Chicory

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Scientific Name and Introduction: Belgium endive or witloof chicory (*Cichorium intybus* L) is a biennial herbceous plant belonging to the Asteraceae family. Besides being a leafy salad vegetable, some chicory cultivars are grown for use as a coffee substitute. Related vegetables of commercial value include lettuce (*Lactuca sativa* L., Cichorium tribe), endive and escarole (*Cichorium endivia* L.), and radicchio (*Cichorium intybus* L.). The edible portion of chicory is the young, enlarged, compact and etiolated terminal bud that is composed of young leaves and the partially suppressed, but enlarging floral stem. In the trade, this product is called a chicon. The chicon results from the forced growth of an apical bud from the defoliated and vernalized root. The roots are harvested after a first year of grown in the field, partially defoliated except for the apical bud, and stored until ready for forcing.

Belgium endive is a popular vegetable in northern European countries and is available year-round because excellent storage capabilities of roots harvested for subsequent forcing permits chicon production throughout the year. Except for European consumption, the crop is of little interest elsewhere. In the U.S. it is not well known or appreciated by the general public. Accordingly, production is minor and supply is augmented by air shipments from Europe.

Quality Characteristics and Criteria: A high quality chicon will be compact with turgid closely overlapping outer leaves having a mother-of-pearl luster or milky white appearance and a tinge light yellow color on leaf margins. The chicon should feel heavy for its size. Leaf tips should not curl back, and the base should be well-trimmed perpendicular to the upright axis, without discoloration. Chicon shapes should be lancelolate, with the length ranging from 2- to 3-times the maximum width. Development of green leaf color is a quality defect. Although leaf greening constitutes quality loss for many markets, it appears that U.S. consumers tolerate a slight amount without significant penalty. Furthermore, a small number of cultivars containing anthocyanin are also produced. For this type of chicory, reddish-purple coloration of the chicon is normal.

Additional quality criteria requite that chicons should be sound, free of reddish blemish, frost damage, or traces of bruises, disease, insects, parasites or rodent attack. Quality is also decreased by flower stem development is excess of three fourths of the bud's length. The butt end should be flat, well trimmed with a fresh appearance and free of abnormal exterior moisture and odors.

Elevated temperatures during holding and retail presentation are the major contributor to product greening in U.S. markets, even more than that attributed to exposure to light.

Horticultural Maturity Indices: Depending on temperature, the optimum harvest period for the forced crop is between 20 to 30 days. Harvest delays result in elongated chicon and loss of compaction. Chicons are harvested when outer leaves are tightly appressed and density is maximal. The basal portions of outermost leaves should be well sheathed. Leaf margins should be thin and smooth. Timely harvest of chicons generally maximizes potential shelf-life when compared to chicons that are harvested at a late stage of development. Deterioration is mainly due to marginal leaf drying or browning, which can occur rapidly (Herregods, 1971).

Grades, Sizes and Packaging: Grading is largely determined by uniformity of chicon shape, overall appearance, and the ratio of chicon length to size. The highest quality chicons have a minimum length of about 9 cm (3.5 in), a maximum length of 16 to 17 cm (6.25 to 6.75 in), and a maximum diameter of 6 cm (2.5 in). The typical ratio of length to width is 2:1 to 3:1.

European quality standards in decreasing order are: Extra, Class I, II, and II irregular. U.S. grades are Extra, Standard, and Baby. Extra category chicons are uniformly shaped, meet appropriate size dimensions, have outer leaves that measure at least half of the chicon length, are firm, and do not exhibit greening or a glassy appearance. Lesser quality involves less uniformity, less favorable appearance, deterioration, and loss of compaction.

Pre-cooling Conditions: The forcing trays can be moved to a cold room for a day or overnight before snapping, ie., removal of chicons from roots. However, possible condensation on the chicons when transferred to a warmer packing area would be undesirable. Additionally, such pre-cooling requires more energy because the roots that will be discarded are cooled along with the chicons. Hydro-cooling is very effective, but water infiltration into the chicons is difficult to fully remove and wet chicons have a lower market value. Vacuum cooling is seldom used since it is very expensive and results in a loss of moisture accounting for 2 to 3% of the product's fresh weight. Forced-air cooling is occasionally used, but it is not effective in cooling product in film packages. Conventional room cooling is the most commonly used method. It is least expensive, but is relatively slow compared to other pre-cooling techniques.

In the US, chicons are packed in pasteboard containers that contain 4.5 kg (10 lb) of product. Perforated plastic film bags are also used for packaging, as are film overwrapped trays. Perforations account for about 0.5% of the bags surface and are intended to limit condensation since moisture on the chicons is detrimental to maintaining quality. Bags are opaque or covered with opaque blue or green paraffin paper in order to minimize moisture loss and to exclude light.

Optimum Storage Conditions: The recommended conditions for commercial storage of chicons are 0 °C (32 °F) with 95 to 100% RH and light excluded (Hardenburg et al., 1986). At 2 ºC (35.6 °F), favorable storage for 2 to 4 weeks can be expected before significant deterioration. At 5 ºC (41 °F), the period is reduced to 1 to 2 weeks, and to 1 week or less at 15 ºC (59 °F). Temperature has a greater influence on greening than does light. At 0 °C (32 °F) there is little or no greening, even in the presence of light, but as the temperature rises, the incidence of greening increases.

Controlled Atmosphere (CA) Considerations: Storage-life in air can almost be doubled by storage in 3 to 4% O_2 + 4 to 5% CO_2 at 0 °C (32 °F). CA storage delays greening of leaf tips in light and leaf spreading.

Retail Outlet Display Considerations: Maintain cold conditions to maximize storage and shelf-life, minimize dehydration, but do not sprinkle or otherwise wet the product. Retailers should not hold packaged chicory in wet storage areas; rather they should receive conditions similar to those given mushrooms.

Chilling Sensitivity: Chicory is not chilling sensitive, but freezing at -0.5 °C (31.1 °F) must be avoided.

Ethylene Production and Sensitivity: Ethylene production is very low, but exposure to ethylene can result in damage such as russet spotting.

Respiration Rates:

Temperature	mg CO_2 kg^{-1} h^{-1}
0 °C	2 to 3
5 °C	5 to 6
10 °C	12 to 14
15 °C	20 to 22
20 °C	35 to 38

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 from Saltveit (2002, unpublished)

Physiological Disorders: These include: brown or hollow core, blackheart, foliage pinking, red discoloration of tissue that has been bruised or cut. A similar reddish-orange coloration occurs when leaves split or are torn. Additional disorders include russet spotting, the formation of light hair-like growth on leaves and leaf greening. Other causes of chicon deterioration are continued growth of the stem, resulting in leaf spreading and opening; leaf greening, loss of turgor and wilting that results in a loss of weight, grade and quality; the appearance of bruises at the base and/or on the leaves that become more apparent at retail. Chicons showing any signs of cuts, drying, burses, or torn tissue should be excluded from sale.

Postharvest Pathology: The most common decays are *Erwinia carotovora, Botrytis cinerea* and other pathogens such as *Phytophthora cryptogea, Sclerotinia sclerotiorum, Phoma exigua,* and several *Pseudomonas spp.* Infection of the chicons in the forcing facilities is most often due to the disease organism being introduced on the roots.

Quarantine Issues: None.

Suitability as Fresh-cut Product: Potential is low, but loose leaves are occasionally marketed in some pre-packaged salad mixes. The marketing of detached leaves is occasionally done to recover some value from fresh market product that is damaged or otherwise would be wasted.

Special Considerations: Chicons must be handled with care to avoid mechanical damage to minimize discoloration and pathological problems. Temperatures must be kept low and light excluded to prevent greening. High RH is necessary to prevent loss of turgor and wilting.

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