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 with thick, compact, and straight (Suslow and Cantwell, 1998). Petioles should be tender, light green, and appear fresh. Additional quality indices are: stalk and midrib length; freedom from defects such as blackheart, pithiness, seed stalks, 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 for celery are Extra No. 1, No. 1, and 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 and 12.7 kg (28 lb) cartons containing 12 or 18 hearts. Florida celery is packed in 7 size grades from 18 to 96 stalks per crate. Celery hearts are generally prepared from stalks that are smaller than regular size. They 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).

Pre-cooling conditions: Celery is typically hydro-cooled or vacuum-cooled with a chilled water spray application. Prompt pre-cooling to near 0 °C (32 °F) is essential to maintain the freshness and crispness, as well as for extended storage.

Optimum Storage Conditions: Celery should be stored at 0 °C (32 °F) with > 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 < 2 weeks at 5 °C (41 °F). Inner petioles may continue to grow during storage at > 0 °C (32 °F) resulting in quality loss.

Controlled Atmosphere (CA) Consideration: CA or MA offer small to moderate benefits to celery in storage (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 at < 2% O_2 or > 10% CO_2, 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 pre-packaged consumer bags typical 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 a small amount of ethylene (< 0.1 μL kg^{-1} h^{-1} at 20 °C (68 °F). The effect of ethylene is temperature and concentration dependent. Celery is not very sensitive to low concentrations of ethylene when exposure occurs at low temperatures. At temperatures above 5 °C (41 °F), but more practically 10 °C (50 °F), exposure to > 10 μL L^{-1} ethylene can result in an accelerated loss of green color 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

To get mL 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 metric ton per day. Data are from Hardenburg et al. (1986).

Physiological Disorders: Pithiness is a major source of quality loss and decreased shelf-life in celery (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 pre-harvest factors, including cold stress, water stress, pre-bolting (seed stalk induction), and root infection. Storage temperature has a major impact on development of pithiness after pre-harvest induction. Progressive 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 pre-harvest 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 is also refereed to as crack stem. The exposed tissues become brown and are susceptible to pathogen infection and decay.

Crushing or cracking 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 starts at temperatures below -0.5 °C (31.1 °F). Mild freezing causes depressions in the tissues that subsequently turn brown. Severely frozen tissues develop 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). Keeping storage temperature near 0 °C (32 °F) is important to minimize losses due to postharvest decay. Controlled atmospheres (1.5% O_2+ 7.5% CO_2) have been shown to 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 sensitive 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, 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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