

Broccoli

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Scientific Name and Introduction

Brassica oleracea L., Italica group, also known as broccoli, calabrese, or sprouting broccoli, is a native of southern Europe and a member of the Brassicaceae (Cruciferae) family. The crop is annual and grows to maturity in about 75 to 95 days, depending on cultivar, season, and planting date. The whole immature inflorescence (head) is the edible portion, with the floret tissue most often preferred by consumers. It grows best in cool climates and is available year-round from many areas of North America, though a large portion is grown in California.

Quality Characteristics and Criteria

High-quality broccoli is either a dark or bright green with closed flower buds (termed “beads”). The head should be firm to hand pressure and compact, and the stalk cleanly cut to the appropriate length for a particular grade standard or for “crowns” (dissected portions of the whole inflorescence).

Horticultural Maturity Indices

Ideal maturity is based on head diameter, compactness, and tightly closed flowers (beads). Overmature heads are characterized by open flower buds or enlarged buds on the verge of opening, resulting in a loose head.

Grades, Sizes, and Packaging

There are three grades: U.S. Fancy, U.S. No. 1, and U.S. No. 2. They are based on external appearance, level of damage, trimming, and stalk diameter (AMS 1943). Two or three heads are normally bunched together for the fresh market. Such bunches are packed 14 to 18 units in waxed cardboard boxes and weigh approximately 10 kg (21 lb) (Boyette et al. 1996). Larger heads may have the stem trimmed to produce “crowns,” and these are packed loose in 9 kg (20 lb) boxes. Individual florets are also cut and packed in 2.5 to 5 kg (5.5 and 11 lb) film bags for hotel, restaurant, and institutional use.

Precooling Conditions

Field-packed broccoli is commonly cooled by injecting liquid ice into waxed cartons (Cantwell and Suslow 1999). Ice maintains the proper temperature and RH for transport and distribution. Hydrocooling and forced-air cooling are also options, but good temperature management is required during transport (Cantwell and Suslow 1999).

Optimum Storage Conditions

Broccoli can be kept in excellent condition for 2 to 3 weeks at 0 °C (32 °F) with 98 to 100% RH. Package icing is required if storage or transport conditions cannot maintain the recommended temperature or RH (Shewfelt et al. 1983). Use of ice is not necessary if temperature can be maintained (Kleiber et al. 1993). Perforated plastic film packaging is recommended to minimize wilting (Toivonen 1997). Loss of quality during prolonged storage is caused by wilting, yellowing of buds and leaves, loosening or opening of buds, and decay.

Controlled Atmosphere (CA) Considerations

The recommended CA for broccoli is 1 to 2% O₂ and 5 to 10% CO₂ at 0 to 5 °C (32 to 41 °F) (Makhlouf et al. 1989, Cantwell and Suslow 1999). Optimal CA conditions can double storage life, especially when broccoli is held above optimum temperatures. However, if O₂ drops to below 1% in storage, there is a risk of off odors caused by the generation of sulfur-containing volatiles (Forney et al. 1991). High rates of air exchange are recommended in shipping containers to avoid accumulation of off odors. Modified atmosphere packaging systems generally maintain both O₂ and CO₂ at 10% to prevent accumulation of off odors.

Retail Outlet Display Considerations

Bottom-icing of the refrigerated display will prolong shelf-life (Perrin and Gaye 1986). Misting of the refrigerated display will also prolong shelf-life and preserve quality (Barth et al. 1992).

Chilling Sensitivity

Broccoli is not sensitive to chilling and should be stored as cold as possible without freezing.

Ethylene Production and Sensitivity

Broccoli produces very little ethylene, <0.1 µL kg⁻¹ h⁻¹ at 20 °C (68 °F), but it is extremely sensitive to ethylene, with floret yellowing being the most prevalent symptom. Exposure to ethylene at 2 µL L⁻¹ at 10 °C (50 °F) halves shelf-life (Cantwell and Suslow 1999).

Respiration Rates

Temperature	mg CO ₂ kg ⁻¹ h ⁻¹
0 °C	20 to 22
5 °C	32 to 36
10 °C	76 to 86
15 °C	160 to 180
20 °C	280 to 320

Data from Cantwell and Suslow (1999).

Respiration rates for cut florets are slightly higher (Izumi et al. 1996).

To get mL CO₂ 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 $\text{mg kg}^{-1} \text{h}^{-1}$ by 220 to get BTU per ton per day or by 61 to get kcal per tonne per day.

Physiological Disorders

Bead (bud) yellowing may occur in overmature broccoli when stored at higher-than-optimal temperatures or in response to exposure to ethylene. Presence of yellow beads ends the commercial marketability of broccoli. There is sometimes confusion between senescence-associated yellow bead and yellow-to-light-green marginal areas of floret that occur due to shading by adjacent floret tissue. This is normal for tissue that is not exposed to light during head growth (Cantwell and Suslow 1999). A disorder called black speck on stems occurs in stored broccoli, and certain cultivars are more sensitive than others (DeEll and Toivonen 1998).

Postharvest Pathology

Grey mold rot (*Botrytis cinerea* Pers.:Fr.) is the most commonly reported mold in shipped broccoli (Ceponis et al. 1987). *Erwinia carotovora* (Jones) Bergey et al. and *Pseudomonas* spp. bacterial head rots are found on shipped and stored broccoli. Injury to the bead tissue during handling may enhance development of these rots (Liao and Wells 1987). While *Erwinia carotovora* decay seldom develops below 5 °C (41 °F), decay caused by *Pseudomonas* spp. can be severe (Liao and Wells 1987) since it grows relatively well even at low storage temperatures (Brocklehurst and Lund 1981). A few cultivars of broccoli have been identified with some resistance to *Pseudomonas* spp. (Canaday et al. 1991).

Quarantine Issues

None.

Suitability as Fresh-Cut Product

Broccoli is commonly converted to fresh-cut floret products. Stems are also shredded into a packaged coleslaw-type product.

Special Considerations

Some cultivars have greater storage life potential than others (Cantwell and Suslow 1999). If long-distance shipping or storage is integral to a marketing strategy, then consideration should be made for appropriate cultivar selection, especially if controlled atmospheres are not being used. Freezing injury may occur during liquid-ice cooling if excessive salt is used in the slurry mixture or if the broccoli is stored below -1 °C (30 °F). Thawed buds will be very dark and translucent and can later turn brown or may serve as sites for development of bacterial decay. Rough handling during harvest and packing can damage floret tissue and lead to increased levels of decay. Hot-water dips prolong shelf-life (Forney 1995).

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