

## Macadamia Nuts

Macadamia nuts are regarded as one of the world's best eating nuts. The plant is native of the sub-tropical forests of eastern Australia, and produces nuts with a white, creamy, highly valued kernel. Australia is now the world's largest commercial producer accounting for roughly 40% of the approximately 100,000 tonnes of nut in shell per year produced globally. India has considerable potential for commercial cultivation of this crop in many areas of tropical and subtropical regions, if suitable varieties are introduced and domesticated.

Macadamia nuts are superior in flavour than other dessert nuts and possess a higher aroma and finer, smoother flavour than the hazel nut, which it most closely resembles. The raw kernel though edible, is usually consumed after roasting. Compared to other common edible nuts such as almonds and cashews, macadamias are high in fat and low in protein. The kernels are a good source of vitamin B<sub>1</sub>, calcium, phosphorus, and iron. They have the highest amount of beneficial monounsaturated fats of any known nut, but also contain approximately 22% of omega-7 palmitoleic acid, which has biological effects similar to saturated fat.

### Climate and soil

Macadamia nut trees grow best in climates ranging from warm temperate dry (without frost) through tropical moist areas. Typically found at altitudes up to about 1,400 m, *Macadamia* species grow as small to large evergreen trees, 2–12 m tall. The trees require 60–120 inches of rainfall annually and air optimum temperature of 25°C. Its growth is adversely affected when temperatures fall below 10°C. As a thumb rule that the macadamia can be produced successfully in areas where avocado, papaya, mango and banana do well. In India, it is being grown successfully around Bengaluru (Karnataka) where fruiting is found satisfactory. It grows well on a wide range of soils, but fails on infertile coastal sands, heavy clays or gravelly ridges. Trees yield well on deep, well-drained loams and sandy loam soils with pH range between 5.5 and 6.5. In many places, it is found enjoying the same agro-climatic conditions as that

of coffee. It is favored by alluvial situations bordering rivers and creeks where the fertile volcanic soils, rich in humus and the sub-tropical climate provide ideal conditions for its successful culture.

### Varieties

Solid blocks of a single variety are not recommended as macadamias do better when various types are mixed to allow cross-pollination, thus increasing yields. Brief salient features of some important varieties are given below.

**Beaumont:** It has a good taste, is high in oil, though not sweet. Mature trees produce about 18 kg nuts per tree. Its shell is easier to open than most commercial varieties.

**Burdick:** *M. tetraphylla*. It yields large nuts, averaging 40/kg. Shell thin, well-filled. Kernel recovery 34%, quality good. It matures in October. Tree bears annually. Also used as a rootstock.

**Cate:** *M. tetraphylla*. Nuts are medium to large. Kernel recovery 40%, cream colored, crisp in texture, flavor good to very good. The nut ripens in late October and November. Tree is precocious, shows no alternate bearing tendencies. The most widely adapted cultivar for commercial use in California.

**Dorado:** *M. integrifolia*. Medium-size, uniform nuts, about 2 cm in dia. Kernel recovery 35%, oil content 75%. Tree self-harvesting, and is cold resistant. It is a very productive cultivar, often yielding 30 kg of nuts/tree/year.

**GT 1:** A good self or cross pollinator which crops heavily with smaller nuts.

**James:** *M. integrifolia*, uniform nuts, about 2-5 cm in diameter. Kernel recovery 40 to 42%, quality high, flavour very good, oil content 75%. Trees columnar, precocious, often producing after 2 or 3 years and self-harvesting. Yields 27 kg/tree.

**Keaau:** *M. integrifolia* produces medium-size nut, averaging about 36 nuts/kg; shell smooth, medium brown, thin. Kernel recovery 42-46%, colour light cream, quality good.

**Keauhou:** *M. integrifolia*. Medium to large nut, averaging about 25 nuts/kg. Shell is very slightly

pebbled, medium-thick. Kernel recovery 37 to 40%. Tree yields well, extremely resistant to anthracnose.

**Maroochy:** It has small nut with good flavor. It is a good pollinizer for Beaumont.

**Nelmac II:** A South African *M. integrifolia* × *M. tetraphylla* hybrid cultivar. The nuts are sweet, and this has to be cooked carefully so that the sugars do not caramelize. Ten-year-old trees average 22 kg/tree. It is a good pollinizer for 'Beaumont'.

**Own Choice:** Large nuts and few prickles (*integrifolia* characteristics). Tends to crop inconsistently.

**PA39:** Matures early and tends to drop nuts. A *tetraphylla* like hybrid that crops well and combines well with Beaumont as a pollinizer.

**Renown:** A *Macadamia integrifolia* × *M. tetraphylla* hybrid, high-yielding (17 kg from a nature tree), and the nuts drop to the ground. The nut is thick-shelled, and does not have much flavour.

**Vista:** Hybrid produces small to medium-size nut, about 2 cm in dia. Kernel recovery 46%, flavour excellent, and oil content is 75%.

**Waimanalo:** *M. integrifolia*. Shell is relatively thick. Kernel 38-50%, flavor good, oil content 75%. It produces nuts in large clusters and is resistant to frost and diseases.

### Propagation and rootstocks

Macadamias are easily grown from seed, but the seedlings take 8 to 12 years to bear a crop. The best seeds for propagation are mature seeds which are not more than 4-month-old. The best pretreatment is nicking or soaking in cold water overnight before sowing in a seedbed or in pots/polythene tubes.

For obtaining uniform plants top wedge grafting and chip budding are the ideal methods of propagation. The ideal rootstock for grafting should be 9-12 months old with at least a dia of 1-1.3 cm. The recommended rootstock is *M. tetraphylla* which is resistant to both macadamia trunk canker and anthracnose. While *tetraphylla* rootstock is reported to imparted greater vigour and earlier cropping, in compatibility was noticed, therefore, *Macadamia integrifolia* is preferred as a rootstock.

### Cultivation

**Planting density:** Tree shape and form, which are the characteristics of varieties broadly, decides the spacing to be adopted in macadamia cultivation. Grafted plants are set out in the field at a spacing of 9 to 10 m apart. Different planting densities, viz. low density - 10 m × 5 m (200 trees/ha), medium density 8 m × 4 m (312 trees/ha), medium-high density - 7 m × 3 m (476 trees/ha) and high density-5 m × 2 m (1000 trees/ha) though was recommended, majority of the new orchards are planted at medium to medium-high densities.

Macadamia is pollinated by insects, as most cultivars are at least partly self-incompatible, planting pollinator trees and introducing bees are both important for good fruit set. After flowering, the nuts takes about 6-8 months to mature. Some grafted varieties of macadamias begin bearing within 2-3 years. A young tree raised from a seedling without grafting takes atleast 7 years to fruit, while the grafted trees takes 2-3 years to start bearing fruits.

**Training and pruning:** Pruning is the most commonly practised method of training the *Macadamia* into the desired form. During the early growth much of the formation of the tree may be controlled by hand pruning, that is by pinching out, with the thumb and finger, from time to time all buds which would become undesirable branches. By this method and -with the aid of the pruning shears the framework of the future top may be developed and excess terminal growth retarded.

**Nutrition:** Response of *Macadamia* to nutrition is strongly influenced by soil type and the local environment. Young trees usually benefit from the application of animal manures.

Macadamia leaf samples must be taken during October and November. It is essential to consider the results of both soil and leave samples when making fertilizer adjustments.

Leaf levels of 1.4-1.5% for N, 0.6-0.7% for K, 0.18% for S and 40-75 mg/kg for Boron are considered to be suitable tentative standards for *Macadamia*. Six-to seven-month-old leaves are sampled in spring after anthesis and prior to the start of the spring flush.

**Fertilization:** Young, transplanted trees must first become well established and start growing vigorously before any applications are made, preferably after atleast 1 year. Fertilizer must be broadcast evenly from about 0.2 m from the stem to about 0.5 m outside the drip area of the tree. When the trees are established and start growing, fertilizer must be applied regularly according to the leaf and soil nutrient analysis report.

A bearing *Macadamia* tree should receive 450 g N, 150 g P<sub>2</sub>O<sub>5</sub> and 500 g K<sub>2</sub>O/plant/year for satisfactory production.

**Irrigation:** Water stress often limits tree growth, as well as the set, growth and quality of nuts. The critical and most sensitive periods to water stress in macadamia are as under-

- Flowering - September
- Nut set - October/November
- Oil accumulation (December/Jan)

Mature macadamia trees can quite easily use up to 350 L of water or more a week in hot dry weather. Usage may require up to five mega litres per hectare per year. When irrigating, soil moisture monitoring system such as tensiometers or capacitance probes may be used to ensure water is being applied efficiently.

### Diseases and pests

The macadamia nut apparently is not attacked by many pest problems. The most troublesome is perhaps a web moth, the caterpillars of which attack the leaves, young shoots and terminal growth. The nuts may also be attacked. The web covering makes the pest difficult to control. Mice and rats are very fond of the nuts, gnawing holes in the shells, and removing the kernels in a remarkably workman like manner. Nut borer burrow into the green husks of macadamia nuts or feed on the kernels. Stinkbugs are the most important pest on macadamias.

### Harvesting and post-harvest management

Grafted tress do not begin to produce commercial quantities of nuts until they are 7-10 years old, but once established, may continue bearing for over 100 years. Nuts mature in 6-7 months after flowering and must be allowed to ripen on the trees. Usually the nuts fall to the ground when mature, but in some cultivars remain on trees and must be removed with rake. To test for maturity, when opened the nut husk interior and the nut should both be brown (not white). The harvest of immature nuts will result in many small and hard kernels which must be hand sorted out and reduce the value of the crop. Immature or improperly dried fruits are difficult to separate from the shell.

Macadamia nuts are collated manually after they have fallen. Harvesting can be done at least every four weeks wherever possible, particularly during extended wet weather or where nuts are exposed to direct sunlight. The green husks around the nuts must be removed as soon as possible after harvesting. Kernels are mature when oil accumulation is complete. Sometimes shake -harvesting is employed to facilitate the harvest while minimizing the amount of immature nuts harvested. The main crop is usually collected from March to July.

Depending on the variety, it may take several more months before all mature nuts drop. Darkening of the inside of the husk gives a good indication that the kernel is mature and ready for harvesting.

The round white kernel of the nut has no epicarp or thin outer covering as is usual with most nuts. It is pleasantly crisp with an appetizing, usually sweetish flavour and is richer in oil than the most edible nuts. The kernel oil is colourless with excellent edible properties, but is not usually extracted as the kernels themselves are in great demand as dessert nuts. The highest quality kernel contains at least 72% oil.

**Maturity indices:** The kernel of a ripe macadamia nut will float in fresh water, whereas kernel from an unripe macadamia nut will sink. A ripe macadamia nut will have a chocolate brown inner to the husk. If the inside of the husk is white, then the nut is not ripe. A

ripe macadamia nut will not be sticky on the outside. It will come away from the husk easily. If the nut feels sticky on the outside when you remove it from the husk, it will not be ripe.

**Handling:** Dehusking the nuts is done within 24 hours of harvesting. This prevents deterioration from over-heating. While the nuts are being dehusked, sort out to remove nuts that have obvious defects, such as rat or insect damage, cracked shells and discolored shells.

**Drying:** If it is, dry the macadamias down to about 12-17% moisture content (exact level depends on kernel recovery), carry out flotation grading, and then dry the nuts down again to the desired moisture content of about 8-10%. Drying must be completed within two weeks of harvesting. Forced-air is used to dry macadamias (sometimes heat is used too). If harvest volumes are smaller, nuts can be spread out to dry in thin layers on racks located in a cool, dry location, such as a shed.

**Yield:** Bearing commences in about the fourth or fifth year and reaches a peak at maturity in about the twelfth to fifteenth year. For a well-managed orchard with tree spacing of 8 m x 4 m (312 trees/ha), expected average peak yields at maturity are approximately 3.5 to 4 tons of nut-in-shell (NIS) per hectare (12 to 13 kg/tree). A well-managed orchard could be expected to be highly productive for at least 30 years, although trees may grow for a hundred years or more.

**Storage:** Macadamia nuts should be dehusked within 24 hours 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 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<sub>2</sub>, so packaging in a material that is impervious to moisture is important. Vacuum packaging or nitrogen flush offers protection from O<sub>2</sub>. Exposure to moisture results in loss of crispness and shelf - life. Likewise, prolonged exposure to O<sub>2</sub> results in rancidity.

**Shelling:** For successful shelling, the nuts should be dried to a moisture content of about 1.5% to ensure that kernels shrink away from the shells. Therefore, nuts should be dried before shelling. The final drying takes place in large containers through which hot air is circulated.

**Drying:** Freshly harvested, dehusked nuts contain 25% moisture and must be dried before they are stored in bulk. The nuts could also be sundried.

The nuts that still have the husk adhering to them deteriorate sooner than dehusked nuts when stored and that a good method of storing the nuts is in wire-bottom trays in a shed or curing house with good ventilation and in a dry situation if possible. If well dried they may be kept under such conditions for 3 months or more. When shelled and dehydrated to approximately 2 per cent moisture and kept in cold storage, in sealed containers they may be stored for as long as a year without deterioration.

Moisture after dehusking is normally around 25% and must be reduced to around 1.5% for cracking. Nuts should be crisp when fully dry and will rattle when shaken to indicate that the kernel has shrunk away from the shell. The minimum moisture content that can be achieved without commercial drying is around 10%.

Failure to store in a dry well ventilated place will lead to mould, rancidity and germination. Prolonged exposure to direct sunlight should be avoided, which can increase rancidity and cracking of the shell. If heating is adopted in the drying process, temperatures in excess of 38°C needs to be avoided if the nut moisture content is above 10% as this can create browning of the kernel. The nuts should be packed into cartons as soon as possible after shelling. They can then immediately be placed in a cold store at 0 to 4°C. Cold storage prevents fungal growth and rancidity. This method is also recommended for the long-term storage of unshelled nuts.

**Packaging:** The fried or roasted nuts are packed in airtight bottles, tins or plastic containers for consignment and marketing. Kernel stability is related to moisture content and to oxidative rancidity.