Brussels Sprouts

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Scientific Name and Introduction: *Brassica oleracea* L., Gemmifera group, also known as Brussels sprouts, is a tall-stemmed cabbage in which the axillary buds in the axis of each leaf form tiny heads or sprouts. It has a common origin from the wild cabbage of southern Europe with other cole crops including cabbage, broccoli, and cauliflower. Brussel sprouts prefer a cool growing environment. A large portion of sprouts grown in the U.S. are from the central coast of California.

Quality Characteristics and Criteria: High quality Brussels sprouts are about 2.5 cm (1 in) in diameter, firm with green outer leaves and a white cut end. The inner leaves are light yellow, fairly tightly arranged and without large air pockets between them.

Horticultural Maturity Indices: Harvest maturity is based on sprout size and compactness. Sprouts should be 2.5 cm (1 in) or more in diameter but not more than 7 cm (2.75 in) in length. Stem elongation, resulting in space between older leaves is a sign of over-maturity.

Grades, Sizes and Packaging: There are two grades, U.S. No. 1 and U.S. No. 2. They are based on size, external appearance, decay, and damage (USDA-Agricultural Marketing Service, 1954). To meet these grades, sprouts should be > 2.5 cm (1 in) in diameter and the length < 7 cm (2.75 in). Brussels sprouts are packaged loose in 11 kg (25 lb) cartons or in 3.6 to 4.6 kg (8 to 10 lb) flats or cartons containing 12 plastic containers of sprouts (Boyette et al., 1996). Plastic liners are often used in cartons with loose sprouts to reduce moisture loss. In addition, polyethylene bags are sometimes used in place of the plastic containers for consumer units.

Pre-Cooling Conditions: Effective cooling methods include vacuum-cooling, hydro-cooling, icing, and forced-air cooling. Vacuum-cooling is most effective when sprouts are pre-moistened to reduce wilting and can be an effective method of cooling even when sprouts are packaged as long as the packaging material is ventilated (Stenvers, 1971). Hydro-cooling is also an efficient method to rapidly cool sprouts from 20 °C (68 °F) to 2 °C (35.6 °F) in about 15 min (Stewart and Barger, 1963). Package or top-icing can also be used, especially if storage or transport conditions cannot maintain recommended temperature or RH. Forced-air cooling effectively cools sprouts if packaging is properly vented to allow good air contact with the product.

Optimum Storage Conditions: The recommended conditions for commercial storage are 0 °C (32 °F) at 95 to 100% RH. Under these conditions, quality can be maintained for 3 to 5 weeks. Their storage-life is half as long at 5 °C (41 °F) and only 10 days at 10 °C (50 °F).

Controlled Atmosphere (CA) Considerations: Atmosphere modification is beneficial to inhibit yellowing and decay and prevent discoloration of the cut end when sprouts are held above optimum temperatures. At 7.5 °C (45.5 °F), an atmosphere of 2.5% O_2 + 10% CO_2 will maintain quality for 4 weeks. CO_2 ranging from 5% to 10% + O_2 of 1% to 2% are beneficial (Lyons and Rappaport, 1962; Isenburg, 1969; Lipton and Mackey, 1987). CO_2 >10% and O_2 < 0.5% can be injurious. CO_2 > 20% cause internal browning and pitting of outer leaves (Lyons and Rappaport, 1962), while ≤ 0.5% O_2 can induce a reddish-tan discoloration of the heart leaves and bitter flavor (Lipton and Mackey, 1987). Brussels sprouts do not produce the severe off-odors when held in low O_2 as do other *Brassica* vegetables, such as broccoli

(Forney and Jordan, 1999).

Retail Outlet Display Considerations: Bottom-icing of the refrigerated display will enhance shelf-life of Brussels sprouts. Plastic over-wraps or misting of bulk displays minimize wilting.

Chilling Sensitivity: Brussels sprouts are not sensitive to chilling temperatures and should be stored as cold as possible without freezing.

Ethylene Production and Sensitivity: Brussels sprouts have a very low ethylene production rate at < 0.25 µL kg^{-1} h^{-1} at 7.5 °C (45.5 °F), although rates increase 10-fold with prolonged storage (Lipton and Mackey, 1987). Brussels sprouts are extremely sensitive to ethylene, with leaf yellowing and abscission being the most prevalent symptoms.

Respiration Rates:

Temperature	mg CO_2 kg^{-1} h^{-1}
0 °C	20 to 60
5 °C	44 to 96
10 °C	126 to 168
15 °C	128 to 272
20 °C	172 to 380

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 Lyons and Rappaport (1959).

Physiological Disorders: Internal browning or tipburn is when the margins of inner leaves in buds turn brown and is caused by inadequate transport of calcium to young expanding leaves. Growing conditions that favor rapid growth promote internal browning (Maynard and Barker 1972).

Postharvest Pathology: Diseases of importance during storage are bacterial soft rots (*Erwinia* sp. and *Pseudomonas* sp.), bacterial leaf spot (*Pseudomonas syringae* pv. *maculicola* (McCulloch)), black or gray leaf spot (*Alternaria* sp), and grey mold (*Botrytis cinerea* Pers.) (Snowdon 1991).

Quarantine Issues: None.

Suitability as Fresh-cut Product: Some trimming of the stem-end could be done to convert the sprouts to a ready-to-cook form.

Special Considerations: Brussels sprouts can be stored attached to their stem to prolong storage-life (Pelleboer, 1982). Packaging in vented poly-bags or over-wrapped cups is advantageous to reduce wilting. Their highest freezing point is -0.8 °C (30.6 °F) (Cantwell 1997)

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