Walnut

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Scientific Name and Introduction

Persian (English) walnut (*Juglans regia* and a few related species) is a member of the family Juglandaceae and is by far the most important commercial walnut. The genus *Juglans* contains three other groups (butternut, east asian species, and black walnut species) that produce edible kernels. Persian walnuts evolved in central and eastern Asia and were introduced into California in the late 1700s. About 95% of U.S. production is in California. The most important cultivars are 'Hartley,' followed by 'Chandler,' 'Serr,' and 'Vina.' Recent cultivars such as 'Tulare' and 'Howard' will become more important.

Nuts are mechanically shaken from trees during an extended harvest period from late August to early November. The edible kernel is surrounded by a husk that dehisces as the kernel nears maturity. The husk, which should be well split and relatively dry at harvest, is generally lost when the nuts fall to the ground. Harvested nuts (the shell and kernel) may be 35% or more water. Nuts are quickly swept from the orchard floor to avoid damage to the fragile nut and are then dehydrated in forced-air dryers to 8% water content. The temperature of the drying air is kept low, <43 °C (110 °F), to avoid damage leading to kernel rancidity.

Quality Characteristics and Criteria

The primary quality criterion is a high oil content (55 to 65% dry weight) and lack of off flavors caused by oxidation of polyunsaturated fatty acids. Thus, an important criterion is maintaining kernel water content below 4%. Not only does this retard the progression of events that lead to rancidity, it also prevents mold growth and maintains the kernel's crispness. If water content drops too low, however, damage to the kernel's covering can enhance O_2 penetration and rancidity.

The skin covering the kernel contains chemicals that protect fatty acids in the kernel from becoming rancid. Light-colored kernels earn a higher price because the light color indicates that the kernel still has a relatively long shelf-life. An important criterion for evaluating new varieties is yield of light-colored kernels (Hendricks et al. 1998). Retention of light color is influenced by the integrity of the seal between the two halves of the shell, because the shell is an important barrier to O_2 entry. Shell strength and seal integrity are also important in protecting kernels from insect damage and fungi infections that often follow insect damage. Two-thirds of the California production is sold as shelled products (see Siebert 1998); therefore, additional characteristics of processing quality are ease of shelling and yield of intact kernel halves.

Horticultural Maturity Indices

Kernels are considered mature when oil accumulation is complete. This is generally indicated by browning of the internal packing tissue. However, harvest should not begin until the husk is well split and separated from the shell. In the hottest growing regions of California, kernels may be mature 3 weeks prior to husk “maturation” (dehiscence). Low temperatures and high RH, as occurs in some growing regions and can occur at night, advance dehiscence. Ethephon applications are used to advance the harvest and make nut maturation more uniform throughout the tree/orchard (Olson et al. 1998)

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. Freedom from off flavors (rancidity) is important. Shelled kernels held for a long period are particularly susceptible. A complete description of Federal quality standards can be found at http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateN&page=FreshNutandSpecCropStandards.

In-shell walnut kernels derive protection against oxidative changes from the intact shell and kernel skin. Packaging should be moisture-proof. Shelled products should be packaged in airtight, moisture-proof, opaque or foil packages to maximize shelf-life. Unroasted kernels are less likely to take up moisture than roasted kernels. FDA-approved antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) can be applied to the kernels in vegetable oil to enhance stability. Edible coatings may be used as O_2 barriers to retard kernel rancidity (Maté et al. 1996).

Optimum Storage Conditions

Low water content and high fat content of the kernel make it relatively stable metabolically and able to tolerate low temperatures. The primary objectives of storage are to maintain the low water content attained after preliminary drying (to suppress enzyme activity, retain texture, and reduce microbial activity) and to limit exposure to O_2 (to minimize rancidity). The optimum temperature range for storage is 0 to 10 °C (32 to 50 °F), with the lower temperature being better. Within this temperature range, a 50 to 65% RH will maintain walnuts at 4% moisture (Beuchat 1978). Lopez et al. (1998) modeled sorption of walnut kernels and concluded that optimum stability and texture were retained in a storage environment of 10 °C (50 °F) and 60% RH in air.

Controlled Atmosphere Considerations

Shelf-life can be extended by storage in <1% O_2. O_2 <0.5% (balance N_2) or CO_2 >80% in air can be effective in insect control.

Chilling Sensitivity

Walnuts are not sensitive to chilling. They may be stored at or below freezing.

Ethylene Production and Sensitivity

Walnuts produce very low levels of ethylene. There are no documented responses of walnut to ethylene that might affect quality.

Respiration Rates

The low water content of properly stored walnuts makes them relatively inert metabolically. Respiration rates are very low.

Physiological Disorders

The most serious postharvest physiological disorder that affects walnut quality is oil rancidity. The problem appears to be caused by poor seed storage conditions: elevated temperature and RH and failure to use CA with reduced O_2 concentration.

Insect Problems

Insect damage can contribute to handling and quality problems. The major insect pest is the codling moth *(Cydia pomonella)*. While nuts attacked in mid season are likely to be rejected, minor early codling moth damage can lead to more serious infestation with navel orangeworm (*Amyelosis transitella* [Walker]), and this is more difficult to detect if the nut is not shelled. The walnut husk fly *(Rhagoletis completa)* is a serious pest in mid to late season. Larval feeding damages the husk tissues, leading to staining of the shell and failure of the husk to split. This reduces the harvest yield and nuts that remain in the orchard serve as a reservoir of insects to threaten the next crop cycle (van Steenwyk and Barnett 1998). In all cases, insect damage will tend to increase problems with pathogen infection.

Postharvest Pathology

Most infections with pathogens are initiated in the orchard and transferred to the postharvest environment. In-shell product is protected unless the shell has been broken or penetrated by insects. The most serious pathogens are fungi such as *Aspergillus flavus* and *A. parasiticus*, which can produce aflatoxins that are both toxic and carcinogenic. It is important that damaged kernels be discarded prior to storage and that the low temperature and RH conditions discussed above be maintained in order to reduce the chance for mold growth. Toxin-producing *Penicillium* sp. have also been found on walnuts.

Quarantine Issues

Insect infestation is a potentially important problem, as are the fungal infections that often accompany insect damage. Fumigation with methyl bromide or phosphine has been used for disinfestation, but the former is being restricted and insect resistance to phosphine has been reported (Zettler et al. 1990). Johnson et al. (1998) have recommended an initial disinfestation treatment of 0.4% O_2 for 6 days followed by a combination of “protective” treatments that includes 10 °C (50 °F) storage in 5% O_2 and application of the indianmeal moth granulosis virus for control of navel orangeworm and indianmeal moth (*Plodia interpunctella* Hübner). Vail et al. (1991) have reported that these same walnut storage pests are susceptible to the *Bacillus* *thuringiensis* insecticidal crystal protein. Researchers have successfully introduced the gene for the *Bt* protein into walnut embryos and demonstrated its efficacy in suppressing larval development (Dandekar et al. 1998).

Special Considerations

This presentation of quality maintenance guidelines for walnuts has introduced some discussion of changes of the fundamental character of the nut that may be brought about by the use of genetic engineering. The anticipated changes in nut quality and stability could have important effects on the potential for use of walnuts in a variety of food products. However, it is not certain that the work will be successful or that engineered products will be acceptable, particularly since an important part of the crop is destined for export. Whether or not new walnuts are introduced, it is certain that the most important aspects of postharvest quality will be based on rapid harvest with minimal exposure to field heat, forced-air drying at relatively low temperature, and cold storage at an RH designed to maintain low nut moisture in a reduced O_2 atmosphere.

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