

# Asparagus

Yaguang Luo, Trevor Suslow, and Marita Cantwell

Luo is with the Produce Quality and Safety Laboratory, Henry A. Wallace Beltsville Agricultural Research Center, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, MD; Suslow and Cantwell are with the Department of Vegetable Crops, University of California, Davis, CA.

## Scientific Name and Introduction

Asparagus (*Asparagus officinalis* L.) is a perennial of the Liliaceae family. The edible portion of asparagus is a rapidly growing stem (shoot) with scale leaves that arise at nodes. There are two forms of marketed asparagus, namely white (blanched) and green. White asparagus is more common in Europe and Asia (Lipton 1990); green asparagus is popular in the United States and is produced predominantly in California and Washington. Asparagus has a high metabolic rate after harvest and is among the most perishable crops.

## Quality Characteristics and Criteria

High-quality asparagus spears are dark green and firm with tightly closed and compact tips (Suslow 1998a,b). Spears are straight, tender, and glossy in appearance. Spears with green butts are preferred over the spears with white butts, as the latter are associated with increased toughness. However, a small amount of white tissue at the butt will delay decay development under typical commercial distribution conditions (Lipton 1990, Suslow 2001).

## Horticultural Maturity Indices

Asparagus spears are harvested as they emerge through the soil from the underground crowns. Typically, spears are cut when they reach 10 to 25 cm (8 to 10 in) in length, with spear tips still tightly closed. Tender, immature (that is, shorter) asparagus may be harvested for special markets.

## Grades, Sizes, and Packaging

Harvested spears are prepared for market by grading, sizing, and bunching. Grades are based on freshness, length and diameter of the stalks, color of spears, tightness of the spear tips, and the extent of bruising. Sizing is based on spear diameter with U.S. No. 1 having a diameter >1 cm (>0.5 in) and U.S. No 2 having a diameter >0.8 cm (>5/16 in). Spears of larger diameter are considered to be superior in quality with less fiber (Peirce 1987). Spears are tied in bunches weighing 0.45 to 1.1 kg (1 to 2.5 lb) and trimmed to a standard length of 18 to 25 cm (7 to 10 in). Color is also important, with U.S. No. 1 spears being green for more than 2/3 their length, while U.S. No. 2 are green for more than half their length. After trimming the butt-end, the bunches are packed upright in trapezoidal-shaped crates to minimize geotropic bending (curving away from gravity) in transit. The container should include a wet pad in contact with the butt end to maintain turgidity. Headspace is provided in the carton to prevent tip curvature or breakage during spear elongation.

## **Precooling conditions**

Asparagus is highly perishable and must be cooled immediately to 0 to 2 °C (32 to 36 °F). A 4-h delay in cooling resulted in an average 40% increase in shear force due to tissue toughening (Hernandez-Rivera et al. 1992). Asparagus is typically partially cooled during the washing, selection, and packing operation, and then hydrocooled to near 0 °C (32 °F) after packing.

## **Optimum Storage Conditions**

The recommended conditions for commercial storage of asparagus are 0 to 2 °C (32 to 36 °F) with 95 to 99% RH, yielding 14 to 21 days of storage life. Maintaining a low storage temperature is critical to delay senescence, tissue toughening, and flavor loss (King et al. 1993). High RH is essential to prevent desiccation and to maintain freshness. Typically, asparagus is packed and shipped with water-saturated pads in the bottom of the containers to maintain high RH and to replenish water lost by the spear or water used during spear elongation; this practice maintains spear turgidity. Excessive free water at elevated storage or shipping temperatures may lead to increased decay.

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

Elevated CO<sub>2</sub> at 5 to 10% is beneficial in preventing decay and slowing toughening of the spears. Short exposure to higher CO<sub>2</sub> concentration is safe and beneficial only if the temperature is maintained at 0 to 1 °C (32 to 34 °F). The combination of intermediate O<sub>2</sub> (2 to 10% O<sub>2</sub>) may or may not provide benefit compared with air enriched with CO<sub>2</sub> alone (Lipton 1990, Kleiber and Wills 1992, Lill and Corrigan 1996, Saltveit 1997). At O<sub>2</sub> levels below 2%, off odors and discoloration may develop. Signs of CO<sub>2</sub> injury are small to elongated pits, generally first observed just below the tips. Severe CO<sub>2</sub> injury results in ribbiness. Asparagus tolerated a 100% nitrogen atmosphere for 6 h at 2.5 °C (37 °F) or 20 °C (68 °F) without affecting sensory quality (Torres-Penaranda and Saltveit 1994). High CO<sub>2</sub> (40 to 60%) can be applied at 5 °C (41 °F) for up to 4 days without affecting sensory quality, and may be used as an insect disinfestation treatment (Corrigan and Carpenter 1993).

## **Retail Outlet Display Considerations**

Asparagus is often displayed upright in shallow trays containing chilled water. It will also tolerate icing on retail displays. The preferred method to maintain freshness at retail display is refrigerated display with light misting.

## **Chilling Sensitivity**

Asparagus is subject to chilling injury after about 10 days at 0 °C (32 °F). Symptoms include loss of sheen and glossiness and graying of tips. A limp, wilted appearance may be observed. Severe chilling injury may result in darkened spots or streaks near the tips.

## **Ethylene Production and Sensitivity**

Ethylene production is low to intermediate, increases with time after harvest, and varies with where the spears are cut relative to the soil surface (Lipton 1990). For spears cut at the soil surface and held at 20 °C (68 °F) for 45 and 90 min, ethylene production changes from 2.1 and 3.1  $\mu\text{L kg}^{-1} \text{h}^{-1}$  (Haard et al. 1974). Exposure to ethylene accelerated the lignification (toughening) of asparagus spears (Hennion et al. 1992). Prompt cooling and maintaining optimal shipping temperatures minimizes ethylene-induced toughening.

## Respiration Rates

Respiration rates depend on storage temperature, time after harvest, and the spear portion on which determinations are made (Lipton 1990). Freshly harvested asparagus is among the highest respiring fresh produce items. However, rates decline rapidly after harvest (King et al. 1990, Lipton 1990). Respiration rates of the apical tips are much higher than those of the basal portions of the stems (Saltveit and Kasmire 1985, Lill et al. 1990). Listed below are respiration rates of asparagus spears held at 20 °C for various times:

Temperature	Time after harvest (days)		
	0.25	1.0	3.0
	----- $\text{mg CO}_2 \text{ kg}^{-1} \text{ h}^{-1}$ -----		
0 °C	80	60	40
5 °C	145	105	65
10 °C	305	215	120
15 °C	325	235	160
20 °C	500	270	185

Data from Lipton (1957).

To get  $\text{mL CO}_2 \text{ kg}^{-1} \text{ h}^{-1}$ , divide the  $\text{mg kg}^{-1} \text{ h}^{-1}$  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  $\text{mg kg}^{-1} \text{ h}^{-1}$  by 220 to get BTU per ton per day or by 61 to get kcal per tonne per day.

## Physiological Disorders

**Elongation and Tip Bending.** Asparagus continues to grow and elongate after harvest if not immediately cooled and stored at temperatures below 5 °C (41 °F). Holding the butt in contact with water (the moist pad) promotes spear growth and elongation. Tip bending occurs as the result of upward growth of the tips when the spears are horizontal. If spears are held in an upright position, tip bending may still occur if the tips reach the top of the package and are physically deflected. Postharvest treatment of asparagus spears in heated water at 45 to 50 °C (113 to 122 °F) for 2 to 5 min reduces tip bending (Paull and Chen 1999).

**Spear Toughening.** Tissue lignification and fiber development, which progresses from butt to tip, cause spear toughening. It develops at >10 °C (50 °F), rapidly above 15 °C (59 °F), and is accelerated by ethylene.

**Feathering.** Feathering is the appearance of bracts of spear tips, which have opened due to outgrowth of the underlying buds. Tip feathering is a sign of senescence, often observed

following extended storage at higher than optimal temperature or harvesting of overmature spears.

**Freezing Injury.** Water-soaked appearance and tissue softening occur at temperatures below -0.5 °C (31 °F).

### **Postharvest Pathology**

The most prominent postharvest disease on asparagus is bacteria soft rot, caused by *Pectobacterium carotovora* or *Pseudomonas* spp. Decay may occur anywhere on the spears in the form of “soft rot pits,” most frequently found on the tips or the butts (Snowdon 1992, Suslow 2001). Spears with green butts are more susceptible to this decay than spears with white butts. Storing asparagus at <5 °C (41 °F) controls this disease. In some production areas, the fungi such as *Fusarium*, *Penicillium*, and *Phytophthora* are associated with postharvest decay or spoilage of asparagus (Snowdon 1992).

### **Quarantine Issues**

Asparagus may be fumigated during international distribution and marketing if live common insects (hitchhikers) are found.

### **Suitability as Fresh-Cut Product**

The tender portion can be prepared as a food service product. There is limited minimal processing of asparagus, but consumer-oriented packing of tips is increasing.

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