Sweetpotato

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Scientific Name and Introduction: The sweetpotato, [*Ipomoea batatas* (L.) Lam.], is a member of the Convolvulaceae family which is grown for its fleshy storage roots. Though a perennial, the crop is grown as an annual. Internationally, the sweetpotato is the 7th most important food crop in the world. However, in the U.S. it is used primarily as an occasional vegetable. The 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 U.S.

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

Horticultural Maturity Indices: The storage roots of the 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 and/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 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), 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 metric ton^{-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 decrease the potential for microbial decay. In addition, curing facilitates synthesis of enzymes 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 lignin-like 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} metric ton^{-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 CA storage has 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 storage 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/processing. All cultivars appear to be susceptible to hardcore, however, there is substantial variation in susceptibility among cultivars, and non-cured 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 (53.6 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 and with lower storage temperature (Lewis and Morris, 1956; Picha, 1987). Total sugar content of roots stored at 7 °C (44.6 °F) was significantly greater than 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 and/or storage due to exposure to anaerobic conditions prior to 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 that is characterized by reduced density and a spongy feel when squeezed. Curing and storage conditions that promote a high metabolic rate, facilitate development, as does sprouting in storage and exposure to low soil temperature of 5 to 10 °C (41 to 50 °C) before harvest.

Postharvest Pathology: Among the more commonly encountered microorganisms causing storage rots 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/storage conditions (Moyer, 1982). Black rot, Fusarium root rot, scurf, and bacterial soft rot infections can occur pre-harvest, 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 incurred 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 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 since 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 and/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, in that the disease is transferred in roots and transplants (slips) produced from them. Roots from most production areas can be shipped throughout the continental U.S., but they may not be imported due to viral diseases.

The sweetpotato weevil is the single most devastating insect pest of the crop worldwide and is both a field and storage pest. To date, there are no adequate field or storage control measures, although 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: Sweetpotatoes are eaten almost exclusively cooked, and while a very small quantity is consumed raw, the high levels of proteinase inhibitor in roots undermine potential nutritional benefits.

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