	20	0	0/0	0/0	260/7	4/1	2/8	2	1	6	30	2	2
Sweet Corn, kernels from 1 medium ear (90 g/3.2 oz)	80	10	1/2	0/0	240/7	18/6	3/12	5	3	2	10	0	2
Sweet Potato, medium, 5" long, 2" diameter (130 g/4.6 oz)	130	0	0/0	45/2	350/10	33/11	4/16	7	2	440	30	2	2
Tomato, 1 medium (148 g/5.3 oz)	35	0	0.5/1	5/0	360/10	7/2	1/4	4	1	20	40	2	2

Most fruits and vegetables provide negligible amounts of saturated fat and cholesterol.

[1] Raw, edible weight portion.
Percent Daily Values are based on a 2,000 calorie diet.

Developed by: Food Marketing Institute, American Dietetic Association, American Meat Institute, Food Distributors International, National Broiler Council, National Cattlemen's Beef Association, National Fisheries Institute, National Grocers Association, National Turkey Federation, Produce Marketing Association, United Fresh Fruit and Vegetable Association

Data Source: U.S. Food and Drug Administration

(7/96)

Fig. 7.6 Vegetables nutri-facts (*Data Source*: US Food and Drug Administration *Developed by*: Food Marketing Institute et al.)

FRUITS

NUTRI-FACTS

UPDATE

NUTRITION FACTS FOR RAW FRUITS[1]

Nutrient / % Daily Value of Nutrient

FRUIT, Serving portion (gram weight/ounce weight)	Calories	Calories From Fat	Total Fat (g/%DV)	Sodium (mg/%DV)	Potassium (mg/%DV)	Total Carbohydrate (g/%DV)	Dietary Fiber (g/%DV)	Sugars (g)	Protein (g)	Vitamin A (%DV)	Vitamin C (%DV)	Calcium (%DV)	Iron (%DV)
Apple, 1 medium (154 g/5.5 oz)	80	0	0 / 0	0 / 0	170 / 5	22 / 7	5 / 20	16	0	2	8	0	2
Avocado, California, 1/5 medium (30 g/1.1 oz)	55	45	5 / 8	0 / 0	170 / 5	3 / 1	3 / 12	0	1	0	4	0	0
Banana, 1 medium (126 g/4.5 oz)	110	0	0 / 0	0 / 0	400 / 11	29 / 10	4 / 16	21	1	0	15	0	2
Cantaloupe, 1/4 medium (134 g/4.8 oz)	50	0	0 / 0	25 / 1	280 / 8	12 / 4	1 / 4	11	1	100	80	2	2
Grapefruit, 1/2 medium (154 g/5.3 oz)	60	0	0 / 0	0 / 0	230 / 7	16 / 5	6 / 24	10	1	15	110	2	0
Grapes, 1 1/2 cups (138 g/4.9 oz)	90	10	1 / 2	0 / 0	270 / 8	24 / 8	1 / 4	23	1	2	25	2	2
Honeydew Melon, 1/10 medium melon (134 g/4.8 oz)	50	0	0 / 0	35 / 1	310 / 9	13 / 4	1 / 4	12	1	2	45	0	2
Kiwifruit, 2 medium (148 g/5.3 oz)	100	10	1 / 2	0 / 0	480 / 14	24 / 8	4 / 16	16	2	2	240	6	4
Lemon, 1 medium (58 g/2.1 oz)	15	0	0 / 0	5 / 0	90 / 3	5 / 2	1 / 4	1	0	0	40	2	0
Lime, 1 medium (67 g/2.4 oz)	20	0	0 / 0	0 / 0	75 / 2	7 / 2	2 / 8	0	0	0	35	0	0
Nectarine, 1 medium (140 g/5.0 oz)	70	0	0.5 / 1	0 / 0	300 / 9	16 / 5	2 / 8	12	1	4	15	0	2
Orange, 1 medium (154 g/5.5 oz)	70	0	0 / 0	0 / 0	260 / 7	21 / 7	7 / 28	14	1	2	130	6	2
Peach, 1 medium (98 g/3.5 oz)	40	0	0 / 0	0 / 0	190 / 5	10 / 3	2 / 8	9	1	2	10	0	0
Pear, 1 medium (166 g/5.9 oz)	100	10	1 / 2	0 / 0	210 / 6	25 / 8	4 / 16	17	1	0	10	2	0
Pineapple, 2 slices, 3" diameter, 3/4" thick (112 g/4 oz)	60	0	0 / 0	10 / 0	115 / 3	16 / 5	1 / 4	13	1	0	25	2	2
Plums, 2 medium (132 g/4.7 oz)	80	10	1 / 2	0 / 0	220 / 6	19 / 6	2 / 8	10	1	6	20	0	0
Strawberries, 8 medium (147 g/5.3 oz)	45	0	0 / 0	0 / 0	270 / 8	12 / 4	4 / 16	8	1	0	160	2	4
Sweet Cherries, 21 cherries; 1 cup (140 g/5.0 oz)	90	0	0.5 / 1	0 / 0	300 / 9	22 / 7	3 / 12	19	2	2	15	2	2
Tangerine, 1 medium (109 g/3.9 oz)	50	0	0.5 / 1	0 / 0	180 / 5	15 / 5	3 / 12	12	1	0	50	4	0
Watermelon, 1/18 medium melon; 2 cups diced pieces (280 g/10.0 oz)	80	0	0 / 0	10 / 0	230 / 7	27 / 9	2 / 8	25	1	20	25	2	4

Most fruits and vegetables provide negligible amounts of saturated fat and cholesterol; avocados provide 1g of saturated fat per ounce.

[1] Raw, edible weight portion.
Percent Daily Values are based on a 2,000 calorie diet.

Developed by: Food Marketing Institute, American Dietetic Association, American Meat Institute, Food Distributors International, National Broiler Council, National Cattlemen's Beef Association, National Fisheries Institute, National Grocers Association, National Turkey Federation, Produce Marketing Association, United Fresh Fruit and Vegetable Association

Data Source: U.S. Food and Drug Administration

(7/96)

Fig. 7.7 Fruits nutri-facts (*Data Source*: US Food and Drug Administration *Developed by*: Food Marketing Institute et al.)

The Academy of Nutrition and Dietetics (Position of The Academy of Nutrition and Dietetics) states that eating a wide variety of foods, including an emphasis on grains, vegetables, and fruits is the best way to obtain adequate amounts of beneficial food constituents: "It is the position of The American Dietetic Association that the best nutritional strategy for promoting optimal health and reducing the risk of chronic disease is to obtain adequate nutrients from a variety of foods. Vitamin and mineral supplementation is appropriate when well-accepted, peer-reviewed scientific evidence shows safety and effectiveness." (Position of The Academy of Nutrition and Dietetics)

> Nutrition continues to drive decision making in supermarket aisles across the country, according to *Shopping for Health* 2012, the 20th in a yearly study released today by the Food Marketing Institute (FMI) and *Prevention*, and published by Rodale Inc. (Prevention Magazine and Food Marketing Institute 2012)
>
> [FMI conducts programs in public affairs, food safety, research, education, and industry relations on behalf of its nearly 1,250 food retail and wholesale member companies in the USA and around the world. FMI's US members operate more than 25,000 retail food stores and almost 22,000 pharmacies with a combined annual sales volume of nearly $650 billion. FMI's retail membership is composed of large multi-store chains, regional firms, and independent operators. Its international membership includes 126 companies from more than 65 countries. FMI's nearly 330 associate members include the supplier partners of its retail and wholesale members].

It is interesting to note that *The American Dental Association* recommends eating fruits such as apples and oranges and many uncooked vegetables such as carrots and celery. These act as "detergent" foods, cleaning teeth, and gums of food debris that may otherwise lead to the major nutrition-related problem of tooth decay.

Nutrient Losses

Nutrient losses may result from:

- Ascorbic acid (vitamin C) and thiamin (B_1) diffused to the water and oxidized.
- Mineral salts lost in soaking or cooking water.
- Excessive peel removal.
- Excessive chopping.
- Prolonged or high temperature storage.

Storage:

- Succulents, and leafy fruits and vegetables—stored covered in the refrigerator.
- Tubers—stored in a dark, cool place for quality.

10 tips
Nutrition Education Series

add more vegetables to your day

10 tips to help you eat more vegetables

ChooseMyPlate.gov

It's easy to eat more vegetables! Eating vegetables is important because they provide vitamins and minerals and most are low in calories. To fit more vegetables in your meals, follow these simple tips. It is easier than you may think.

1 discover fast ways to cook

Cook fresh or frozen vegetables in the microwave for a quick-and-easy dish to add to any meal. Steam green beans, carrots, or broccoli in a bowl with a small amount of water in the microwave for a quick side dish.

2 be ahead of the game

Cut up a batch of bell peppers, carrots, or broccoli. Pre-package them to use when time is limited. You can enjoy them on a salad, with hummus, or in a veggie wrap.

3 choose vegetables rich in color

Brighten your plate with vegetables that are red, orange, or dark green. They are full of vitamins and minerals. Try acorn squash, cherry tomatoes, sweet potatoes, or collard greens. They not only taste great but also are good for you, too.

4 check the freezer aisle

Frozen vegetables are quick and easy to use and are just as nutritious as fresh veggies. Try adding frozen corn, peas, green beans, spinach, or sugar snap peas to some of your favorite dishes or eat as a side dish.

5 stock up on veggies

Canned vegetables are a great addition to any meal, so keep on hand canned tomatoes, kidney beans, garbanzo beans, mushrooms, and beets. Select those labeled as "reduced sodium," "low sodium," or "no salt added."

6 make your garden salad glow with color

Brighten your salad by using colorful vegetables such as black beans, sliced red bell peppers, shredded radishes, chopped red cabbage, or watercress. Your salad will not only look good but taste good, too.

7 sip on some vegetable soup

Heat it and eat it. Try tomato, butternut squash, or garden vegetable soup. Look for reduced- or low-sodium soups.

8 while you're out

If dinner is away from home, no need to worry. When ordering, ask for an extra side of vegetables or side salad instead of the typical fried side dish.

9 savor the flavor of seasonal vegetables

Buy vegetables that are in season for maximum flavor at a lower cost. Check your local supermarket specials for the best-in-season buys. Or visit your local farmer's market.

10 try something new

You never know what you may like. Choose a new vegetable—add it to your recipe or look up how to fix it online.

USDA United States Department of Agriculture
Center for Nutrition Policy and Promotion

Go to www.ChooseMyPlate.gov for more information.

DG TipSheet No. 2
June 2011
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10 tips
Nutrition
Education Series

focus on fruits

10 tips to help you eat more fruits

ChooseMyPlate.gov

Eating fruit provides health benefits. People who eat more vegetables and fruits as part of an overall healthy diet are likely to have a reduced risk of some chronic diseases. Fruits provide nutrients vital for health, such as potassium, dietary fiber, vitamin C, and folate (folic acid). Most fruits are naturally low in fat, sodium, and calories. None have cholesterol. Any fruit or 100% fruit juice counts as a part of the Fruit Group. Fruits may be fresh, canned, frozen, or dried, and may be whole, cut-up, or pureed.

1 keep visible reminders

Keep a bowl of whole fruit on the table, counter, or in the refrigerator.

2 think about taste

Buy fresh fruits in season when they may be less expensive and at their peak flavor. Add fruits to sweeten a recipe.

3 think about variety

Buy fruits that are dried, frozen, and canned (in water or 100% juice) as well as fresh, so that you always have a supply on hand.

4 don't forget the fiber

Make most of your choices whole or cut-up fruit, rather than juice, for the benefits that dietary fiber provides.

5 be a good role model

Set a good example for children by eating fruit every day with meals or as snacks.

6 include fruit at breakfast

At breakfast, top your cereal with bananas, peaches, or strawberries; add blueberries to pancakes; drink 100% orange or grapefruit juice. Or, try a fruit mixed with fat-free or low-fat yogurt.

7 try fruit at lunch

At lunch, pack a tangerine, banana, or grapes to eat, or choose fruits from a salad bar. Individual containers of fruits like peaches or applesauce are easy and convenient.

8 experiment with fruit at dinner, too

At dinner, add crushed pineapple to coleslaw, or include orange sections, dried cranberries, or grapes in a tossed salad.

9 snack on fruits

Dried fruits make great snacks. They are easy to carry and store well.

10 keep fruits safe

Rinse fruits before preparing or eating them. Under clean, running water, rub fruits briskly to remove dirt and surface microorganisms. After rinsing, dry with a clean towel.

USDA United States Department of Agriculture
Center for Nutrition Policy and Promotion

Go to www.ChooseMyPlate.gov for more information.

DG TipSheet No. 3
June 2011
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Safety of Vegetables and Fruits

Safety is a food characteristic that the public expects. Foods should be safe, and in fact, the public is encouraged to eat more fruits and vegetables for health. Fruits and vegetables are *not* considered "potentially hazardous foods" that allow the "rapid and progressive growth of infectious or toxigenic microorganisms" (Model FDA Food Code).

In comparison to animal-based foods, there are few problems with plant-based products, yet, unfortunately, plant-based products can carry disease. Recently fresh, bagged spinach was pulled off the market nationwide, due to E-coli bacteria. Health Departments across the USA advised that washing the bagged spinach could not guarantee safety. One death and illness in many states followed ingestion of the spinach.

Pathogenic microorganisms are found in the environment and can contaminate food, causing illness. Imports from less-developed regions of the world may be implicated as a contributing factor in the increase in fruit- and vegetable-related foodborne illness.

Check your steps at FoodSafety.gov. Also see the chapter on Food Safety.

Some foods are more frequently associated with foodborne illness. With these foods, it is especially important to:

- CLEAN: Wash hands and food preparation surfaces often. And wash fresh fruits and vegetables carefully.
- SEPARATE: Don't cross-contaminate! When handling raw meat, poultry, seafood, and eggs, keep these foods and their juices away from ready-to-eat foods.
- COOK: Cook to proper temperature. See the Minimum Cooking Temperatures chart for details on cooking meats, poultry, eggs, leftovers, and casseroles.
- CHILL: At room temperature, bacteria in food can double every 20 min. The more bacteria there are, the greater the chance you could become sick. So, refrigerate foods quickly because cold temperatures keep most harmful bacteria from multiplying.

Regardless of its source, it is recommended that "ready-to-eat" value-added fresh produce be *washed* prior to consumption, and then refrigerated in order to maintain food safety. Washing is recommended despite the label statement that the product is washed and ready-to-eat.

Cross-contamination from other foods, such as meats, should be avoided, pull dates should be adhered to, and assembly/preparation areas should be sanitary. Of course personal hygiene is crucial to food safety.

Hydrogen peroxide is a generally recognized as safe (*GRAS*) substance that has also been used as a bleaching agent (as in milk used for cheese), and as an antimicrobial agent in foods. Some antimicrobials are effective due to their low pH, yet are not usable due to the unacceptable flavor that they impart. Other substances having antimicrobial properties include essential oils from citrus, coriander, mint, parsley, and vanillin juice peels.

Conclusion

Plant tissue is composed primarily of parenchyma tissue. The structure and composition of a fresh fruit or vegetable changes as the cell is destroyed. As fruits and vegetables typically contain a very large percentage of water, the maintenance of turgor pressure is an important factor in determining plant material quality.

The desirable pigments and flavor compounds contained in fruits and vegetables may undergo unacceptable changes upon preparation and cooking. Discoloration of some cut vegetables or fruits is known as EOB, which must be controlled. Improper storage or cooking can result in quality losses.

The nutritive value of vitamins, pro-vitamins (carotene) minerals, fiber, and other compounds contained in fruits and vegetables are extremely important to the diet, and there are medicinal benefits of fruits and vegetables. Many are low in fat content. Vegetarian food choices may be met with consumption of a variety of fruits and vegetables. "Vary your veggies" and "focus on fruits" is the USDA advice in selecting vegetables and fruits as part of a healthy diet.

Biotechnology provides the consumer with greater economy and convenience. Coupled with an understanding of the role of phytochemicals in disease prevention, vegetables and fruits may provide a greater nutrient contribution to the human diet. Irradiation is utilized as a means of ensuring food safety. Items of high nutritional value that were once unfamiliar and not used, as well as new items from around the world are now available on grocery shelves.

Notes

CULINARY ALERT!

Glossary

Allium Flavor compounds in the genus *Allium* that contain sulfur compounds and offer phytochemical value.

Anthocyanin Red-blue pigmented vegetables of the Flavone family.

Anthoxanthin Whitish pigmented fruits and vegetables of the Flavone group of chemicals.

Biotechnology Biogenetic engineering of animals, microorganisms, and plants to alter or create products that have increased resistance to pests, improved nutritive value, and shelf life.

Brassica Flavor compound of *Brassica* genus including cruciferous vegetables with sulfur compounds.

Carotenoid The group of red-orange pigmented fruits and vegetables; some are precursors of vitamin A and also have antioxidant value.

Cellulose Glucose polymer joined by β-1,4 glycosidic linkages; cannot be digested by human enzymes, thus it provides insoluble dietary fiber.

Cell sap Found in the plant vacuole; contains water-soluble components such as sugars, salts, and some color and flavor compounds.

Chlorophyll The green pigment of fruits and vegetables.

Cytoplasm Plant cell contents inside the cell membrane, but outside the nucleus.

Diffusion Movement of solute across a permeable membrane from an area of greater concentration to lesser concentration in heated products that do not have an intact cell membrane.

Enzymatic oxidative browning Browning of cut or bruised fruits and vegetables due to the presence of phenolic compounds, enzymes, and oxygen.

Fresh Alive and respiring as evidenced by metabolic and biochemical activities.

Fruit The mature ovaries of plants with their seeds.

Hemicellulose The indgestible fiber in cell walls that provides bulk in the diet; may be soluble, but primarily insoluble.

Lignin The noncarbohydrate component of fiber of plant tissue that is insoluble and excreted from the body. It provides the undesirable woody texture of mature plants.

Middle lamella The cementing material between adjacent plant cells, containing pectic substances, magnesium, calcium, and water.

Nutraceuticals The name given to a proposed new regulatory category of food components that may be considered a food or part of a food and may supply medical or health benefits including the treatment or prevention of disease. A term not recognized by the FDA.

Osmosis The movement of water across semipermeable membranes from an area of greater concentration to lesser concentration in products with an intact cell membrane.

Parenchyma tissue Majority of plant cells containing the cytoplasm and nucleus.

Pectic substances The intercellular "cement" between cell walls; the gel-forming polysaccharide of plant tissue.

Phytochemicals Plant chemicals; natural compounds other than nutrients in fresh plant material that help in disease prevention. They protect against oxidative cell damage and may facilitate carcinogen excretion from the body to reduce the risk of cancer.

Turgor pressure Pressure exerted by water-filled vacuoles on the cytoplasm and the partially elastic cell wall.

Vacuole Cavity filled with cell sap and air.

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Academy of Nutrition and Dietetics (formerly American Dietetic Association.) Chicago, IL

American Cancer Society (ACS)

American Soybean Association. St. Louis, MO

Arrowhead Mills. Hereford, TX

Centers for Disease Control and Prevention (CDC)

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