Sweetpotato

Stanley J. Kays
Kays is with the Department of Horticulture, University of Georgia, Athens, GA.

Scientific Name and Introduction

The sweetpotato, *Ipomoea batatas* (L.) Lam., is a member of the Convolvulaceae family that is grown for its fleshy storage roots. Though a perennial, the crop is grown as an annual. Sweetpotato is the seventh most important food crop in the world. However, in the United States it is used primarily as an occasional vegetable. Sweetpotato confers a wide range of health benefits (Kays and Kays 1998) that have recently enhanced its popularity. The traditional North American type of sweetpotato, typified by the cultivars 'Beauregard' and 'Jewel,' are deep orange in color, moist (soft) in texture, and very sweet when cooked. The orange/moist types, however, are not preferred in most other areas of the world, nor by certain ethnic groups within the United States

Quality Characteristics and Criteria

Sweetpotato cultivars vary in color (white to cream to orange to purple), flavor (sweet to nonsweet; mild to intensely flavored), and textural properties (firm to very soft). In the United States, postharvest conditions that favor a very sweet, moist-textured cooked product are desirable.

Horticultural Maturity Indices

The storage roots of sweetpotato do not have a developmental stage at which they are mature. Rather the roots continue to grow and under favorable conditions will enlarge until the interior of the root becomes anaerobic or rots. As a consequence, the crop is harvested when the majority of roots have reached the desired size.

Grades, Sizes, and Packaging

Sweetpotatoes are graded into U.S. Extra No. 1, U.S. No. 1, U.S. Commercial, U.S. No. 2, and Unclassified. Grading is based largely on size, condition, and absence of defects. Desired sizes are 8.3 to 8.9 cm (3.25 to 3.5 in) in diameter and 0.53 to 0.59 kg (18 to 20 oz). During storage, roots are handled in 360-kg (800-lb) bulk bins but are generally marketed in 18-kg (40-lb) boxes. At the retail level, roots are typically displayed loose.

Curing

Roots should be cured immediately after harvest at 29±1 °C (84±2 °F) and 90 to 97% RH for 4 to 7 days (Kushman 1975). During curing, ventilation is required to remove CO_2 and replenish O_2 because roots consume about 63 L tonne^{-1} day^{-1} (2 ft^3 ton^{-1} day^{-1}) of O_2 and release equivalent amounts of CO_2. Curing heals wounds from harvest and handling, helping reduce moisture loss during storage and decreasing the potential for microbial decay. In addition, curing facilitates the synthesis of enzymes that are operative in flavor development during cooking (Wang et al.

1998). The effect of temperature and RH on the rate of wound healing has been extensively investigated (Morris and Mann 1955).

During curing, initially the outermost parenchyma cells at the wound site desiccate. The subtending parenchyma cells subsequently become suberized (Walter and Schadel 1983), which is followed by formation of a ligninlike wound periderm beneath the suberized layer. Roots are adequately healed when the wound periderm is 3 to 7 cells thick, the status of which can be assessed using a relatively simple color test (Walter and Schadel 1982). The structure and chemical composition of suberin and lignin in both the epidermis and healed wounds have been characterized (Walter and Schadel 1983).

Radiation Treatments

Extension of sweetpotato shelf-life via treatment with gamma irradiation in general offers no advantage over proper storage temperature management.

Optimum Storage Conditions

Following curing, sweetpotatoes should be carefully moved, usually in palletized containers, to a separate storage room and held at 14±1 °C (57±2 °F) with 90% RH (Kushman 1975). Long-term storage experiments have shown that roots can be stored successfully under these conditions for up to 1 year without sprouting (Picha 1986), though sensory quality declines with extended storage. Storage room air flow should be 1,125 L min^{-1} $tonne^{-1}$ (36 ft^3 min^{-1} ton^{-1}) of roots at optimal temperature and RH. Storage at 19 °C (66 °F) or above results in considerable sprouting after several months of storage and an associated loss in root quality and marketability. Storage of roots at <12 °C (55 °F) results in chilling injury.

Controlled Atmosphere (CA) Considerations

Sweetpotatoes can be stored under CA conditions that reduce the rate of respiratory losses and increase total sugars (Chang and Kays 1981). However, additional research on O_2 and CO_2 concentrations, timing, and cultivar requirements are needed. Uncured roots have been shown to decay rapidly when stored in low O_2; though after curing, 2 and 4% O_2 did not appear to be harmful (Delate and Brecht 1989). To date, the beneficial effects of CA storage have not been shown to outweigh the additional expense.

Retail Outlet Display Considerations

Sweetpotatoes are typically displayed loose (unpackaged) in unrefrigerated display cases at approximately 21°C (70 °F).

Chilling Sensitivity

Sweetpotato roots freeze at -1.9 °C (28.6 °F) (Whiteman 1957) and are susceptible to chilling injury when stored at <12 °C (55 °F) (Lewis and Morris 1956, Picha 1987). Symptoms of chilling injury include root shriveling, surface pitting, abnormal wound periderm formation, fungal decay, internal tissue browning, and hardcore formation (Buescher et al. 1975a, Daines et al. 1976). Synthesis of chlorogenic acid and other phenolic compounds has been associated with tissue browning symptoms (Walter and Purcell 1980).

Hardcore is a physiological disorder in which various areas within the root become hard, apparently due to cold-induced alterations in cellular membranes (Yamaki and Uritani 1972). The disorder is not apparent in fresh roots but appears after cooking or processing. All cultivars appear to be susceptible to hardcore; however, there is substantial variation in susceptibility among cultivars, and noncured roots appear to be more susceptible than cured roots.

The severity of chilling injury depends on the temperature and length of exposure below 12 °C (54 ºF). The respiratory rate of roots at 16 °C (61 °F), after holding at chilling temperatures, increased in relation to the duration of the holding period. Lower storage temperature also increased respiratory rate after removal from the cold storage (Lewis and Morris 1956, Picha 1987). Total sugar content of roots stored at 7 °C (45 °F) was significantly greater than in those stored at 16 °C (61 °F), though the effect was highly cultivar-dependent.

Ethylene Production and Sensitivity

Exposure of sweetpotatoes to ethylene should be avoided. Roots exposed to 10 µL L^{-1} ethylene had reduced β-amylase activity (Buescher et al. 1975b). In addition, ethylene enhances synthesis of phenolic compounds and phenolic oxidizing enzymes, resulting in increased discoloration. The effect, however, requires exposure of roots to ambient ethylene that would normally not be encountered during storage with proper ventilation. Therefore, ethylene exposure under normal storage conditions is a relatively minor concern.

Physiological Disorders

In addition to chilling-induced hardcore, the sweetpotato is susceptible to other physiological disorders. Roots may be lost during curing or storage because of exposure to anaerobic conditions before harvest caused by excessive moisture (Ahn et al. 1980, Chang et al. 1982). Roots may appear sound, only to decompose rapidly once in storage, emitting a distinctive sour, fermented odor. Pithiness is another disorder found in apparently sound roots; it is characterized by reduced density and a spongy feel when squeezed. Curing and storage conditions that promote a high metabolic rate facilitate development, as do sprouting in storage and exposure to low soil temperatures of 5 to 10 °C (41 to 50 °C) before harvest.

Postharvest Pathology

Storage rots are caused by a number of microorganisms. Among the more commonly encountered are *Lasiodiplodia theobromae* (Java black rot) (synomyous with *Botryodiplodia theobromae* and *Diplodia gossypina*), *Ceratocystis fimbriata* (black rot), *Erwinia chrysanthemi* (bacterial soft rot), *Fusarium oxysporum* (surface rot), *Fusarium solani* (root rot), *Macrophomina phaseolina* (charcoal rot), *Monilochaetes infuscans* (scurf), and *Rhizopus stolonifer* (soft rot) (for details on etiology, see Clark and Moyer 1988). Timing of infection varies with the organism and field, harvest, and storage conditions (Moyer 1982). Black rot, fusarium root rot, scurf, and bacterial soft rot can occur preharvest, during harvest, and postharvest. In contrast, soft rot infections tend to occur at harvest or postharvest, while charcoal rot, dry rot, surface rot, and root rot occur during harvest. Harvest and postharvest pathogens are typically opportunistic pathogens that require wounds to gain entry into the root.

Internal cork is a virus-mediated disorder in which root tissue develops necrotic lesions during storage (Kushman and Pope 1972). The number and size of lesions varies widely and increases with storage duration and elevated storage temperature. Lesions are found primarily in the interior, but may also be present on the surface.

Control of postharvest diseases centers on prevention, since little can be done once the root is infected. During harvest, care must be taken to minimize damage to roots and exercise proper sanitation. After harvest, roots should be cured immediately and then stored at the proper temperature. Creating entry wounds via mechanical damage during movement from the curing room to storage areas should be judiciously avoided, as well as after storage during washing, sorting, and grading prior to marketing. Wash-water should be frequently changed to prevent accumulation of inoculum, and the use of calcium hypochlorite in the water is recommended. Postharvest pesticides, if used, must be applied in accordance to State and Federal laws.

Postharvest Entomology

The sweetpotato weevil (*Cylas formicarius* [F.]) (Coleoptera:Brentidae) is a serious storage insect pest. Infested roots should not be stored, because adequate control measures are unavailable. Fruit flies (*Drosophila* spp.) and soldier flies *(Hermetia illucens)* (Diptera:Stratiomyidae) can be problems when there are diseased, soured, or damaged roots in storage. Both can be controlled with sanitation or appropriate insecticide treatment.

Quarantine Issues

Viruses and the sweetpotato weevil are serious quarantine issues. Viral diseases are of concern if roots are used for propagation material because the disease is transferred in roots and transplants (slips) produced from them. Roots from most production areas can be shipped throughout the continental United States, but they may not be imported because of the risk of viral diseases.

The sweetpotato weevil is the single most devastating insect pest of the crop worldwide and is a pest in both field and storage. To date, there are no adequate field or storage control measures, though CA storage treatments may have promise (Delate and Brecht 1989). Roots should not be shipped from weevil-infested production sites to other areas of the country.

Suitability as Fresh-Cut Product

No current potential.

References

Ahn, J.W., W.W. Collins, and D.M. Pharr. 1980. Gas atmosphere in submerged sweet potato roots. HortScience 15:795-796.

Buescher, R.W., W.A. Sistrunk, J.L. Bowers, and C.F. Boettinger. 1975a. Susceptibility of sweet potato lines to development of hardcore, a chilling disorder. Ark. Farm Res. 24(6):2.

Buescher, R.W., W.A. Sistrunk, and P.L. Brady. 1975b. Effects of ethylene on metabolic and quality attributes in sweet potato roots. J. Food Sci. 40:1018-1020.

Chang, L.A., and S.J. Kays. 1981. Effect of low oxygen on sweet potato roots. J. Amer. Soc. Hort. Sci. 106:481-483.

Chang, L.A., L.K. Hammett, and D.M. Pharr. 1982. Ethanol, alcohol dehydrogenase and pyruvate decarboxylase in storage roots of four sweet potato cultivars during simulated flood damage and storage. J. Amer. Soc. Hort. Sci. 107:674-677.

Clark, C.A., and J.W. Moyer. 1988. Compendium of Sweet Potato Diseases. American Phytopathological Society, St. Paul, MN.

Daines, R.H., D.F. Hammond, N.F. Haard, and M.J. Ceponis. 1976. Hardcore development in sweet potatoes. A response to chilling and its remission as influenced by cultivar, curing temperatures and time and duration of chilling. Phytopathology 66:582-587.

Delate, K.M., and J.K. Brecht. 1989. Quality of tropical sweetpotatoes exposed to controlled-atmosphere treatment for postharvest insect control. J. Amer. Soc. Hort. Sci. 114:963-968.

Kays, S.J., and S.E. Kays. 1998. Sweetpotato chemistry in relation to health. *In* Sweetpotato Production Systems toward the 21st Century, pp. 231-272. Kyushu National Agricultural Experiment Station, Miyakonojo, Japan.

Kushman, L.J. 1975. Effect of injury and relative humidity during curing on weight and volume loss of sweet potatoes during curing and storage. HortScience 10:275-277.

Kushman, L.J., and D.T. Pope. 1972. Causes of pithiness in sweet potatoes. Tech. Bull. 207, North Carolina Agricultural Experiment Station, Raleigh, NC.

Lewis, D.A., and L.L. Morris. 1956. Effects of chilling storage on respiration and deterioration of several sweet potato varieties. Proc. Amer. Soc. Hort. Sci. 68:421-428.

Morris, L.L., and L.K. Mann. 1955. Wound healing, keeping quality and compositional changes during curing and storage of sweet potatoes. Hilgardia 24:143-183.

Moyer, J.W. 1982. Postharvest disease management for sweet potatoes. *In* Proceedings of the First International Symposium of the Asian Vegetable Research and Development Center, pp. 177-184. AVRDC, Shanhua, Tainan, Taiwan.

Picha, D.H. 1986. Weight loss in sweet potatoes during curing and storage: contribution of transpiration and respiration. J. Amer. Soc. Hort. Sci. 111:889-892.

Picha, D.H. 1987. Chilling injury, respiration and sugar changes in sweet potatoes stored at low temperature. J. Amer. Soc. Hort. Sci. 112:497-502.

Walter, W.M. Jr., and A.E. Purcell. 1980. Effect of substrate levels and polyphenol oxidase activity on darkening in sweet potato cultivars. J. Agric. Food Chem. 28:941-944.

Walter, W.M. Jr., and W.E. Schadel. 1982. A rapid method for evaluating curing progress in sweet potatoes. J. Amer. Soc. Hort. Sci. 107:1129-1133.

Walter, W.M. Jr., and W.E. Schadel. 1983. Structure and composition of normal skin (periderm) and wound tissue from cured sweet potatoes. J. Amer. Soc. Hort. Sci. 108:909-914.

Wang, Y., R.J. Horvat, R.A. White, and S.J. Kays. 1998. Influence of postharvest curing treatment on the synthesis of the volatile flavor components in sweetpotato. Acta Hort. 464:207-212.

Whiteman, T.M. 1957. Freezing points of fruits, vegetables and florist stocks. Marketing Research Report 196, U.S. Department of Agriculture, Washington, DC.

Yamaki, S., and I. Uritani. 1974. The mechanism of chilling injury in sweet potato. XI. Irreversibility of physiological deterioration. Plant Cell Physiol. 15:385-388.

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.