

## **Chicory (Belgian Endive or Witloof Chicory)**

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### **Scientific Name and Introduction**

Belgium endive or witloof chicory (*Cichorium intybus* L) is a biennial herbaceous plant belonging to the Asteraceae family. In addition to chicory's use as a leafy salad vegetable, the roots of some 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. This large bud results from the forced growth of the apical bud on a defoliated and vernalized root in storage. The roots are harvested after a year of growth, partially defoliated except for the apical bud, and stored until ready for forcing.

Belgium endive is a popular vegetable in northern European countries, where it is available year-round. The crop is mostly for European consumption and of little interest elsewhere. In the United States, 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**

High-quality chicons are compact and turgid with closely overlapping outer leaves having a mother-of-pearl luster or milky-white appearance and a light yellow tinge on leaf margins. They should be sound, free of reddish blemish, frost damage, or traces of bruises, disease, insects, parasites, or rodent attack. A 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 and without discoloration. It should be lanceolate in shape, with the length ranging from 2 to 3 times the maximum width. Quality is decreased by flower stem development in excess of three-fourths of the bud's length.

Development of green leaf color is a quality defect. Though leaf greening constitutes quality loss for many markets, U.S. consumers tolerate a slight amount without significant penalty. A small number of cultivars produce anthocyanin and are reddish-purple in coloration. Elevated temperatures during holding and retail presentation are more important than exposure to light in inducing greening.

### **Horticultural Maturity Indices**

Depending on temperature, optimum harvest is 20 to 30 days after forcing. 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 the outermost leaves should be well sheathed. Leaf margins should be thin and smooth. Timely harvest maximizes potential shelf-life compared to harvesting at a later 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 shape, overall appearance, and the ratio of length to width. Highest quality chicons are 9 to 17 cm (3.5 to 6.8 in) in length and have a maximum diameter of 6 cm (2.5 in). The typical ratio of length to width is 2:1 to 3:1.

U.S. grades are Extra, Standard, and Baby, while European standards are Extra, Class I, II, and II irregular. 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.

### **Precooling Conditions**

Trays holding the forced roots can be moved to a cold room for a day or overnight before snapping (that is, removal of chicons from the roots). Condensation on the chicons when transferred to a warmer packing area is undesirable. Precooling in this manner wastes energy because the entire roots of both marketable and unmarketable chicons are cooled. Hydrocooling is very effective, but water infiltration is difficult to remove and reduces shelf-life. Vacuum cooling is seldom used since it is 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 the least expensive but is relatively slow compared with other precooling techniques.

In the United States, 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 because moisture on the chicons is detrimental to maintaining quality. Bags are opaque or covered with translucent blue or green paraffin paper to exclude light.

### **Optimum Storage Conditions**

Chicons should be stored in the dark at 0 °C (32 °F) and 95 to 100% RH (Hardenburg et al. 1986). Storage life is reduced to 2 to 4 weeks at 2 °C (36 °F), 1 to 2 weeks At 5 °C (41 °F), and 1 week or less at 15 °C (59 °F). There is little greening at 0 °C (32 °F), even in the presence of light, but greening increases with increasing temperature.

### **Controlled Atmosphere (CA) Considerations**

Storage life can almost be doubled by storage in 3 to 4% O<sub>2</sub> with 4 to 5% CO<sub>2</sub> 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 and minimize dehydration, but do not sprinkle or otherwise wet the product. Packaged chicons should be held in conditions similar to those of packaged mushrooms, not in wet storage areas.

### **Chilling Sensitivity**

Chicory is not chilling sensitive, but it freezes at -0.5 °C (31 °F).

### **Ethylene Production and Sensitivity**

Ethylene production is very low, but exposure to ethylene can produce physiological disorders such as russet spotting and accelerated senescence.

### **Respiration Rates**

Temperature	mg CO <sub>2</sub> kg <sup>-1</sup> h <sup>-1</sup>
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

Data from Saltveit (2002, unpublished).

To get mL CO<sub>2</sub> kg<sup>-1</sup> h<sup>-1</sup>, divide the mg kg<sup>-1</sup> h<sup>-1</sup> 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<sup>-1</sup> h<sup>-1</sup> by 220 to get BTU per ton per day or by 61 to get kcal per tonne per day.

### **Physiological Disorders**

Disorders include brown or hollow core, blackheart, foliage pinking, and 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 hairlike 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; and the appearance of bruises at the base 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 prepackaged 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 must be excluded to prevent greening. High RH is necessary to prevent loss of turgor and wilting.

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