Brussels Sprouts

Charles Forney and Peter M.A. Toivonen
Forney is with Atlantic Food and Horticulture Research Centre, Agriculture and Agri-Food Canada, Kentville, Nova Scotia, Canada; Toivonen is with Pacific Agri-Food Research Centre, Agriculture and Agri-Food Canada, Summerland, British Columbia, Canada.

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 (all members of the Brassicaceae [Cruciferae] family). Brussels sprouts prefer a cool growing environment. Most sprouts grown in the United States 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 overmaturity.

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 (AMS 1954). To meet these grades, sprouts should be larger than 2.5 cm (1 in) in diameter and shorter than 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.

Precooling Conditions

Effective cooling methods include vacuum cooling, hydrocooling, icing, and forced-air cooling. Vacuum cooling is most effective when sprouts are premoistened 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). Hydrocooling is also an efficient method to rapidly cool sprouts from 20 to 2 °C (68 to 36°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 movement about the product.

Optimum Storage Conditions

Quality can be maintained for 3 to 5 week ats 0 °C (32 °F) and 95 to 100% RH. 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 inhibits yellowing and decay and prevents discoloration of the cut end when sprouts are held above optimum temperatures. At 7.5 °C (46 °F), an atmosphere of 2.5% O_2 and 10% CO_2 can maintain quality for 4 weeks. CO_2 ranging from 5 to 10% and O_2 of 1 to 2% are beneficial (Lyons and Rappaport 1962, Isenburg 1969, Lipton and Mackey 1987). CO_2 above 10% and O_2 below 0.5% can be injurious. CO_2 above 20% causes internal browning and pitting of outer leaves (Lyons and Rappaport 1962), while O_2 at 0.5% or less can induce a reddish-tan discoloration of the heart leaves and bitter flavor (Lipton and Mackey 1987). Brussels sprouts do not produce 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 overwraps or misting of bulk displays minimize wilting.

Chilling Sensitivity

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

Ethylene Production and Sensitivity

Brussels sprouts produce <0.25 μL kg^{-1} h^{-1} ethylene at 7.5 °C (46 °F), though 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

Data from Lyons and Rappaport (1959).

To get mL CO_2 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 tonne per day.

Physiological Disorders

Internal browning, or "tipburn," is the margins of inner leaves in buds turning 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. Packaging in vented poly-bags or overwrapped cups reduces wilting. Sprout freeze at -0.8 °C (30.6 °F) (Cantwell 2001).

References

AMS [USDA Agricultural Marketing Service]. 1954. United States Standards for Grades of Brussels Sprouts. *At* http://www.ams.usda.gov/AMSv1.0/standards.

Boyette, M.D., D.C. Sanders, and G.A. Rutledge. 1996. Packaging requirements for fresh fruits and vegetables. *At* http://www.bae.ncsu.edu/programs/extension/publicat/postharv/ag-414-8/index.html.

Cantwell, M. 1997. Properties and recommended conditions for storage of fresh fruits and vegetables. *At* http://postharvest.ucdavis.edu.

Forney, C.F., and M.A. Jordan. 1999. Anaerobic production of methanethiol and other compounds by *Brassica* vegetables. HortScience 34:696-699.

Isenburg, F.M. 1969. The use of controlled atmosphere on cold crops. *In* D.H. Dewey, R.C. Herner, and D.R. Dilley, eds., Controlled Atmospheres for the Storage and Transport of Horticultural Crops, pp. 95-96. Horticulture Report 9, Michigan State University, East Lansing, MI.

Lipton, W.J., and B.E. Mackey. 1987. Physiological and quality response of Brussels sprouts to storage in controlled atmospheres. Proc. Amer. Soc. Hort. Sci. 112:491-496.

Lyons, J.M., and L. Rappaport. 1959. Effect of temperature on respiration and quality of Brussels sprouts during storage. Proc. Amer. Soc. Hort. Sci. 73:361-366.

Lyons, J.M., and L. Rappaport. 1962. Effect of controlled atmospheres on storage quality of Brussels sprouts. Proc. Amer. Soc. Hort. Sci. 81:324-331.

Maynard, D.N., and A.V. Barker. 1972. Internal browning of Brussels sprouts: a calcium deficiency disorder. J. Amer. Soc. Hort. Sci. 97:789-792.

Ryall, A.L., and W.J. Lipton. 1979. Handling, Transportation and Storage of Fruits and Vegetables, vol. 1, Vegetables and Melons. AVI Publishing Co., Westport, CT.

Snowdon, A.L. 1991. A Color Atlas of Postharvest Diseases and Disorders of Fruits and Vegetables, vol. 2, Vegetables. Wolfe Publishing Ltd., London, U.K.

Stenvers, N. 1971. Preliminary experiments on vacuum cooling of vegetables and berries. Sprenger Institute Report 1630 (Suppl.), Sprenger Institute, Berlin, Germany.

Stewart, J.K., and W.R. Barger. 1963. Effects of cooling method, prepacking and top-icing on the quality of brussels sprouts. Proc. Amer. Soc. Hort. Sci. 83:488-494.

The editors of this Handbook will appreciate your input for future editions of this publication. Please send your suggestions and comments to HB66.Comments@ars.usda.gov.