Pecan

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Scientific Name and Introduction: *Carya illinoinsis* L. is a member of the hickory family (Jugulaceae). The edible seed is surrounded by a shuck that opens (dehisces) when the seed is mature. Nuts are harvested in late Fall and early Winter by mechanical shaking the trees and gathering the nuts from the orchard floor. Nuts are covered by a shell surrounding the kernel (cotyledons) that is divided into two relatively equal sized halves. Pecans are native to the southern US and Mexico and are classified for marketing either as seedling (primarily natives) or cultivars. Seedling pecans are typically thicker shelled with smaller kernels, lower shellout percentage and higher oil content than cultivars. The majority of commercial production is in cultivars, such as Western, Desirable, Stuart, Wichita and Pawnee.

Quality Characteristics and Criteria: Pecan kernels should be yellow-golden to light-brown in color, be of roughly equal width from one end to the other and free of any shell or other foreign material as well as off-odor or flavor. Water content should be < 4% to prevent mold growth and retard rancidity development. Water content < 2% increases brittleness and induces greater kernel breakage during handling, and enhances cracking of the testa that increases O_2 permeation of the nutmeat favoring rancidity. Oil content of pecan kernels inversely affects shelf-life, and oil content varies from 55 to 75% (w/w) and is influenced by cultivar, geographic location and year of production (Wells and McMeans, 1978).

Horticultural Maturity Indices: Kernels are considered mature after oil accumulation is complete, which coincides with shuck split (Eddy and Storey, 1988). Maturation of fruit within a tree occurs non-uniformly and can be influenced by cultivar and weather conditions.

Grades, Sizes and Packaging: In-shell and shelled grades exist and are primarily determined by size, degree of kernel fill, color and freedom from defects and foreign material. Grades for in-shell pecans include U.S. No. 1 and U.S. No. 2, based primarily on uniformity of shell color, absence of shell defects, kernel defects and extraneous or foreign material. Sizes of in-shell pecans are based on number of nuts per 0.45 kg (1 lb) and include: Oversize (≤ 55); Extra Large (56 to 63); Large (64 to 77); Medium (78 to 95); and Small (96 to 120). In-shell pecans are packaged in bags containing 36.4 to 54.5 kg (80 to 120 lb) or in palletized containers.

Grades for shelled pecans include U.S. No. 1 and U.S. Commercial for Halves, Halves and Pieces and for Pieces based primarily on testa color, degree of kernel fill, moisture content, freedom from shell or extraneous material and freedom of damage. When the color of kernels in a lot conforms to the "light" or "light amber" classification, these color designations may be used to describe the lot in connection with the grade. Size classifications for halves are based on number of halves per 0.45 kg (1 lb) and include: Mammoth (≤ 250); Junior mammoth (251 to 300); Jumbo (301 to 350); Extra large (351 to 450); Large (451 to 550); Medium (551 to 650); Small or Topper (651 to 750); and Midget (≥ 751). Size classification for Pieces are based on the maximum and minimum round diameter in inches through which the pieces will or will not pass and include: Mammoth (> 1.3 cm; 1/2 in); Extra large (1.4 to 1.1 cm; 9/16 to 7/16 in); Halves and pieces (> 0.8 cm; 5/16); Large (1.3 to 0.8 cm; 1/2 to 5/16 in); Medium (1.0 to 0.5 cm; 3/8 to 3/16 in); Small (0.6 to 0.3 cm; 1/4 to 1/8 in); Midget (0.5 to 0.2 cm, 3/16 to 1/16 in); and Granules (0.3 to 0.2 cm, 1/8 to 1/16 in). Shelled pecans are packaged in 13.6 kg (30 lb) grease-proof boxes, either loose or vacuum-sealed inside plastic bags.

Optimum Storage Conditions: Mechanically-harvested in-shell pecans should be dried to 4.5% moisture prior to storage to preserve quality and prevent mold growth (Heaton et al., 1977). Pecan nutmeats contain 7 to 9% moisture after shelling and should be dried to 3 to 4% moisture to maintain quality. Drying temperatures greater than 38 °C (100 °F) should be avoided because they cause darkening of nutmeats. Recommended conditions for storage of pecans is < 2 °C (36 °F) at 70% RH. Long-term storage should be near -18 °C (0 °F) with 70% RH. In-shell pecans can be stored for 6 mo at 22 °C (72 °F), 12 mo at 0 °C (32 °F) or 24 mo at -18 °C (0 °F); whereas shelled pecans can only be stored for 3 mo at 22 °C (72 °F), 9 mo at 0 °C (32 °F) or 18 mo at -18 °C (0 °F) (Woodroof and Heaton, 1967).

Frozen pecans are brittle and should be handled with care to prevent excessive breakage. Pecans may be thawed and refrozen without damage, provided they are properly tempered. Tempering involves slowly raising the temperature of pecans at low RH and high airflow, with each 10 °C (50 ºF) increase in temperature occurring over 48 h. This can be accomplished by placement of pecans from frozen storage sequentially into two rooms for several days each. The first room should be at 5 °C (41 °F) and the second room at 16 °C (61 °F) (Santerre, 1994). Tempering prevents moisture condensation onto nutmeats during thawing that could induce a soggy texture and promote mold growth.

Modified Atmosphere Considerations: Shelf-life of pecans may be increased by storage in 2 to 3% O_2 in N_2, and less frequently in CO_2 as the balance gas. Storage at < 2% O_2 for 52 days can cause a "fruity" flavor to develop (Santerre, Sciuten and Chinnan, 1990). O_2 transmission rates for packaging materials should be > 0.08 ml/100 cm per 24 h (Dull and Kays, 1988). Vacuum- packaging can offer a further benefit of protection from breakage.

Retail Outlet Display Considerations: Use of packaging to reduce O_2 concentration and prevent excessive light exposure is recommended for shelled pecans. In-shell pecans may be displayed in bulk containers. Exposure to moisture should be prevented.

Chilling Sensitivity: Pecans are not sensitive to chilling temperatures and are commonly stored at temperatures at or below freezing.

Ethylene Production and Sensitivity: Pecans produce very low amounts of ethylene. Prolonged exposure to ethylene may cause pecans to darken and shorten their shelf-life.

Respiration Rates: Pecans have a low respiration rate at < 5 mg CO_2 kg^{-1} h^{-1} at 5 °C (41 °F); about 2.5 mL CO_2 kg^{-1} h^{-1}. Heat production is about 1,100 BTU per ton per day or 305 kcal per metric ton per day.

Physiological Disorders: Poor kernel fill during development may result in "wafering," a condition characterized by asymmetric width of halves along the longitudinal axis. This condition is most prevalent during a year in which the crop load on trees is excessive (Smith et al., 1993).

Stink bug and pecan weevil feeding during pecan development results in a round or irregular shaped black discoloration of the testa that is only evident after pecan shelling. Pecan weevils lay eggs in developing pecans and larvae hatch soon after kernel maturity, consume the nutmeat and exit the pecan leaving a small round hole in the shell. Pecans containing pecan weevil larvae can sometimes be identified by an oil soaked and/or reddish appearance.

Opalescence, a condition characterized by opaque or oil stained appearance of all or a portion of the nutmeat has been recently identified and attributed to breakdown of oil bodies and subsequent leakage of oil within the cotyledon. This leakage increases O_2 exposure of oil and decreases shelf-life due to acceleration of oxidative rancidity development.

Sticktights are nuts that fail to shed the shuck at harvest. Insufficient moisture in the Fall season, or insect feeding on the shuck, may cause this condition because shuck splitting is an active process that requires the shucks to remain turgid and for abscission layers to form at the sutures and at the peduncle

(Worley, 1982). Early Fall freeze or potassium insufficiency may also increase prevalence of sticktights. Kernels from sticktight pecans are often of lower quality due to premature death of the vascular system feeding the developing kernels.

Vivipary (sprouting of nuts on the tree) renders affected pecans unmarketable and may be reduced by late season irrigation (Stein et al., 1989) or by fruit thinning (Sparks et al., 1995).

Postharvest Pathology: The most common decay found in pecans is due to molds, with *Penicillium* and *Aspergillus* most prevalent (Huang and Hanlin, 1975). The intact shell provides some defense against mold. Some strains of *A. flavus* and *A. parasiticus* have been isolated from pecans that can produce aflatoxins, a heat resistant carcinogenic and toxic byproduct. Storage at refrigerated or frozen temperatures prevents or slows mold growth. Reduction of nutmeat moisture content to < 4.5%, and storage at RH < 70%, will provide a water activity of 0.65 to 0.70 that will not support growth of most molds. *E. coli* is a common shell contaminant, especially for nuts harvested in orchards where animal grazing is practiced (Marcus and Amling, 1973). Contamination of nutmeats may occur if shells are broken during harvest or if shells are not properly sanitized by addition of chlorine to heated soak-water just prior to cracking. Because of high amounts of organic material on the surface of pecan shells, chlorine should be monitored and replenished as needed to maintain the desired concentration.

Quarantine Issues: Pecan shucks, shells and nuts in the shell, as well as containers, equipment and vehicles used in association with them, must be free of pecan casebearer, pecan weevil and hickory shuckworm prior to transportation into California.

Special Considerations: Pecans marketed in-shell should be cracked and sampled periodically to assess nutmeat quality. Pecan halves and pieces marketed in plastic bags should be handled with care to prevent excessive breakage and grade change. Since most bags for marketing shelled pecans are clear, care in prevention of exposure to direct sunlight or excessive UV radiation should be exercised to prevent darkening of the testa. Increased temperature during handling can also enhance darkening and promote rancid flavor development. Pecans will absorb lipophilic volatiles in the environment that can introduce off-flavors. Absorption of ammonia will cause darkening of nutmeats. Although frozen storage increases shelf-life, once out of storage, pecans should be utilized quickly due to their short shelf-life at room temperature, compared to pecans never frozen.

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