

Tropical and Subtropical Nuts

Macadamia



Macadamia integrifolia

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CHRONICA
HORTICULTURAE v. 45, n. 2

Macadamia

- Family *Proteaceae*
 - Two species cultivated for their nuts:
 - *Macadamia integrifolia* Maiden and Betche
 - *Macadamia tetraphylla* L. Johnson
- Both species native to the east coast of Australia, from rain forest-like climates



Macadamia integrifolia

- Commonly known as the Queensland nut or Australian nut
- *integrifolia*, from the Latin *integer* = whole, and *folia* = leaf

- A favorite food of the Australian aborigines
- First described by German botanist Baron Ferdinand Jakob Heinrich Von Mueller
- He named the species in honor of his friend John Macadam (1827-1865), Australian doctor and chemist

- *M. integrifolia* is more tropical in its requirements than *M. tetraphylla*
- Industry is based on the former
- Small production in southern California is based on the latter

- Nuts were brought to Hawaii and California in the late 1880's
 - Some of the original trees brought to Hawaii are still alive
- The islands soil and weather conditions provided ideal growing conditions

- Only the Hawaiians developed nut culture, whereas the Californians used it as an ornamental
- Not considered an important crop until the 1950s
- Hawaii's harvest of macadamia nuts brings in over 40 million pounds a year

The largest macadamia plantings are on the Big Island, followed by Maui, Oahu and Kauai



Botany

- Medium sized, tropical evergreen tree, with spreading, full canopies, reaching widths of 30 ft and heights of 20-30 ft



- Leaves are linear-obovate, 4-6" long, sparsely dentate with sharp teeth, and thick; gives the overall impression of a large holly leaf



- Perfect flowers
- Most cultivars are self-fruitful, but sometimes yield better when cross-pollinated
- Flowers are borne on long, fragrant racemes (4-8") of dozens of individual flowers, from lateral buds on 1-yr wood



- Flowering occurs in mid-winter
- Each branch of the Macadamia tree produces 300 to 600 sweet scented white blossoms



- 2-10 nutlets/inflorescence develop into spherical nuts encased in green fibrous husks, then a smooth brown very hard shells around the macadamia nut kernels
- Flowering is not synchronized



- Fruit is a **drupe**
 - fleshy outer portion removed to reveal the nut
- Shiny green hulls (=mesocarp and exocarp) are adherent to the shell (=endocarp)



- Nuts harvested 7-8 months later (Jul-Nov), although some nuts mature more-or-less year round
- Nuts are round, with kernels enclosed in hard shells, with shelling percentages of 40%.



- The shell of a Macadamia nut is the hardest shell of any edible nut
- It takes a carefully applied 300 psi of pressure to shatter the shell without damaging the kernel inside



Climate

- Although tropical trees, macadamias tolerate mild freezing (28-32 F), and do not tolerate excessive heat
- In Hawaii, cool ocean breezes allow cultivation at sea level, but inland in the tropics, trees must be grown at 1500-3500 ft
- No chilling requirement
 - a seasonal change in temperature may help to synchronize bloom.

Cultivation

- Trees begin bearing in 4-5 years, and have productive lives of 75-100 yr
- Trees require spacings of 35 x 35 ft in the tropics to prevent crowding



Harvest

- Harvesting mature macadamia nuts is tedious and can be done by three methods:
 - By picking from the ground by hand
 - By shaking the tree and picking by hand
 - By picking with a mechanical harvester (still under development)

Harvest

- Harvesting may extend over a 6-12 week period
- Harvested nuts de-hulled mechanically and dried to low water contents (< 2%)

- Nuts cracked and sorted to remove off-color kernels and pieces of shell
- Kernels are graded into 2 classes flotation
 - Grade I kernels (>72% oil) float
 - Grade II (<72% oil) sink



- Most crop used for confectionery, but whole kernels are roasted and salted and sold in jars/cans
- Considered to be among the finest table nuts in the world
- They contain high quantities of oil (mostly high level of mono-unsaturated fatty acids, MUFA)

World production

- Australia is now the world's largest macadamia producer (~30,000 tons), having recently overtaken the US (Hawaii, ~25,000 tons), and is also the largest macadamia exporter, shipping about 70% of output.
- Exports in 1999/2000 were about 24,000 tons, with the US being the largest market, accounting for 40% of the total.

Production

- Also grown in subtropical regions like South Africa and Central America
- Regaining importance as the nutritional value of nuts is being studied and people learn about the importance of 'good' fats

- United States is a significant importer of macadamias
- The United States is the largest single export market for Australia, South Africa, Costa Rica, Guatemala, and Brazil.

Nutritional properties

- One of the few foods containing reasonable amounts of palmitoleic acid (16%)



- Similar molecule to oleic acid (18:1 n9)



- All other nuts contain 0.2-0.4%
- It seems that palmitoleic acid replaces most of the polyunsaturated fatty acids, making macadamia the nut with the highest percentage of MUFA

- Studies indicate that diets with macadamia lower blood cholesterol
- More clinical studies necessary to study the effects of this type of fat on health

Nutritional facts (100 g)

Nutrient (100% DV)	<i>Macadamia</i> <small>dry roasted w/o salt</small>	<i>C. illinoensis</i>
Water	1.6 g	3.5 g
Energy	718 kcal	691 kcal
Protein	7.8 g	9.2 g
Total lipid (fat)	76.1 g	72 g
saturated (<20)	11.9 g	6.2 g
MUFA (?)	59.3 g	40.8 g
PUFA (?)	1.5 g	21.6 g
Carbohydrates (300)	13.4 g	13.9 g
Dietary fiber (25)	8.0 g	9.6 g
Vitamin C (60)	0.7 mg	1.1 mg
Vitamin A (5000)	0 IU	77 IU
Vitamin E (30)	0.6 IU	0.6 IU
Copper (2)	0.6 mg	1.2 mg
Iron (18)	2.7 mg	2.5 mg

Brazilian Nut



Bertholletia excelsa



- One of the most important economic plants of the Amazon is the Brazil nut (*Bertholletia excelsa*, family Lecythidaceae)
- The edible seeds of this species, along with the latex of *Hevea brasiliensis* (rubber tree), are often cited as the most important products of extractive reserves in the Amazon

- Also known as Amazon nut
- It has resisted any attempt to successfully grow it in any other regions of the world

- Very large tree, 75-150 feet high
- Trunks often 10 feet in diameter
- Large picturesque forests along the Amazon and Rio Grande rivers in South America
- No evident alternate bearing



- Brazil nut trees are a valuable non-timber forest product
- Harvested from natural stands in tropical rainforests, their market facilitates forest conservation as well as creating revenue for local peoples

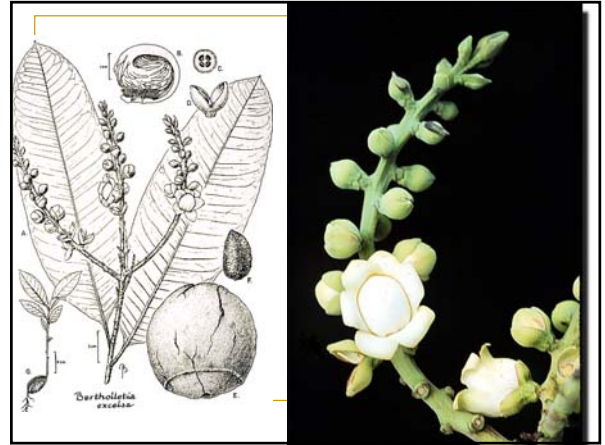
Brazil Nut Gallery

<http://www.bertholletia.org/bertholletia/gallery/gallery.html>

- Flowering of *Bertholletia excelsa* occurs during the dry season and into the wet season.



Brazil nuts begin as flowers high up in the canopy



These flowers become food for many forest inhabitants, such as the leafcutter ants seen here, and even animals like deer. The leafcutters will carry them to their underground gardens where they will use them to grow fungus for food



But before the flowers fall, many of them are pollinated by orchid bees with long, specialized tongues. These bees are native to undisturbed rainforest, and this is just one of the reasons that Brazil nuts can't be grown in plantations



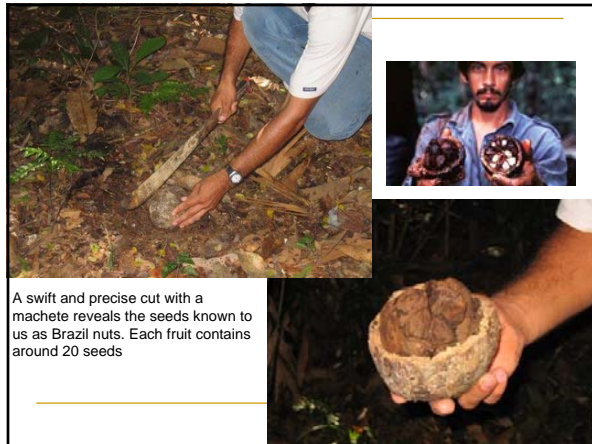
Macaws eat the developing, immature fruits (pods) with their sharp, powerful bill



Only when the pod is soft can the macaws access the nutritious seeds inside



Eventually the mature fruits fall to the forest floor, where many are collected by the local "castañeros" (Brazil nut harvesters)



A swift and precise cut with a machete reveals the seeds known to us as Brazil nuts. Each fruit contains around 20 seeds



© W.P. Armstrong 2000



In Peru, the Brazil nut concessions are managed primarily by families. Everyone helps out with the harvest.



After being extracted from the pods, the nuts are carried out of the forest in large sacks that may weigh over 100 pounds



Many families dry the nuts in the sun as soon as they arrive in the camp. This will prevent rot and facilitate peeling



The nuts are incredibly rich in oil, which can be extracted for cooking and many other purposes



The sacks of nuts are transported from the camp in long dugout canoes, or sometimes on a balsa raft like this one



Most of the nuts are brought to ports where the many different families come to sell their harvest



The Brazil nuts are then brought to large factories where they are prepared for exportation



Although many of the nuts are exported with their shells (center), they fetch a higher price when they are peeled (right). This is done with nut-cracking machines (left) and provides one of the only sources of income for women in the area. Unshelled nuts are also in demand by companies that use the oil in their products such as soap, shampoo, and body lotions



Recently, scientists discovered a species of frog specialized only for breeding inside empty Brazil nut pods



The agouti is a key player in the life of the Brazil nut tree. It is the only animal capable of opening the mature Brazil nut pods. It collects the pods left behind by the harvesters and scatterboards the nuts underground. The nuts that are forgotten may grow into another massive Brazil nut tree!



Since it is illegal to cut down a Brazil nut tree in Peru, it is common to see them scattered around cow pastures and other clear-cut areas. These stark reminders of the once majestic rainforest will slowly die as they cease to produce fruit and regenerate.

Nutritional facts (100 g)

Nutrient (100% DV)	Brazil Nuts <i>dry</i>	<i>C. illinoensis</i>
Water	3.5 g	3.5 g
Energy	656 kcal	691 kcal
Protein	14.3 g	9.2 g
Total lipid (fat)	66.4 g	72 g
saturated (<20)	15.1g	6.2 g
MUFA (?)	24.5 g	40.8 g
PUFA (?)	20.6 g	21.6 g
Carbohydrates (300)	12.3 g	13.9 g
Dietary fiber (25)	7.5 g	9.6 g
Vitamin C (60)	0.7 mg	1.1 mg
Vitamin A (5000)	0 IU	77 IU
Vitamin E (30)	5.7 IU	0.6 IU
Copper (2)	1.7 mg	1.2 mg
Iron (18)	2.4 mg	2.5 mg

'Brazil nut lamp'



Cashew



Anacardium occidentale L.,

Anacardium occidentale L.,

- Fam. Anacardiaceae
 - Same as pistachio
 - The family contains 73 genera and about 600 species
 - *Anacardium* contains 8 species, native to tropical America, of which the cashew is by far the most important economically



From *Flore d'Amérique dessinée d'après nature...*, 1843-1844 by Etienne Denisse. The fruit of the cashew.

Anacardiaceae

- Resinous bark and often **caustic oils** in leaves, bark, and fruits
- Several species cause some form of **dermatitis** in humans
- Today, the caustic substance that made plant domestication difficult is a valued by-product of cashew nut production.

Origin

- Native to northeastern Brazil, in the area between the Atlantic rain forest and the Amazon rainforest
- The vegetation type of the region is dry forest, savannah woodland or thorn scrub



Origin

- Sometimes referred to as a rainforest species
- Nuts are found in products with 'rainforest-friendly' label
- Although the trees will grow in tropical wet forests, they rarely produce many nuts
- Production greater in areas with a distinct wet and dry season



History of cultivation

- Native South Americans discovered that roasting nuts in fire would remove the caustic oil, allowing the nut to be cracked and consumed without any ill effects
- Natives also knew of many medicinal uses for the apple juice, bark, and caustic seed oil that were later exploited by Europeans
- The roasting practice was either not known or not appreciated outside the native range, and as a result the cashew apple was the first product consumed, with the nut being discarded

History of cultivation

- The Portuguese discovered it in 1578 and introduced it to the west coast of India and east Africa in the 16th century
- It was planted in **India** initially to reduce erosion, and uses for the nut and pseudofruit, the cashew apple, were developed much later
- The trees were well adapted to the region, and became naturalized
- Trees also became naturalized in Central America and the Caribbean islands

- India developed more refined methods for removing the caustic shell oil, and this country is given credit for developing the modern nut industry
- India led the world in cashew production for many years until just recently, when production in Vietnam surged about 3-fold in a few years
- In its native Brazil, cashew nut production ranks in the top 5 of the world, and virtually all cashew apples and juice products come from this country

Breeding programs

- Several cultivars have been selected in India, and show exploitable variation in kernel oil and shell oil content
- In Brazil, an ongoing **breeding program** has produced dozens of dwarf clones, some yielding twice as much as seedling trees, with higher percent kernel (38% more) and good cracking characteristics (<2% broken kernels)
- Cashew is easily **grafted**, and future release of these cultivars may improve productivity and profitability of cashew production greatly

Botanical Description

- A small to medium tree, generally single-trunked and spreading in habit, up to 40' in height but generally 10-20' in cultivation
- Leaves are thick, prominently veined, oval to spatulate in shape, with blunt tips and entire margins
- New foliage contains reddish pigment



- Flowering is similar to the close relative mango: both male and perfect flowers are borne in the same inflorescence (polygamous)
- Individual flowers are 1/4" across, with crimson petals, often striped longitudinally and reflexed.



- Flowers borne generally at the beginning of the dry season
- Flowering may occur over several weeks
- Frequently not synchronized



- Trees are at least partially self-fruitful, as lone trees can bear many fruit
- Cashews often grown from seed, and cross pollination in orchards must occur to a high degree
- Various insects, even flies and ants, provide pollination.

- The true botanical fruit is a nut, about 1" long, shaped like a small boxing glove, hanging below a fleshy, swollen peduncle called the **cashew apple** or **pseudofruit**



Cashew apple

- Similar to pear in shape and size
 - juicy, fibrous, and astringent tasting
- Skin of either yellow or light red color, and yellow flesh.
- Mature in 60-90 days
- The nut develops first, followed by the rapid swelling of the cashew apple in the last few weeks.



Cashew apple

- Not only edible but delicious
- Very rich in Vitamin C
- Practically unknown outside regions where cashews grow
- Can be used to make a cashew juice or wine



- The cashew apple may be consumed fresh, but contains high quantities of tannins yielding a bitter taste and dry mouth feel.
- It is more often cooked, partially dried, or candied, as in the Dominican Republic ('cajuil') and India



Nut shell

- It has an inner and outer wall, separated by a honeycomb tissue infused with **caustic oil**
- Cracking the nuts fresh results in the oil contaminating the kernel, so nuts are roasted to drive off oils before they are shelled
- The nuts are about 22-30% kernel by weight, and kernels are difficult to extract whole compared to other tree nuts

Cultivation

- Few improved cultivars exist, at least in commercial production
- Yellow and red apple forms exist naturally, and do not appear to hybridize readily, but each is genetically variable in its own right and is not recognized as a cultivar

Soils and Climate

- Cashews are said to be **tolerant of sandy, poor soils** where many other crops will not thrive
- Cashews are especially intolerant of poor soil drainage
- Soil pH is generally on the acidic side, 4.5-6.5
- Trees are strongly taprooted and drought tolerant if soils are deep, and can grow in areas receiving only 30-50" of rain per year

Soils and Climate

- High rainfall and humidity favor diseases that destroy the flowers and reduce fruit set
- They have **no cold tolerance** whatsoever, requiring protection from cold even in extreme southern Florida

Propagation

- Propagation is most often **by seed**, planted directly in the field where the tree is to be sited
- Improved cashews are propagated by grafting, layering, or cuttings
- Fruit production occurs in 4-5 yr from seed, and 2-3 yr from vegetative propagation.

Rootstocks

- Generally none, but cashew seedlings can be used for rootstocks for grafted trees.

Planting

- Cashews are planted at various densities, depending on the intensity of production, amount of rainfall, and other factors
- New plantings often with 20-35 ft between trees and rows

Maturity and harvest

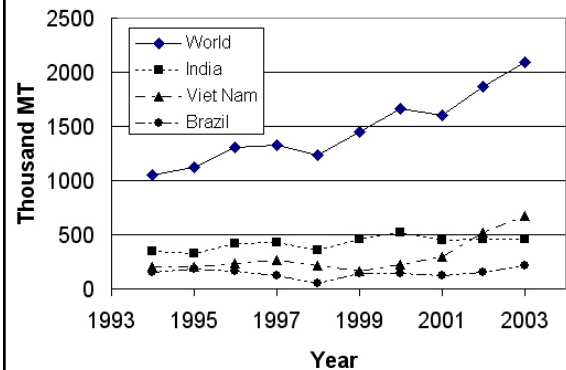
- The cashew apple and nut abscise from trees naturally when ripe
- Nuts collected from the ground by hand
- Frequent passes though the planting must be made if apples are to be utilized, as they are highly perishable
- Rain at harvest may increase rot and stimulate nut germination.

- The presence of caustic cashew nut shell liquid (CNSL) in the shells makes cashew processing more difficult and hazardous than for other nut crops.
- After harvest, the nuts are dried in the sun or in simple tray driers and stored for processing later
- After roasting, nuts are shelled either by hand or in machines

Production

- Produced commercially in 32 countries
- World production doubled since 1994
- Now the #1 nut crop in the world, since its production surpassed that of almond in 2003 (by over 300,000 MT).

- In 2002, 1,668,010 MT (3.7 billion pounds) of cashew apples were produced, 96% from Brazil.
- Cashews are not produced commercially in the USA, but can be grown in extreme south Florida and Hawaii.



Cashew consumption

- Per capita consumption of cashew is unknown, but that of all tree nuts is 2.7 lbs/year in the USA
- Cashews are likely to be less than 1 lb/year

- Medicinal uses of cashew bark, leaves, and apple juice are plentiful, and were well known prior to recorded history in the native region of Brazil:
- **Bark teas:** diarrhea
- **Caustic shell oil:** skin infections, warts, worms, and botfly larvae beneath the skin
- **Teas and fruit juices:** antimicrobial, anti-inflammatory, astringent, diuretic, hypoglycemic, and other medicinal properties
- The active principles are thought to be **tannins, anacardic acid, and cardol**
- Modern uses of shell oil and fruit juice include facial peels and scalp conditioners and shampoos.

Nutritional facts (100 g)

Nutrient (100% DV)	Cashews <i>Dry roasted w/o salt</i>	<i>C. illinoensis</i>
Water	1.7 g	3.5 g
Energy	574 kcal	691 kcal
Protein	15.3 g	9.2 g
Total lipid (fat)	46.4 g	72 g
saturated (<20)	9.2g	6.2 g
MUFA (?)	27.3 g	40.8 g
PUFA (?)	7.8 g	21.6 g
Carbohydrates (300)	32.7 g	13.9 g
Dietary fiber (25)	3.0 g	9.6 g
Vitamin C (60)	0 mg	1.1 mg
Vitamin A (5000)	0 IU	77 IU
Vitamin E (30)	0.9 IU	0.6 IU
Copper (2)	2.20mg	1.2 mg
Iron (18)	6.0 mg	2.5 mg

References

- Gene Spiller. Healthy Nuts. Avery Publishing Group
- <http://www.uga.edu/fruit/macnut.htm>
- <http://www.uga.edu/fruit/cashew.htm>