Macadamia Nut

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Scientific Name and Introduction

The family Proteaceae includes about 10 species of the genus *Macadamia,* 2 of which produce edible nuts: *M. integrifolia* and *M. tetraphylla* or hybrids of these. The major species of commerce is *M. integrifolia*. Macadamia nuts are native to Australia and are produced there as well as in Hawaii, Central and South America, and parts of Africa. Nearly all production consists of grafted trees of cultivars developed in Hawaii or Australia. The edible kernel is enclosed in a thick, hard shell that, in turn, is enclosed in a husk that separates from the tree at about the time the seed is mature. The kernel is nearly spherical, consisting of joined equal-sized halves (cotyledons).

Quality Characteristics and Criteria

Kernels should be a light cream color, nearly spherical in shape, and free of blemishes, rancidity, mold, decay, insect damage, extraneous material, hollow centers, discoloration, and adhering shell. Fully developed macadamia kernels should contain ≥72% oil; the highest quality kernels contain 72 to 78% oil and 1.5% moisture. Kernels of *M. tetraphylla* typically contain less oil. Oil content is a major quality factor that varies with cultivar and maturity and is inversely related to sugar content (Ripperton et al. 1938).

Horticultural Maturity Indices

Following a prolonged flowering season, macadamia nuts mature over a long period from late summer until late spring. Kernels are mature when oil accumulation is complete. Shortly after this time, the nuts fall to the ground and are harvested. Sometimes shake-harvesting is employed to facilitate the harvest while minimizing the amount of immature nuts harvested. Recommended harvest interval for ground-harvested nuts is 1 mo. Damage by the tropical nut borer (*Hypothenemus obscurus* [F.]) can begin to increase rapidly after 3 weeks on the ground (Jones 1992).

Grades, Sizes, and Packaging

No U.S. grades are established for macadamia nuts, but the State of Hawaii has standards and grades for shelled macadamia nuts, in-shell macadamia nuts, and roasted macadamia nuts (Hawaii Department of Agriculture 1984). The minimum export grade for shelled nuts is Hawaii No. 1, which defines defects and damage, development, and cleanliness as well as maximum moisture content of 1.5% by weight. Off-grade is not a grade, but is a descriptive term applicable to shelled nuts which have a market value and designates a quality lower than the lowest applicable Hawaii grade for shelled nuts. The standards also define eight styles: Style I (wholes), Style II (wholes and halves), Style III (cocktail), Style IV (halves and pieces), Style V (large

diced), Style VI (chips), Style VII (bits, diced), and Style VIII (fines). There are also standards for in-shell nuts and for roasted kernels. Shelled nuts are usually packaged in 11.4 to 22.7 kg (25 to 50 lb) vacuum-packed or nitrogen-flushed foil bags for the wholesale market. Larger nitrogen-flushed containers are sometimes used.

Optimum Storage Conditions

Macadamia nuts should be husked within 24 h of harvest, after which the drying process should be initiated. Freshly fallen nuts contain about 25% kernel moisture, although nuts that have remained on the ground for extended periods may have as little as 10 to 15% moisture. Drying should begin with ambient air, followed by a gradual increase in temperature that will not exceed 60 °C (140 °F) in the final stage of drying. Drying may be completed in-shell (to 1.5% kernel moisture); or the nuts can be dried partially in-shell (to about 5 to 6% kernel moisture), followed by cracking and finish drying of kernels alone to 1.5% moisture. It is important to protect the dry kernels from moisture and O_2, so packaging in a material that is impervious to moisture is important. Vacuum packaging or nitrogen flush offers protection from O_2. Exposure to moisture results in loss of crispness and shelf-life. Likewise, prolonged exposure to O_2 results in rancidity. Cold storage is normally not necessary for short-term storage but might be desirable for extended periods. Frozen storage (-18 °C, 0 °F) can be very effective in extending shelf-life.

Retail Outlet Display Considerations

Packaging should protect kernels from moisture and O_2. Storage temperature is less critical. Nuts are rarely sold in-shell due to difficulty in cracking.

Chilling Sensitivity

Macadamia nuts are not sensitive to chilling provided they have been dried. Dry kernels are commonly stored below 15 °C (59 °F) for bulk storage and can successfully be frozen to extend shelf-life. Care must be taken in thawing frozen nuts to prevent condensation and resulting moisture gain.

Physiological Disorders

Nuts that fail to develop properly will produce kernels that are low in oil content and may appear shriveled or small. If too immature, kernels are very small and become hard upon drying. Immature kernels also have high sugar content and will brown excessively when roasted. High-moisture kernels dried at higher temperatures develop brown centers when roasted as a result of high reducing sugar levels. It is necessary to begin the drying process at ambient temperature or with circulating air heated to no more than 38 °C (100 °F) when the kernels are very wet. Minimum reducing-sugar levels can be obtained if kernel moisture content is reduced to 8% before increasing the temperature to 52 °C (126 °F) and to 6% before increasing the temperature to 60 °C (140 °F) (Prichavudhi and Yamamoto 1965).

Postharvest Pathology

Extended harvest intervals may result in mold, yeast, or bacterial contamination in the field, as well as insect damage. Southern green stinkbug (*Nezara* viridula [L.]), tropical nut borer (*Hypothenemus obscurus* [F.]) koa seed worm (*Cryptophlebia illepida* [Butler]), and litchi fruit moth *(C. ombrodelta)* are the major insect pests causing damage to macadamia nuts in Hawaii, resulting in an unmarketable kernel (Jones and Aihara-Sasaki 1999). Delay in husking the nuts following harvest can also result in mold growth and fermentation. Husking should occur within 24 h of harvest. The thick shell provides considerable protection for the kernel, but cracked shells and open micropyles can provide entry of fungi and bacteria as well as ants. When the nuts fall from the tree, the kernels contain about 25% moisture. At harvest, moisture level can range from about 10 to 25%. Once the nuts have been dried to 1.5% kernel moisture, the water activity is 0.3 (Beuchat 1978), insufficient to support the growth of mold or bacteria.

Quarantine Issues

There are no significant quarantine issues. A possible issue is the occasional presence of storage insects such as almond moth *(Ephestia cautella),* merchant grain beetle (*Oryzaephilus mercatur* [Fauvel]) and the dried fruit beetle (*Carpophilus hemipterus* [Linnaeus]) (Cavaletto 1983)

Special Considerations

Kernel stability is related to moisture content and to oxidative rancidity. Of these, moisture content is the most critical. Raw kernels with moisture content exceeding 2% have poor stability (Cavaletto et al. 1966). These kernels brown excessively when roasted and have poor texture. Likewise, roasted kernels must be well protected from moisture to ensure preservation of texture and flavor. Protection from O_2 is usually accomplished with vacuum or nitrogen acking.

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