Celery

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Scientific Name and Introduction

Celery (*Apium graveolens* L.) is a biennial of the Umbelliferae (Apiaceae) family but is planted and harvested as an annual crop. The edible portion is the long, thick, green fleshy petioles and, if present after trimming, associated leaves. California supplies 75% of U.S. production, with other significant production coming from Florida and Michigan (Schaffer 2000).

Quality Characteristics and Criteria

High-quality celery consists of petioles that are well-formed, thick, compact, straight, tender, and light green (Suslow and Cantwell 2002). Additional quality indices are stalk and midrib length; absence of defects such as blackheart, pithiness, seed stalks, and cracks; and absence of insect damage and decay. Any leaves remaining on the stalk after trimming should not be wilted, yellow, or decayed.

Horticultural Maturity Indices

Celery is harvested when the overall field reaches the desired marketable size of 35 to 41 cm (14 to 16 in) stalk length, and before the outer petioles develop "pithiness." Early harvests before the plants reach full size produce stalks with high market quality, and the prices received may more than compensate for lower yield.

Grades, Sizes, and Packaging

U.S. grades are U.S. Extra No. 1, U.S. No. 1, and U.S. No. 2. Celery may be sold as "unclassified" to designate a lot that has not been graded according to U.S. standards. In California, fresh-market celery is field-packed in 27.2-kg (60-lb) cartons containing 48 stalks or in 12.7-kg (28-lb) cartons containing 12 or 18 hearts. Florida celery is packed in seven size grades from 18 to 96 stalks per crate. Celery hearts are prepared from smaller stalks that are trimmed to 20, 25, or 30 cm (8, 10, or 12 in) in length, and packed in 8- or 13-kg (18- or 28-lb) cartons (Peirce 1987).

Precooling Conditions

Celery is typically hydrocooled or vacuum-cooled with a chilled water spray application. Prompt precooling to near 0 °C (32 °F) is essential to maintain freshness and crispness, as well as for extended storage.

Optimum Storage Conditions

Celery can be stored for up to 5 to 7 weeks at 0 °C (32 °F) and 95% RH. At optimum conditions, celery can be stored for up to 5 to 7 weeks with good quality (Hardenburg et al. 1986). Storage life is reduced to less than 2 weeks at 5 °C (41 °F). Inner petioles may continue to grow during storage at temperatures above 0 °C (32 °F), resulting in quality loss.

Controlled Atmosphere (CA) Considerations

CA and MA offer small to moderate benefits (Saltveit 1997). CA-stored stalks maintain better texture and crispness than those stored in air (Gariepy et al. 1984). Reduced O_2 (2 to 4%) and elevated CO_2 (3 to 5%) delay senescence, leaf yellowing, and decay (Leshuk and Saltveit 1990). However, low-O_2 or high-CO_2 injuries may occur when O_2 is under 2% or CO_2 is over 10%, resulting in off odors, off flavors, and internal leaf yellowing.

Retail Outlet Display Considerations

Celery stalks can be displayed as twist-tied stalks, with or without a plastic sleeve, or in prepackaged consumer bags typically used for celery hearts. The use of both top ice and misting are acceptable to reduce moisture loss and maintain freshness.

Chilling Sensitivity

Celery is not chilling sensitive and should be stored as cold as possible without freezing. The freezing point for celery is -0.5 °C (31.1 °F) (Whiteman 1957).

Ethylene Production and Sensitivity

Celery produces little ethylene, <0.1 µL kg^{-1} h^{-1} at 20 °C (68 °F). The effect of ethylene depends on temperature and concentration. Celery is not very sensitive to low concentrations of ethylene when exposed at low temperatures. Above 5 °C (41 °F), ethylene levels higher than 10 µL L^{-1} accelerate yellowing and development of pithiness.

Respiration Rates

Temperature	mg CO_2 kg^{-1} h^{-1}
0 °C	10 to 20
5 °C	13 to 26
10 °C	20 to 42
15 °C	26 to 54
20 °C	46 to 95

Data from Hardenburg et al. (1986).

To get mL CO_2 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 per ton per day or by 61 to get kcal per tonne per day.

Physiological Disorders

Pithiness is a major source of quality loss and decreased shelf-life (Saltveit and Mangrich 1996). It is characterized by the appearance of whitish regions and air spaces within the tissues and reduced tissue density and is caused by the breakdown of the internal pith parenchyma tissues of the petiole to produce aerenchyma. Pithiness may be induced by preharvest factors, including cold stress, water stress, bolting (seed stalk induction), and root infection. Storage temperature has a major impact on development of pithiness after preharvest induction. Development of pithiness is delayed by storage at 0 °C (32 °F).

Blackheart is a physiological disorder caused by cell death resulting from calcium deficiency and preharvest water stress. Internal leaves develop brown discoloration, which eventually becomes deep black.

Brown check is a disorder related to boron deficiency. It appears as cracks on the inner petiole surface, and exposed tissues become brown and are susceptible to pathogen infection and decay.

Crushing or cracking of the petiole are signs of mechanical damage and may lead to rapid browning and decay. Harvesting, packing, and handling should be done with great care to prevent damage to the highly sensitive turgid petioles.

Freezing injury occurs below -0.5 °C (31.1 °F). Mild freezing causes depressions in the tissues that subsequently turn brown. Severely frozen tissues develop a wilted and water-soaked appearance on thawing.

Postharvest Pathology

The most prominent storage decay is bacteria soft rot (primarily caused by *Pectobacterium* or *Pseudomonas*), gray mold *(Botrytis cinerea),* and watery soft rot (*Sclerotinia* spp.) (Snowden 1992). Storage at 0 °C (32 °F) is important to minimize losses due to postharvest decay. Controlled atmospheres (1.5% O_2 and 7.5% CO_2) suppress the growth of *Sclerotinia* and watery soft rot (Reys and Smith 1986, Reys and Smith 1987). However, careful maintenance of atmospheric composition is required as celery is susceptible to low-O_2 and high-CO_2 injury.

Quarantine Issues

None. However, export loads of celery may be fumigated at entry ports if common insects (aphids and thrips) are found.

Suitability as Fresh-Cut Product

The majority of fresh-cut celery is in the form of celery sticks (cut petioles). Fresh-cut celery can be packed alone or in combination with other vegetables, such as carrots and broccoli. The shelf-life of fresh-cut celery is typically 12 to 14 days at 0 to 5 °C (32 to 41 °F). Discoloration of vascular tissue, splitting of the cut ends, and bacteria decay are major problems limiting shelf-life of fresh-cut celery (Robbs et al. 1996, Saltveit and Mangrich 1996).

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