

Pepper

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Scientific Name and Introduction

Pepper (*Capsicum annul* L.), also called bell pepper, chili, chilies, aji, pimiento, paprika, and capsicum, is a warm-season crop that is a member of the Solanaceae family. Sweet bell peppers are green at the immature stage (when most are sold) and turn red, gold, purple, orange, or brown as they ripen. Because sugar content increases as they ripen, colored peppers tend to be sweeter than green peppers. The most notable feature of peppers is flavor, which can be sweet, mild, or strongly pungent. Sweet bell peppers are available year round, with ‘California Wonder’ being the most common cultivar.

Chili peppers include a number of varieties: ancho, anaheim, cayenne, cherry hot pepper, cheese, fresno (red and green), habanero (red, green, and orange), jalapeno, poblano, serrano (green and red), yellow, chiltepin, cuban, long wax, new mexican, tabasco, thai, etc. Chili peppers vary greatly from mild to very hot. Heat is determined by capsaicin content. Some chili peppers are dried and sold individually or tied together in ornamental arrangements.

Peppers are eaten raw in salads and salsa; processed by canning, freezing, or pickling; and dehydrated and powdered to produce paprika and chili powder. Unlike in the United States, most European paprika is mildly pungent. Chili powder prepared at different levels of pungency is usually composed of ground, dried, pungent peppers mixed with other spices, such as oregano, cumin, and garlic. Various pepper forms, usually chili types, are extensively used in combination with other spices such as turmeric, cumin, and coriander to produce curry powder, the pungency of which depends on the pepper cultivars used. For instance, cayenne powder is a high-pungency condiment produced from dried mature fruit of cayenne-type cultivars

Quality Characteristics and Criteria

Good-quality sweet bell peppers are uniform in shape and are the size and color typical of the variety. The flesh (pericarp) should be firm and relatively thick with a bright skin color and sweet flavor; it should be free from defects such as cracks, decay, and sunburn. Peppers should not be shriveled and dull-looking or pitted. The same quality criteria apply to fresh chili peppers. Dry lines or striations across the skin are not an indication of poor quality—they indicate a hotter pepper.

Horticultural Maturity Indices

Criteria for the maturity of green peppers include fruit size, firmness, and color. For colored peppers the additional criteria of having a minimum of 50% coloration is important.

Chili peppers are harvested by hand. They are generally picked when ripe and then dried and allowed to equilibrate in moisture content in covered piles. The major dried peppers are hot red

peppers for cayenne and occasionally pimientos for paprika. The pods may be sliced before drying to shorten drying time and improve color and flavor. Seeds may be removed by screening and water sprays.

Grades, Sizes, and Packaging

Grades for fresh sweet bell peppers include U.S. Fancy, U.S. No.1, and U.S. No. 2. Not all sweet peppers are graded; ungraded peppers are “unclassified.” Differences between grades are based primarily on external appearance. Sizes include Small, Medium, Large, and Extra Large/Jumbo. Cardboard boxes commonly hold 6.8 to 15.9 kg (15 to 35 lb) of randomly packed peppers. Very high quality peppers are often marketed in 5-kg (11-lb) flat cartons with one or two layers of fruit.

There are no U.S. grades for chili peppers.

Precooling Conditions

After harvest, fresh market peppers should be rapidly cooled to no lower than 7 °C (45 °F) at high RH to reduce water loss and shrivel. Precooling can be done using forced-air cooling, hydrocooling, or vacuum-cooling. Properly vented cartons are required to facilitate forced-air cooling. If hydrocooling is used, care should be taken to prevent development of decay. High RH is necessary to avoid desiccation. Waxing has been used to reduce desiccation, but it tends to increase bacterial soft rot. Shelf-life varies among different pod types. Deterioration is often due to moisture loss, with some pod types more prone to desiccation than others.

Optimum Storage Conditions

Fresh peppers can be kept for 2 to 3 weeks at 7 °C (45 °F) with 90 to 95% RH. Storage life can be extended another week by packaging in moisture-retentive films at 7 to 10 °C (45 to 50 °F). Peppers are subject to chilling injury when stored below 7 °C (45 °F) and to accelerated ripening and bacterial soft rot when stored above 13 °C (55 °F). Storage at 5 °C (41 °F) reduces water loss and ripening, but after 2 weeks chilling injury will appear. Some pepper cultivars can be sensitive to chilling if stored at 7 °C (45 °F), so a good storage temperature range is 7 °C (45 °F) to 13 °C (55 °F).

Controlled Atmosphere (CA) Considerations

Peppers derive a slight benefit from CA storage (Saltveit 1997). Low-O₂ atmospheres (2 to 5% for bell peppers and 3 to 5% for chilies) retard ripening and respiration during transit and storage and benefit quality slightly. At 10 °C (50 °F), high CO₂ (>5%) can cause calyx discoloration, skin pitting, and discoloration and softening in both bell and chili peppers. An atmosphere of 3% O₂ and 5% CO₂ is more beneficial for red than for green peppers stored at 5 to 10 °C (41 to 50 °F) for 3 to 4 weeks. Before processing, chili peppers can be stored under 3 to 5% O₂ and 15 to 20% CO₂ for up to 3 weeks at 5 °C (41 °F) without appreciable chilling injury or quality loss. Freshly harvested chili or other hot peppers should be stored under the same temperature and RH conditions as sweet peppers.

Retail Outlet Display Considerations

Fresh bell and chili peppers should be displayed at 7 °C (45 °F). They should not be sprinkled or top iced. Dried chili peppers should be kept dry.

Chilling Sensitivity

Peppers are sensitive to chilling injury when stored below 7 °C (45 °F). Symptoms include surface pitting, water-soaked areas, decay (especially *Alternaria*), and discoloration of the seed cavity. Symptoms can appear after a few days at 0 °C (32 °F) or a few weeks at 5 °C (41 °F). Sensitivity varies with cultivar; ripe or colored peppers are less chilling sensitive than green peppers.

Ethylene Production and Sensitivity

Peppers are nonclimacteric and produce very low levels of ethylene: 0.1 and 0.2 $\mu\text{L kg}^{-1} \text{h}^{-1}$ at 10 and 20 °C (50 and 68 °F), respectively. The use of ethylene to enhance ripening or color change is not recommended because it stimulates respiration and softening more than coloration. The most effective way to color peppers is to hold partially colored fruit at 20 to 25 °C (68 to 77 °F) with RH >95%. To maintain quality, store them away from ethylene-producing fruits and ripening rooms.

Respiration Rates

Temperature	mg CO ₂ kg ⁻¹ h ⁻¹
5 °C	7 to 8
10 °C	10 to 15
15 °C	24 to 30
20 °C	32 to 36

To get mL CO₂ kg⁻¹ h⁻¹, divide the mg kg⁻¹ h⁻¹ rate by 2.0 at 0 °C (32 °F), 1.9 at 10 °C (50 °F), and 1.8 at 20 °C (68 °F). To calculate heat production, multiply mg kg⁻¹ h⁻¹ by 220 to get BTU ton⁻¹ day⁻¹ or by 61 to get kcal tonne⁻¹ day⁻¹.

Physiological Disorders

Blossom end rot is characterized by a slightly discolored or dark sunken lesion at the blossom end of the fruit. It is caused by calcium deficiency during growth. Pepper speck appears as spotlike lesions that penetrate the fruit wall. The cause is unknown; some varieties are more susceptible. Chilling injury is described above.

Postharvest Pathology

The most common decay microorganisms are *Botrytis*, *Alternaria*, and soft rots of fungal and bacterial origin. *Botrytis* (grey mold) is a common organism on peppers. Field sanitation and

prevention of wounds on the fruit reduce its incidence. *Botrytis* grows well at the recommended pepper storage temperatures. High CO₂ levels (>10%) can control *Botrytis* but damages peppers. Hot water dips at 53 to 55 °C (126 to 130 °F) for 4 min can effectively control botrytis rot without causing fruit injury. The presence of alternaria black rot, especially on the stem end, is a symptom of chilling injury. The best control is to store peppers at 7 °C (45 °F). Bacterial soft rot is caused by several bacteria that attack damaged tissue. Soft rots can occur on washed or hydrocooled peppers when water sanitation is inadequate. Peppers are also affected by many of the disease, virus, insect, and nematode pests that affect tomato.

Quarantine Issues

There are no known quarantine issues.

Suitability as Fresh-Cut Product

Before cutting, peppers should be stored at 7 to 10 °C (45 to 50 °F). After cutting, fresh-cut peppers should be held at 0 to 5 °C (32 to 41 °F). Pepper slices (red and green) can be stored for up 12 days at 5 °C (41 °F) using a CA of 3% O₂ and 10% CO₂.

Special Considerations

Mechanically harvested peppers are usually unsuitable for fresh market because of extensive injuries but can be used for processing. Peppers must be handled with care to avoid mechanical damage that may cause discoloration and pathological problems. Before packaging, peppers can be washed with 300 µL L⁻¹ chlorine to reduce disease. Waxing with fungicides reduces water loss and disease.

After drying, chili peppers are packaged tightly into sacks holding ≥200 lb (≥91 kg) and are generally stored in nonrefrigerated warehouses for up to 6 mo. The temperature of the warehouse depends on its construction and the way it is managed, but mainly on ambient outdoor temperature. Insect infestation is a major storage problem. In Southern States, chili and other hot peppers are dried, packaged, and stored at 0 to 10 °C (32 to 50 °F). Storage at low temperature retards loss of red color and slows insect activity.

Moisture content of chili and other hot peppers during storage should be low (10 to 15%) to prevent mold growth. A RH of 60 to 70% is desirable. With a high moisture content, pods may be too pliable for grinding and may have to be redried. With lower moisture content (<10%), pods may be so brittle they shatter during handling, causing loss and release of dust, which is irritating to the skin and respiratory system.

The use of polyethylene film liners within bags allows better storage and reduces dust. The liners ensure that the pods maintain constant moisture content during storage until the time of grinding. Thus, they permit successful storage or shipment under a wide RH range. Peppers can be stored 6 to 9 mo at 0 to 4 °C when packed in this manner.

Manufacturers of hot-pepper products hold part of their raw material in cold storage at 0 to 10 °C

but prefer to grind peppers immediately and store the dried product in air-tight containers.

Whole peppers are also dried until they are brittle and the seeds and pulp are completely dry. The dried product is used in flavoring and improving the appearance of various products, including canned products. Some sliced peppers are partially dried and mixed with salt for preservation for ultimate use in various processed products.

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