Cranberry

Robert K. Prange
Agriculture and Agri-Food Canada, Atlantic Food and Horticulture Research Center
Kentville, Nova Scotia, Canada

Scientific Name and Introduction: *Vaccinium macrocarpon* Ait., the American cranberry, is a perennial, woody, creeping, evergreen species in the Vacciniaceae (Blueberry) family (Dana, 1990). It is native to acid bogs from Newfoundland south to North Carolina and west to Minnesota. It is popular for its tart-flavored red fruit. Canada and the U.S. produce almost 98% of the world's commercial crop of cranberries (http://aceis.agr.ca/misb/hort/cran.html). Between 92 and 95% is processed; the remainder is sold fresh during the autumn and early Winter. The major U.S. production States in order of production, are Wisconsin, Massachusetts, New Jersey, Oregon and Washington. (http://www.usda.gov/nass/pubs/agstats.htm).

Quality Characteristics and Criteria: Fruit red color intensity, glossiness, uniformity and freedom from defects are the major quality characteristics for fresh and frozen cranberries (Spayd et al., 1990).

Horticultural Maturity Indices: Since the amount of red color (anthocyanin content) in the fruit is the major factor determining cranberry crop value, harvesting is timed to achieve the maximum red color without allowing the fruit to become too over-mature (Eck, 1990). Over-maturity results in physiological breakdown (see section on "Physiological Disorders").

Grades, Sizes and Packaging: There is only one grade standard for fresh cranberries, U.S. No. 1. It has a specified tolerance for: color, not less than 75% of the fruit surface pink or red; size, minimum diameter of 10.3 mm (13/32 in); no soft or decayed fruit and freedom from other defects. Fresh cranberries are commonly packed in cartons containing twenty-four 12 oz polybags or in cartons of 20, 25 or 30 lb (9.0, 11.4, or 13.2 kg; http://www.ams.usda.gov/standards/frutmrkt.htm). Occasionally, nine 2 lb (0.9 kg) and four 5 lb (2.3 kg) polybag cartons are used for some retail customers, and wood totes may be used for sale of bulk cranberries.

Pre-cooling Conditions: The storage length can be increased if the fruit are immediately cooled after harvest and packaged just before shipment (Kaufman et al., 1958; Ringel et al., 1959). If cranberries are not at the desired temperature, they can be forced-air cooled (Kasmire and Thompson, 1992; Spayd et al., 1990).

Optimum Storage Conditions: The minimum recommended storage temperature is 2 °C (35.6 °F). The maximum recommended temperature is 4 to 5 °C (39.2 to 41.0 °F) (Hardenburg et al., 1986; Kader, 1997; Lidster et al., 1988; Spayd et al., 1990), although there is one recommendation of 7 °C (44.6 °F) (Kasmire and Thompson, 1992). The recommended RH is 90 to 95% (Hardenburg et al., 1986; Kader, 1997; Spayd et al., 1990). Some researchers have recommended lower RH in the belief that it may reduce fungal decay, eg., 65 to 70% (Stark et al., 1974); 70 to 75% (Wright et al., 1937); and 80 to 90% (Lidster et al., 1988). Red color can be increased after harvest by holding fruit, especially early harvested fruit, at 7 to 10 °C (44.6 to 50.0 °F) for a few weeks rather than at the lower recommended temperatures (Levine et al., 1941). The expected storage-life is 2 to 4 mo.

Controlled Atmosphere (CA) Considerations: There is no known commercial use of CA in cranberry storage. Some research suggests CA containing various combinations of O_2 and CO_2 does not extend cranberry storage-life, compared with ambient air (Anderson et al., 1963; Stark et al., 1969). Conversely,

Kader (1992, 1997) suggested a CA condition of 1 to 2% O_2 + 0 to 5% CO_2 is beneficial. The maximum CO_2 tolerance may be > 5%, as Stark et al. (1969) used 10% CO_2 without detrimental effects. In a 2-mo test at 3 °C (37.4 °F) with 98% RH using ten CA combinations of 2, 21 and 70% O_2 + 0, 15, and 30% CO_2 + 100% N_2, Gunes and Watkins (2001) concluded that 21% O_2 + 30% CO_2 was optimal. Cranberries can be held in an anaerobic condition (100% N_2) for up to 14 mo at 3.3 °C (38 °F) in low RH (Stark et al., 1974). Such fruit have little decay but a high amount of physiological breakdown, rendering them unacceptable for fresh or juice use but still very acceptable as cranberry sauce.

Retail Outlet Display Considerations: Water sprinkling or top icing are not recommended.

Chilling Sensitivity: Cranberry is considered to be a chilling sensitive fruit (Kader, 1992; Levine et al., 1941; Wright et al., 1937). Storage at temperatures near 0 °C for more than about 4 weeks may result in low-temperature breakdown (Lidster et al., 1988). Chilling injury symptoms include dull appearance, rubbery texture and increased decay (Mitcham et al., 1999). If fruit are held at 0 °C, intermittent warming to 21 °C (69.8 °F) for 1 day a month can reduce chilling injury (Hruschka, 1970).

Ethylene Production and Sensitivity: Cranberry has a low ethylene production rate of 0.1 to 1.0 µL kg^{-1} h^{-1} at 5 °C (41 °F) (Kader, 1992; Mitcham et al., 1999). Postharvest treatment of fruit with as little as 10 µL L^{-1} markedly increases anthocyanin content, which is enhanced further if the fruit are treated in the presence of light (Craker, 1971; Fudge, 1930). Eck (1990) and Reid (1992) indicate the use of ethephon, a source of ethylene approved in some U.S. states, accelerates cranberry maturity and/or red color development. More recently, a 1995 U.S. Environmental Protection Agency "Reregistration Eligibility Decision (RED) on Ethephon" indicates that cranberries have been deleted from ethephon product labels (http://www.epa.gov/oppsrrd1/reds/0382.pdf).

Respiration Rates: Cranberries have a low respiration rate, compared with other berry crops which have a moderate to high rate (Kader, 1992).

Temperature	mg CO_2 kg^{-1} h^{-1}
0 °C	4
4 to 5 °C	4 to 5
10 °C	8
15 to 16 °C	-
20 to 21 °C	11 to 18

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 ton per day or by 61 to get kcal per metric ton per day. Data are from Hardenburg et al. (1986) and Mitcham et al. (1999).

Physiological Disorders: Physiological breakdown of cranberry is manifested by a soft and/or rubbery condition, dull external appearance, and diffusion of red anthocyanin pigment throughout internal tissues (Ceponis and Stretch, 1981). No fungal organisms are associated with this condition. It is correlated with one or more of the following: impact bruising; late-harvested, more intensely colored fruit; immersion of free berries for 8 h or more in a flooded bog or similar smothering effects where cranberries are held in poorly ventilated conditions (Ceponis and Stretch, 1981; Graham et al., 1967; Massey et al., 1981; Patterson et al., 1967). Chilling injury can have the same symptoms.

Postharvest Pathology: Postharvest cranberry diseases are almost entirely caused by fungi, with the exception of Ringspot, which is thought to be a virus-induced disease (Caruso and Ramsdell, 1995; Prange and DeEll, 1997). Cranberry is not only attacked by several common postharvest fungi but also by a large

number of fungi that are unknown on other fruit crops (Caruso and Ramsdell, 1995; Prange and DeEll, 1997). The principal storage rots, which can be found in all the major cranberry-growing area, are end rot, black rot, viscid rot, yellow rot and Botryosphaeria fruit rot (Eck, 1990; Prange and DeEll, 1997). Since the occurrence of these fungi can vary with location and season and some are not easily identified visually, confirmation of the causal organism(s) usually requires extensive culturing and spore examination. Decay may be reduced if the storage O_2 is < 1%, since there is no decay control at 1% (Anderson et al., 1963), but 100% N_2 for 3 weeks at 3.3 °C (38 °F) reduces the number of pathogenic species and decay, compared with air-stored fruit (Lockhart et al., 1971).

Quarantine Issues: There are no current restrictions for shipments within Canada and the U.S. There has been little, if any, international trade in fresh cranberries between other countries. Such future trade may be subjected to quarantine restrictions, depending on the countries involved.

Suitability as Fresh-cut Product: No current potential.

Special Considerations: Cranberries can be stored fresh for 2 to 4 mo, depending on season, cultivar, maturity, handling and storage conditions (Hardenburg et al., 1986). The storage-life of cranberries is limited by the development of decay, shrinkage resulting from moisture loss, and physiological breakdown (Lidster et al., 1988). Early harvested fruit usually have a longer storage potential than late-harvested fruit (Doughty et al., 1967). Physical damage, which can occur during mechanical or rough hand-harvesting, transport, or mechanical cleaning, sorting and packing, increases physiological breakdown, postharvest softening and decay and reduces storage-life (Graham et al., 1967; Massey et al., 1981; Patterson et al., 1967). There is more fungal decay and physiological breakdown in water-harvested than hand-harvested cranberries, especially if cranberries are kept in the water more than 1 h after detachment from the plant (Mitcham et al., 1999; Blake Johnson, personal communication).

References:

Anderson, R.E., R.E. Hardenburg and H.C. Vaught. 1963. Controlled atmosphere storage studies with cranberries. Proc. Amer. Soc. Hort. Sci. 83:416-422.

Caruso, F.L. and D.C. Ramsdell. 1995. Compendium of blueberry and cranberry diseases. Amer. Phytopath. Soc., St. Paul MN.

Ceponis, M.J. and A.W. Stretch. 1981. The influence of water immersion time at harvest on physiological breakdown of 'Early Black' cranberries in storage. HortScience 16:60-61.

Craker, L.E. 1971. Postharvest color promotion in cranberry with ethylene. HortScience 6:137-139.

Dana, M.N. 1990. Cranberry management. In: G.J. Galleta et al. (eds) Small fruit crop management. Prentice Hall, NJ, pp. 334-262.

Doughty, C.C., M.E. Patterson and A.Y. Shawa. 1967. Storage longevity of the 'McFarlin' cranberry as influenced by certain growth retardants and stage of maturity. Proc. Amer. Soc. Hort. Sci. 91:192-204.

Eck, P. 1990. The American cranberry. Rutgers Univ. Press, New Brunswick, N.J.

Fudge, B.R. 1930. Increasing the Color of Cranberries after Removal from the Vines. N.J. Agr. Exp. Sta. Bull. No. 504.

Graham, S.O., M.E. Patterson and B. Allan. 1967. Bruising as a predisposing factor in the decay of stored cranberries. Phytopathology 57:497-501.

Gunes, G. and C.B. Watkins. 2001. Postharvest quality of cranberries as affected by controlled atmosphere. HortScience 36:571 (Abstract).

Hardenburg, R.E., A.E. Watada and C.Y Wang. 1986. The commercial storage of fruits, vegetables, and florist and nursery stocks. USDA, Agric. Handbook No. 66 (revised).

Hruschka, H.W. 1970. Physiological breakdown in cranberries - inhibition by intermittent warming during cold storage. Plant Dis. Rptr. 54:219-222.

Kader, A.A. 1992. Postharvest biology and technology: An overview. In: A.A. Kader (ed) Postharvest

technology of horticultural crops. Univ. Calif. Div. Agric. Nat. Res. Pub. No. 3311, pp. 15-20.
Kader, A.A. 1997. A summary of CA requirements and recommendations for fruits other than apples and pears. Proc. 7th Intl. Contr. Atmos. Conf., Univ. Calif., Davis CA, 3:1-34.
Kasmire, R.F. and J.F. Thompson. 1992. Selecting a cooling method. In: A.A. Kader (ed) Postharvest technology of horticultural crops. Univ. Calif., Dir. Agric. Nat. Res. Pub. No. 3311, pp. 63-68.
Kaufman, J., S.M. Ringel, A.A. Hamer, E.P. Atrops and G.B. Ramsey. 1958. Effect of pre-cooling on market quality of cranberries shipped by rail or truck. USDA Market. Res. Rpt. 287, 9 pp.
Levine, A.S., C.R. Fellers and C.I. Gunness. 1941. Carbon dioxide-oxygen and storage relationships in cranberries. Proc. Amer. Soc. Hort. Sci. 38:239-242.
Lidster, P.D., P.D. Hildebrand, L.S. Bérard and S.W. Porritt. 1988. Commercial storage of fruits and vegetables. Publ. 1532/E. Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada.
Lockhart, CL., F.R. Forsyth, R. Stark and I.V. Hall. 1971. Nitrogen gas suppresses microorganisms on cranberries in short term storage. Phytopathology 61:335-336.
Massey, L.M., B.R. Chase and M.S. Starr. 1981. Impact-induced breakdown in commercially screened 'Howes' cranberries. J. Amer. Soc. Hort. Sci. 106:200-203.
Mitcham, E.J. C.H. Crisosto and A.A. Kader. 1999. Bushberries: Blackberry, Blueberry, Cranberry, Raspberry. In: Fresh Produce Facts, http://postharvest.ucdavis.edu/produce/producefacts/index.html
Patterson, M.E., C.C. Doughty, S.O. Graham and B. Allan. 1967. Effect of bruising on postharvest softening, color changes, and detection of polygalacturonase enzyme in cranberries. Proc. Amer. Soc. Hort. Sci. 90: 498-505.
Prange, R.K. and J.R. DeEll. 1997. Preharvest factors affecting postharvest quality of berry crops. HortScience 32:824-830.
Reid, M.S. 1992. Ethylene in postharvest technology. In: A.A. Kader (ed) Postharvest technology of horticultural crops. Univ. Calif. Div. Agric. Natural Res. Pub. No. 3311, pp. 97-108.
Ringel, S.M., J. Kaufman and M.J. Jaffe. 1959. Refrigerated storage of cranberries. USDA Market. Res. Rpt. No. 312, 17 pp.
Spayd, S.E., J.R. Morris, W.E. Ballinger and D.G. Himelrick. 1990. Maturity standards, harvesting, postharvest handling and storage. In: G.J. Galleta et al. (eds) Small fruit crop management. Prentice Hall, NJ, pp. 504-531.
Stark, R., I.V. Hall, F.R. Forsyth and P.R. Dean. 1969. Cranberries evaluated for fresh fruit and processing quality after reduced O_2 storage. Cranberries 34(6) :14, 16 and 34(7):14, 16.
Stark, R., F.R. Forsyth, C.L. Lockhart and I.V. Hall. 1974. Processing quality of cranberries after extended storage in N_2 atmosphere with low and high relative humidities. Can. Inst. Food Sci. Technol. J. 7:9-10.
Wright, R.C., J.B. Demaree and M.S. Wilcox. 1937. Some effects of different storage temperatures on the keeping of cranberries. Proc. Amer. Soc. Hort. Sci. 34:397-401.

Acknowledgments: Some of the information included was from the Produce Marketing Association's "Fresh Produce Manual" and from B. Johnson, Bezanson and Chase Ltd., Aylesford, Nova Scotia.