



# Growing high priority fruits and nuts in Kenya: Uses and Management



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TRANSFORMING LIVES AND LANDSCAPES



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The World Agroforestry Centre (ICRAF) is a non-profit research organisation whose vision is a rural transformation in the developing world resulting in a massive increase in the use of trees in rural landscapes by smallholder households for improved food security, nutrition, income, health, shelter, energy and environmental sustainability. We are one of the 15 centres of the Consultative Group on International Agricultural Research (CGIAR).

Headquartered in Nairobi, Kenya, we operate five regional offices located in Brazil, Cameroon, Indonesia, Kenya, and Malawi, and conduct research in eighteen other countries around the developing world. We receive our funding from over 50 different governments, private foundations, international organisations and regional development banks.

ICRAF has been engaged in research on fruit and nut trees with a wide range of local, national and international partners for more than 15 years, and has been a strong promoter of the domestication, cultivation and conservation of these species.’

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## **Growing high priority fruits and nuts in Kenya: Uses and management**

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Cover photo: Extracted marula fruits, a child eating a marula fruit, fresh black plum fruits on sell, processed packed tamarind fruits and a background of a farmer from Meru in her mango farm

Back photo: Fresh macadamia nuts on a tree branch and mature nuts opposite and fresh black plum fruits

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## **Introduction**

Growing fruits and nuts offers tremendous opportunities for enhancing the incomes of small-scale farming families in Kenya and elsewhere in Africa, and for improving the nutrition of the poor who currently suffer from deficiencies in vitamins, minerals and other micronutrients as a consequence of low consumption of these foods. Many fruits are, for example, important sources of vitamins A and C that are lacking in the diets of many Africans. Low intake of vitamin A – around 50 million African children are at risk of deficiency – is considered to be Africa's third greatest public health problem after HIV/AIDS and malaria. Vitamin C, on the other hand, is essential for protecting cells and keeping the body healthy and also absorbing iron from food. Vitamin C is an important mineral that is present in significant quantities in many fruits. Action on improving fruit and nut availability and quality, when co-ordinated, is likely to have a major positive impact on the health of African consumers and increase income generation.

If farmers receive good incomes from cultivating high quality fruits and nuts, that consumers can afford and are informed about the benefits of eating them, a strong domestic production sector can develop in Kenya. The cultivation of fruits and nuts by smallholders to feed local markets and support of export markets presents a tremendous opportunity for investment, especially if the indigenous species that are recognised and valued by domestic consumers are considered as well as exotic ones. At present, about 80% of the total market value of fruit and nut crops is earned locally in Kenya, and this market is likely to grow further in the coming decade. The total value of all traded production was estimated to be 650 million USD in

Kenya in 2007, of which around 85% was contributed by fruits and 15% by nuts.

Many fruit and nut species are rare assets in that they can be established on farms with a very modest initial investment and their value increases with time and is maintained over many years, continuing to contribute to family livelihoods and to bringing women, men and children out of poverty in a sustainable way. By conserving these genetic resources in farmland – of indigenous species that are threatened in the natural landscape as forests recede, and of locally adapted exotic species – they are also made available to future generations, so that their livelihoods and health can also benefit. Moreover, fruit and nut production is not amenable to much mechanisation and is therefore labour-intensive, and thus plays to one of the key strengths of smallholders, which is their low labour cost, enabling them to compete with larger farmers. Although the potential for improving fruit and nut production to improve incomes for small-scale farmers in Kenya and elsewhere in Africa is evident, smallholders face a number of bottlenecks in the cultivation and sale of produce. These include production constraints, such as limited species and variety development, inefficient delivery systems for delivering superior cultivars to farmers, and poor farm management practices, with smallholders being unaware of better propagation, pest management and irrigation methods to improve quality, increase productivity and profits. In addition, farmers face market constraints, such as poor post-harvest practices that reduce sale ability, poor market delivery systems, lack of knowledge about the species and varieties for which markets are available, and lack of awareness among consumers of the health benefits of eating fruits and nuts.



Kenya has a very big market potential, since in most parts of Kenya, fruits are available through out the year. This is a very long period and can be utilized to beat the export market. The major challenges facing the fruit marketing in Kenya are the competition from other producers such as South Africa and Israel and the EREPGAP requirements; these can only be addressed by improving the quality of the fruits produced. This book thus addresses issues of improving fruit production in quality and quantity and also highlights the way forward. The development of this publication was probated by the results of a survey carried out in Eastern Kenya by some ICRAF staff on consumption of indigenous fruits and the recommendations (P. Simitu; et 2008.)

Our purpose in this publication is to begin to address the lack of knowledge faced in smallholder fruit and nut production in Kenya. Through the sharing of information on how to use and manage these resources, we hope that many more Kenyan farmers will be able to benefit from their cultivation. The country has a very wide diversity of exotic and indigenous fruits, and a few nuts, that are utilised locally and are occasionally grown for export. Among the most popular are avocado, baobab, black plum, custard apple, passion fruit, macadamia nuts, mango, tamarind and water berry. Several publications are available on the production of avocado, mango, and temperate fruit trees in Kenya e.g. Apple, pears, etc. this guide therefore addresses some of the other species that are important.’ For all the indigenous fruit species (baobab, black plum, tamarind, wild habitats are the main sources of these fruits, with planting in farmland currently rarely practiced, although householders will often protect existing wild trees in the agricultural landscape.

## **The Baobab (*Adansonia digitata*): Africa's Upside-Down Tree**



*A grafted baobab tree with short stature, allowing easier access for harvesting in Mali*

### **Introduction**

The Baobab tree, which is among the largest and longest living trees on earth, is also one of the most unusual and remarkable tree. It has flourished for thousands of years in the arid savannah close to the equator. The tree, which can grow up to 30 metres in height, has a very strange appearance. It has an

enormous, thick bulbous trunk and stunted branches that look like gnarled roots spreading wide. The branches are bare for nine months of the year, since the tree puts out leaves only twice a year, for a few weeks at a time when the rains come to the plains. Thus, the Baobab tree, for most of the time, looks as if it has been pulled out of the ground and stuffed back in upside down!

The African baobab (*Adanosonia digitata*) belongs to Bombacaceae family and the genus Adansonia. Its other common names are in *English* (baobab, cream-of-tartar tree, guinea tamarind, lemonade tree, monkey bread tree, sour gourd, upside-down tree) and in Swahili-*mbuyu*. The name commemorates the French botanist Michel Adanson (1727-1806), who is one of the first scientists who studied the plant characteristics. Linneaus dedicated the genus to him, while the species; ‘digitata’ means hand shaped, referring to the typical fingered shape of the leaves.

Baobab grows from altitudes of 0-1500m and areas with 250-1500mm mean annual rainfall. It prefers well-drained soils that are acidic (ph <6.5), preferably with sandy top soils overlaying loamy substrates. *Adansonia digitata* is a multipurpose tropical fruit tree used primarily for its fruits, which are eaten fresh or processed for non-food uses, The species has a wide geographical distribution in the subtropics and semi-arid tropics and is cultivated in numerous regions. It’s thick, fibrous bark is remarkably fire resistant, and even if the interior is completely burnt out, the tree continues to live. Re-growth after fire results in a thickened, uneven integument that gives the tree its gnarled appearance resembling an elephant’s skin but that serves as added protection against fire. Flowers have an unpleasant scent. Fruit ovoid, 12 cm or more in length, with

a hard, woody shell, covered with yellowish-grey velvety hairs, indehiscent; seeds smooth, embedded in a whitish powdery pulp, have little or no endosperm.

The information on propagation especially grafting in this booklet is obtained out of the research work undertaken by Cinzanan Research Station and The Forest Department of Mali.

### **Distribution of *Adansonia digitata* L. in Kenya**



Native Range: Angola, Benin, Botswana, Burkina Faso, Cameroon, Chad, Cap Verde, Congo, Cote d'Ivoire, Eritrea, Ethiopia, Gambia, Ghana, Guinea, Kenya, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Tanzania, Togo, Zambia, Zimbabwe.

Exotic Range: Antigua and Barbuda, Bahamas, Barbados, Central African Republic, Comoros, Cuba, Democratic Republic of Congo, Dominica, Dominican Republic, Egypt, Gabon, Grenada, Guadeloupe, Guyana, Haiti, India, Indonesia, Jamaica, Malaysia, Martinique, Madagascar, Montserrat, Netherlands Antilles, New Caledonia, Philippines, Puerto Rico, Sao Tome et Principe, St Kitts and Nevis, St Lucia, St Vincent and the Grenadines, Trinidad and Tobago, United States of America, Virgin Islands (US).

### **Propagation**

Reproductive Biology: Mostly bats (*Ephormorphus wahlbergii* and *Rousettus aegyptiacus*) pollinate the flowers. The flowers emit what some describe as a strong carrion smell, which is presumably attractive to the bats; it is also known to attract the bluebottle fly (*Chrysomya marginalis*) and at least 3 nocturnal moths: American bollworm (*Heliothis armigera*), red bollworm (*Diparopsis castanea*) and spring bollworm (*Earias biplaga*). In East Africa, the bush baby (*Galago crassicaudatus*) feeds nocturnally on the flowers, thus aiding in pollination. In southern Africa the tree flowers from October to December and fruits from April to May. One of the most common ways of natural regeneration is when the fruits fall off the tree and crack. Ants enter the fruit and feed on the pulp. In this way, soil is introduced into the fruit and it becomes moist with the onset of the rains, thereby allowing germination to take place. There are normally 2000-3000 seeds/kg.

### **Propagation methods:**

(a) *Use of Seed:* Artificial propagation is by direct sowing of the seed. Pretreatment is not necessary. However, germination is more successful if the seeds are nicked or boiling water is poured on them, after which they are left to soak for 24 hours.

Soaking in water overnight softens the seed coat and makes water absorption easy thus hastens germination. When the seed coat is nicked it may take only 6 days to germinate. Germination is usually 90-100% and takes 1-3 months. It is preferable to sow the seed directly into the soil or straight into polythene tubes. It is advisable to prune the roots only twice before planting out.

*(b) Stem cuttings:* Since pruned branches frequently sprout young leaves when minimal conditions are present, stem cutting may be taken, rooted in the nursery and transplanted to the field.

*(c) Grafting:* The Forestry Department of Mali has proved that it's easy to graft baobab. A veneer graft is used with a plastic film to control transpiration. Rootstocks used are 3 months old nursery seedlings. A success rate of 46% was found with scions kept for 8 days while the best rate of success (92%) was obtained using scions that are 1 to 2 days old. Scions are collected from trees with fruits with high vitamin C.

*Planting and spacing:* The size of the hole in the field is 60cm x 60cm x 60 cm depending with the size of planting space can also be 40cm<sup>3</sup>. The seedlings are transplanted into the field at 10m x 10m spacing. Planting should be done during rainy season. Once established, the seedlings grow well, becoming 2 m tall in 2 years, and 7 m tall in 10 years. The tree then grows slowly but lives long; under favourable conditions some *A. digitata* may live for more than 1000 years. The trunk may even shrink during periods of severe drought. *A. digitata* may be pollarded or lopped to encourage abundance of leaves.

## **Production**

First flowering after grafting is 3 years. Baobab is pollinated by the fruit bats. The tree bears fruit once a year. This is extremely significant because grafting noticeably shortens the time to first flowering (8-23 years in plants raised from seed) (Wickens, 1982) Data on growth rates relate to seed-propagated trees. On average, a height of 2m is reached in 2 years and about 12 m in 15 years (Von Maydell, 1986). Young trees add 30cm per year in diameter. (Sidibe et al., (1996) reported that transplanted individual plants of 0.5 m height grew to 2m in the first year after transplanting. An average mature fruiting baobab produces 200kg of fruit per season (Arum (1989)

## **Market analysis**

Large quantities of fruit harvested and sold in coastal areas, Semi-arid areas of Eastern Kenya (Kitui, Mwingi, Kibwezi, Tharaka. Coloured pulp sold as snacks in big towns like Nairobi, Mombasa, Malindi, etc

Baobab has the potential to become a major regional export Commodity. A sustainable potential supply of 700,000 mt of baobab fruit per annum could be sourced from the countries in the Southern and Eastern African regions. There is potential demand for baobab as industrial and specialized novel food, cosmetic and pharmaceutical ingredients. Focus markets include the European Union (EU), United States (US) Japan and South Africa (SA). Potential demand exists in all major and minor developed and developing economies.

Key market access issues that need to be addressed: Residual tariffs on baobab and its potential products in high value markets need to be negotiated away Tariff escalation still exists in some markets such as Japan Significant non-tariff barriers, such as food safety and novelty rules, need to be addressed

Trade facilitation problems constrain regional and international trade in small quantities of products. Complex and overlapping rules of origin may impact on development of baobab. There is already a Senegal's Baobab Fruit Company which claims to be the largest global harvester and producer of baobab ingredients. The African firm, which began by designing equipment capable of extracting raw materials from the tree in 1999, has recently joined forces with Canadian company BaobabTek. This shows that baobab fruit pulp has a lot of potential as an economical tree, which can improve livelihood of many farmers in semi-arid lands of Africa.

### **Nutritional value**

Baobab contains naturally dehydrated fruit pulp, which contains five times the vitamin C present in oranges (53mg/100g of fruit pulp), as well as vitamins A, B1, B2, B6 and PP. Minerals present include calcium, phosphorus, potassium, iron, sodium, zinc and magnesium. The seed endocarp is also said to contain naturally occurring omega 3, 6 and 9. The edible white, powdery pulp is very rich in vitamin C and B2 and makes a refreshing drink. Ripe fruits are collected and cracked to remove the 'flour', which is mixed with water to prepare a flavoured fermented porridge.



*Nutritional composition of baobab fruit pulp and fresh leaves  
Per 100g of raw edible portion*

Nutritional composition per 100g portion	Baobab pulp	Baobab raw leaves
Vitamin C	270 grams	50 grams
Protein	2.2 grams	3.8 grams
Fibre	6.8 grams	2.8 grams
Carbohydrates	76.7 grams	
Iron	7.4 milligrams	
Calcium	284 milligrams	400 milligrams
Potassium	118 milligrams	
Fat	0.8 grams	
Ash	4.3 grams	
Water%	16.0	77
Energy kj	1214 kj	289 kj
Nitrogen-free extract	69.9 milligrams	



*Baobab fruits on display at ICRFA HQs, Nairobi, Kenya*

## **Economic Importance**

*Food:* An edible white, powdery pulp found in the fruit is very rich in vitamin C and B2 and makes a refreshing drink. Ripe fruits are collected and cracked to remove the 'flour', which is mixed with water to prepare a flavoured fermented porridge. Young leaves are also rich in Vitamin C, contain uronic acids, and are high in demand in West Africa as a soup vegetable. In Ferlo, North Senegal, an extract of the leaves, called 'lalo', is used to give couscous (millet porridge) a smooth consistency. The leaves also form an excellent condiment and seasoning.

The small stem and roots of the seedlings are eaten as vegetable; mature, thick roots are cooked and eaten during famine. A root decoction is widely used in Sierra Leone as food. It is prepared by boiling, roasting, soaking or fermenting the roots, and tastes like almonds. Having high water content, the wood is chewed by humans and animals in case of extreme water scarcity. The wood can be used as a salt substitute. The acid pith is used as a substitute for cream of tartar in baking, to curdle milk and smoke fish. It is also roasted and used as a coffee substitute. The seeds contain appreciable quantities of tartaric acid and potassium bitar; they are refreshing to suck, and when soaked in water make a palatable drink.

*Fodder:* Young leaves, fruit, pods and seeds provide fodder for game and domestic animals. During drought, donkeys and game animals chew both the bark and fibrous wood for sap. Livestock and game often destroy young trees.

*Apiculture:* The tree is a source of fine quality honey. Wild bees manage to perforate the soft wood and lodge their honey in the holes. In many parts of Africa, the hollow trunks are used for beekeeping.

*Fuel:* The long-fibred wood is suitable for firewood. The shell and seeds are also used for fuel, which potters use to smooth earthenware necklaces before firing.

*Fibre:* The bark from the lower part of the stem of younger trees and of the roots can be removed to produce a valuable fibre. If managed properly the trees are not seriously damaged, and even after repeated use the bark regenerates and can be stripped again some years later. It is used to make excellent cordage, ropes, harness straps, mats, snares and fishing lines, fibre cloth; musical instrument strings tethers, bed-springs and bow strings. In both Senegal and Ethiopia, the fibres are woven into waterproof hats that may also serve as drinking vessels. The fibre is the best for making the famous 'kiondo' (baskets) of Kenya. Strong, tough and tear-resistant paper is produced from the fibre. It is commercially exploited in India for currency notes.

*Timber:* The wood is whitish, spongy and light (air-dried 320 kg/cubic m). It is used for making canoes, rafts, insulating boards, wooden platters and trays, boxes and floats for fishing nets.

*Gum or resin:* Glue can be made by mixing flower pollen with water.

*Tannin or dyestuff:* The wood contains some tannin, and the acid pith is used to coagulate rubber. In East Africa, the roots produce a useful red dye.

*Lipids:* A non-drying, golden yellow oil of agreeable taste, which is used in gala occasions in Senegal, may be obtained by distilling the seeds. In Bicha and Mondo villages in Tanzania, *A. digitata* seeds are used as a substitute for cooking oil.

*Alcohol:* The Wasandawe of Tanzania use the liquid from the pulp for brewing beer, as do the Akamba people of Kenya, who use the seed pulp as fermenting agent in some local beer.

Ash from the shell, bark and seed, rich in potash, is widely used in making soap, prepared by boiling the bark and fruit ash in oil. The shell can be used as a dish, water dipper, vessel for liquids, snuffbox, fishing float; it also makes an excellent rat trap. The powdered husk or penducule may be smoked as a tobacco substitute or added to snuff to increase pungency. The pulp extract can be used as a hair wash.

*Poison:* The bark is boiled for days to extract a substance poisonous to ants. Fruit pulp burns with an acrid, irritating smoke that can be used to deter insects troublesome to livestock.

*Medicine:* Hyposensitive and antihistamine properties are present in the leaves, which are used to treat kidney and bladder diseases, asthma, general fatigue, diarrhoea, insect bites, and guinea worm. Leaf and flower infusions are valued for respiratory problems, digestive disorders and eye inflammation. The seed paste is used for curing tooth and gum diseases. The fruit pulp, seed and bark are reputedly an antidote to *Strophanthus* poisoning. Gum from the bark is used for cleansing sores. It is also used as an expectorant and a diaphoretic. The bark is used in steam baths for calming shivering and high fever. A decoction of the roots is taken as a remedy for lassitude impotence and kwashiorkor. The bark is boiled and taken as a cure for body pains. This infusion is also used to treat colds, fever and influenza. Seeds are used to cure gastric, kidney and joint diseases; they are roasted then ground and the powder smeared on the affected part or drunk in water.

### **Services**

Soil improver: Decaying wood of a tree that has died of old age or from lightning is spread on fields as a fertilizer. Ashes from the shell, bark and seed are rich in potash and are useful as a fertilizer.

Other services: In dry regions, *A. digitata* plays a vital role in water storage; a hollowed trunk may be carved out in 3-4 days. A medium-sized tree may hold 400 gallons while a large tree could contain over 2000 gallons, and water stored in them is said to remain sweet for several years if the hollow is kept well closed.

In East Africa the trunks are hollowed out to provide shelter and storage, and in West Africa the hollowed trunks are sometimes used as tombs.

### **Challenges**

1. Limited knowledge on propagation techniques
2. A negative attitude towards the use of wild fruits, especially among men, who consider that only children and women eat wild fruits
3. Poor marketing outlets and low pricing of products
4. Slow growth and low quality of indigenous fruit species seedlings compared with exotic fruits
5. Lack of awareness by farmers on the need to plant and manage more Indigenous fruit trees
6. Limited amounts of indigenous fruit tree seedlings in tree nurseries

### **Way forward**

Most of the baobab production and processing aspects requires further Research, but the most urgent aspects which require further research are;

- a. Seed collecting (rather than choosing “superior mother trees’ what is essentially needed is a scientific-based programme of evaluation we should identify desirable genotypes) and provenance testing

- b. Selection and clonal propagation of specific genotypes for different production objectives to shorten the fruit maturity and improve fruit quality e.g. tastes.
- c. Extension gaps relating to the use of products such as food and their correct processing in terms of nutrition contents; and promotion of local Micro-industries for such products; and more use of intensive Production and simple processing to add value to end products
- d. Marketing strategy need to be developed to improve the market

### **Further reading**

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## Growing black plum (*Vitex payos*) or the “chocolate berry”



*Mature fruits of black plum fruits*

### **Introduction**

**Common names:** English: black plum, *Swahili:* mfudu, *Kamba:* Kimuu, *Embu:* Muburu, *Giriama:* mfudu

**Vitex payos-**The “chocolate berry” (black plum) is a tree with round leather-like leaves and fruits which resemble black olives. The strong smelling fruits are surprisingly pleasant to the taste, something like crumbled chocolate.

*Vitex payos* is a species of hot, low and semi-arid places with high water table. In more arid zones it is found near rock outcrops. The most commonly associated tree species are *Acacia polyacantha*, *Dalbergia melanoxylon*, *Brachystegia spiciformis* etc. It grows from altitudes of 0-1600m, in areas with 650-850mm mean annual rainfall. It can also grow to a height of up to 10m. *V. payos* often grows in sandy soils, less often clay red and rocky ones. *Vitex payos* belongs to the Verbenaceae family.

The main objective of this booklet is to provide simple information in a readily available form to extension agents, NGOs, Students, nutritionist, farmers growing *Vitex payos* in Kenya and to highlight it's importance as a fruit tree, which has already being ranked number one among the ten indigenous fruit tree species (B.O. Muok, B. Owuor, I. Dawson & J. Were. *Agroforstry Today* 2002 Volume 12 no 1 'the potential of indigenous fruit trees: results of a survey in Kitui District, Kenya, pg 13-16'). Some of the information in this publication is one of the author's (Anne Mbora) personal experience, obtained working in Semi-arid parts of Eastern and Western Kenya.

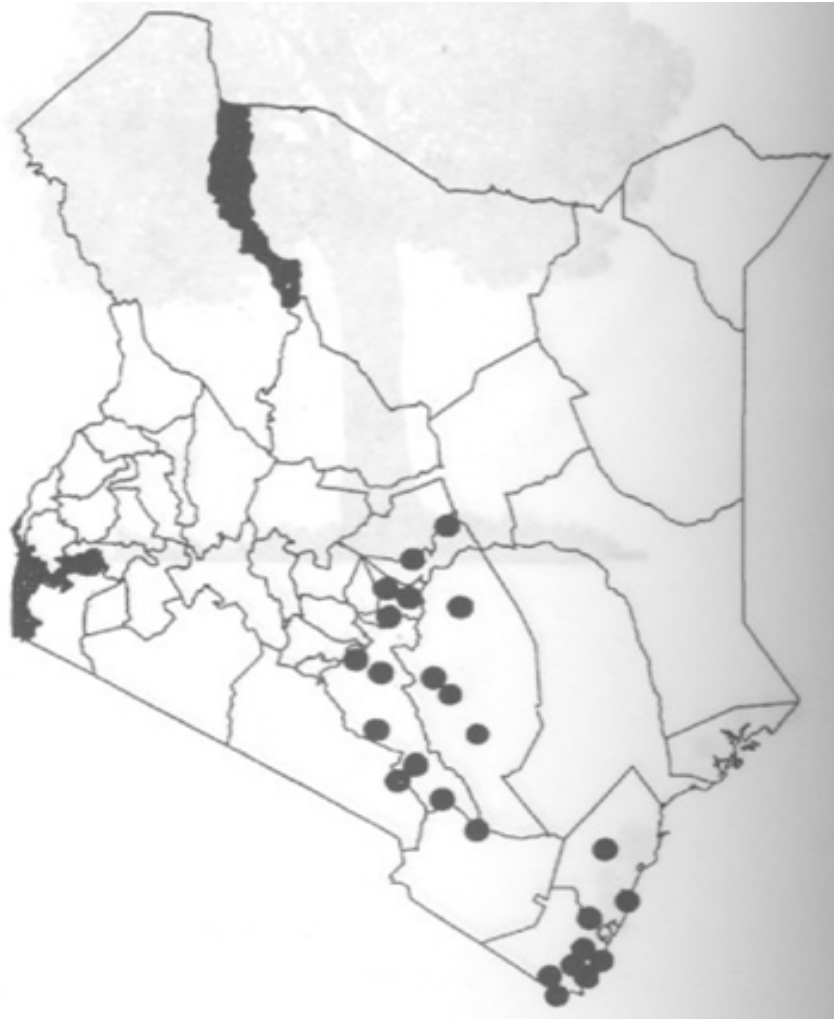
### **Distribution**

Native Range: Kenya, Malawi, Mozambique, Tanzania, and Zimbabwe

Exotic Range: No data

In Kenya, it grows in Semi-arid parts of Eastern, Costal and Central Kenya e.g. Kitui, Embu, Machakos, Kilifi, Kwale, Tharaka, Mberee and Mwingi.





### **Propagation**

Seed germination is hindered by the hard seed coat. This is normally broken by annual fires in the wild; however fresh seeds, germinates more easily. Seeds can be stored at 3-5 deg. C for up to a year. The weight of 1000 fruit stones is about one kg. The tree is propagated by direct sowing of seeds, transplanting seedlings from wildlings, transported either from the bush or from arable land during the rainy season, and root cuttings arising from accidentally or deliberately damaged roots. Many farmers in Kenya do not prefer root cuttings as it results in unstable trees. There has been little success with vegetative propagation using stem cuttings. There is no

literature on grafting and air-layering, suggesting that it has not been tried.

Partial clearing of vegetation is essential before planting out to open up space. Tending should include spot weeding (clearing 1m diameter the space of planted seedling) and slashing until the crop is well established. The tree coppices well.

In Kenya, Flowering takes place during the rainy season (September-December), while fruit ripening occurs during the dry season (April-June). *Vitex* species generally exhibit hermaphroditism, where both functional male and female organs are in the same flower (Lars Schmidt, 2000). *Vitex payos* is another *Vitex* that has received some horticultural exploration. Its woody seed has proven reluctant to germinate, but one method for overcoming this natural resistance is leaving seeds out in the open for a year then nick the end where there are two holes. Trees grow slowly during the first three years in the nursery, but then growth speeds up.

### **Production**

In Kenya, the tree Flowers during the rainy season (October-December), while fruit ripening occurs during the dry season (May-August). *Vitex* species generally exhibit hermaphroditism, where both functional male and female organs are in the same flower (Lars Schmidt, 2000). The flowers are commonly visited by bees and sunbirds. The growth rate of *Vitex payos* is moderate; the tree height is from 4-10m. Stones should be sown fresh after removal of the pulp and soaking in cold or warm water for 24 hours. In Côte d'Ivoire, stones dipped into sulphuric acid 95% for 60 minutes and subsequently in water for 72 hours germinated after 26 days, but the germination rate was only 34%. Untreated fruits may take very long (even up to 90 days) to germinate; fire

normally, accelerate germination. Stones may contain several seeds and several seedlings may germinate from one stone. Seeds can be stored for up to 1 year at 3–5°C. Propagation by cuttings has been successful in Malawi. Survival rates in plantations are normally good, about 80–90% after 3 years. In Tanzania fruits ripen in April–July, in Zambia in April–September.

### **Market Analysis**

*Vitex payos* (Lour.) Merr. These fruits, the “real” chocolate berries, are very popular in parts of southern and Eastern Africa, from roughly Malawi, Mozambique to Tanzania. Zimbabwean villagers are said to collect them in quantity every winter; while in Kenya fruits are collected in July–August. Each fruit is about 2 cm long, with pointed tips and a chocolate brown or black skin. The juicy pulp surrounds a single hard stone. However, it is definitely an acquired taste, the powdery texture, the oily mouth feel, and the strong smell. But even then not all is lost: Since 1990, Zimbabwean entrepreneurs have been making jam from the fruit and selling it in the city markets. In Zimbabwe *Vitex payos* fruits are sold for 1.5\$ per pack (of 30–35 pieces of fruits). In Kenya fruits are sold in Kitui, Mutomo, Mbeere (Ishiara) and also in Dodoma, Singida and Kondaa in Tanzania. In order to increase farmers’ income from *Vitex payos* fruits appropriate processing technologies for the fruits need to be developed to add value to the products. Research into the development of appropriate processing technology must have emphasis on simple technologies that are appropriate at village level to allow rural people the opportunity to generate income throughout the year, with maximum value added at the village level.

### **Nutritional value**

Nutritional composition of *vitex payos* (black plum) fruit pulp  
Per 100g of raw edible portion.

Energy	63kj
Water %	70.6
Carbohydrates	27.4 grams
Fibre	27 grams
Protein	0.7 grams
Ash	5.5 grams
Fat	0.8 grams
Vitamin C	1.96 milligrams
Calcium	34.0 milligrams
Phosphorous	50 milligrams
Iron	2.7 milligrams

### **Economic importance**

Fresh fruits are eaten by human beings, monkeys, gorillas, chimpanzees and elephants, which probably disperse the seeds later. The blackish pulp of the fruits is edible and eaten raw. It is often used to make jam. A beverage is made from the fruit juice, and boiled fruits are the basis for an alcoholic liquor and wine. The seeds inside the fruit stone are also edible. Cooked young leaves are eaten as a vegetable or in sauces.

The wood is popular for house building, vats, furniture, stools, carving, tool handles, gunstocks, bowls, spoons and beehives. It is also suitable for light construction, light flooring, joinery, interior trim, boxes, crates, matches, veneer, plywood, hardboard, particle board, wood-wool and pulpwood. The wood is used as firewood and for charcoal production.

*Vitex payos* has numerous applications in traditional medicine. Pounded bark is administered to treat threadworm and skin problems. Leaf sap is used as an eye drop to treat conjunctivitis and other eye complaints. Leaves are boiled and the liquid drunk by patients who have lost their appetite. A Paste of pounded leaves and bark are applied to wounds and burns. Leaf infusions are added to alcoholic drinks to make them stronger. A root decoction is administered orally to treat stomach problems or gastro-intestinal disorders. Powdered bark added to water is taken to treat colic, and a bark extract is used to treat stomach complaints and kidney troubles. The bark is also used against leprosy, liver diseases, and to control bleeding after childbirth. Dried and fresh fruits are eaten against diarrhea. The twigs are used as chewing sticks for teeth cleaning.

The blackish extract obtained by boiling leaves, bark, roots and/or fruits is used as ink and as a dye for clothes. The flowers serve as source of nectar for honeybees. Cattle browse the foliage as fodder

### **Services**

*Shade or shelter:* The heavy rounded crown of *V. payos* provides good shade.

*Nitrogen fixing:* The tree has nitrogen-fixing roots.

*Soil improver:* Leaves can be used for mulch which improves soil fertility.

*Boundary/barrier/support:* Grown in fields and along boundaries.

### **Challenges**

Little has been done to improve the tree propagation methods or growth.

Poor marketing of fruits or jam made from the fresh fruits.

Poor germination of seeds after storage-seeds germinate easily when sown fresh.

### **Way forward**

- a. Develop propagation methods to shorten fruit maturity, Improve fruit Production and the growth rate
- b. Explore the full potential of this tree species.
- c. Assess the market potential for fruits and other tree products
- d. To analyse current marketing practices (including marketing channels, harvesting, storage and processing) of the fruits and fruit products
- e. Develop best storage methods which can extend seed life or good germination ability after storage
- f. Carry out More research on vitamin content and minerals.

## **Further reading**

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*Mature macadamia nuts in fruit and extracted*

## **Introduction**

Common names: English (Macadamia nut, Australian nut), Swahili (Mkadamia)

Species: “Smooth-shelled Macadamia” (*Macadamia integrifolia* Maiden & Betche), “Rough-shelled Macadamia” (*M. tetraphylla* L. Johnson). Hybrid forms exist between the two species.

The macadamia nut tree is indigenous to Australia but introduced in Kenya in 1945 to 1948. In Kenya it grows roughly in the same climate suitable for growing coffee.

The macadamia nut trees remained almost totally unknown in Kenya until after independence in 1964 when a Kenya farming family, Bob Harries and Peter Harries started multiplying the trees in a seedling nursery, planting them on their farms and selling some to other interested farmers. In 1969 -1971 Bob



Harries Limited, a company founded by the late Robert Harries initiated a campaign to sensitise the Kenya Government to commercialise macadamia nut growing and establish processing and marketing the edible nuts. The Kenya Nut Company Limited was formed in 1974.

This company was appointed by the Kenya Government to spearhead and invest in the development of the macadamia nut industry in Kenya. The tree thrives best at 0-2000m attitude and grows to 9-20m a height and 45 cm diameter (dbh-diameter at breast height). The tree also grows best in areas with mean annual temperature of 15-29 Deg C. and mean annual rainfall of 700-2600 mm. It also requires well-drained soil which is fertile red loams or alluvia derived largely from basic igneous rock such as basalt with a pH of 5.5 to 6.5. Macadamias will not tolerate soil or water with high salt concentrations. It is most suited to deep, well-drained loams and sandy loams with good organic matter content.

The most popular varieties grown in Kenya are *Macadamia integrifolia* and *Macadamia tetraphylla*. The *Macadamia tetraphylla* is more adaptive to cooler climate and has rough-shelled bush nut while the *Macadamia integrifolia* has smooth nut surface and is adaptive to diverse agro-climatic conditions. In Kenya the two species grafts are used to produce a more improved variety which is now very marketable and in high demand. *Macadamia Integrifolia* is highly dominant in the commercial clonal production area. Hybridisation occurs freely between *Macadamia intergrifoila* and *Macadamia tetraphylla*. In Kenya the bulk of selections being currently grown is from such hybrids such as KIAMBU 3, KIAMBU 9 and 5, MURANGA 12 and 20, KIRINYAGA 1 and EMBU 1. More selections are being developed from the research programs in K.A.R.I. Thika. Most of the information in this publication is

farmer's experiences obtained from farmers growing macadamia in their nursery and on farm; this also includes challenges most farmers are facing in production of macadamia nuts. These are the issues which made the authors come up with this document to enable most farmers improve their nuts quality and quantity of nuts production.

### **Distribution**

Native Range: Australia

Exotic Range: Brazil, California, China, Colombia, Costa Rica, Ethiopia, Fiji, Guatemala, Hawaii, India, Indonesia, Jamaica, Kenya, Malawi, New Zealand, Samoa, South Africa, Tanzania, Thailand, United States of America, Venezuela, Zimbabwe

In Kenya, it grows in high potential areas of Eastern, Central and Rift valley provinces.

### **Propagation**

Macadamias are easily grown from seed, but the seedlings may take 8 to 12 years to bear a crop and the quality of the nuts is unpredictable. The wood of macadamia is hard, thus, requiring the propagator to have experience to make it successfully. It's important to note that seeds of *Macadamia tetraphylla* are collected and seedlings raised from them since it's recommended as a rootstock due to it's resistant to different rootstock diseases. The best seeds for propagation are mature seeds which are not more than 4 months old. The best pretreatment is nicking or soaking in cold water overnight before sowing in a seedbed or in pots/polythene tubes. If sown in a seed bed then transplant the sprouted seedlings from the seedbed to polythene bags when they are 2 cm in height. These seedlings are good as rootstocks if one is to graft. Grafting is the only option to obtain good varieties of fruit in a short

period. The rootstock to be used for grafting should be usually seedlings of 9-12 months old with at least a diameter of 1-1.3 cm. The scion wood is girdled (remove a narrow section of bark on about 80% of the circumference of the twig) about 6 to 8 weeks before grafting to promote accumulation of carbohydrates. The recommended graft method is a top-wedge grafting or chip budding. Softwood cutting and air-layering is also possible as propagation method. The scion wood can be either, but *M. integrifolia* is preferred for the best nuts production while the recommended rootstock is *M. tetraphylla* for it's resistant to diseases. It's important to note that *M. tetraphylla* is resistant to both macadamia trunk canker and anthracnose, grafting cultivars of *M. integrifolia* onto rootstock of *M. tetraphylla* minimizes these problems

The grafted seedling takes 3-4 months to be ready for planting out in the farm. Seedlings are planting out in the field at a spacing of 9m x 9m or 10 m x 10 m or more if the trees are intercropped with coffee or any other crop e.g. maize; however if they are been planted as pure orchard, the spacing should be 4m x 10 m or 5 m x 10 m.

### **Production**

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 years-3 years.

A young tree raised from a seedling without grafting takes at least 7 years to fruit, while the grafted trees takes 2-3 years to start bearing fruits The nuts turn brown when mature and one

harvest by shaking the tree branches where by all mature fruits or nuts fall down. Sort out the mature nuts from the few immature which may fall down. One can also pick from the tree.

A good tree can yield 45-90 kg nuts on average per year. Harvesting is usually by manual collection of the nuts from the ground or Picking from the crown-picking the fruits which have cracked or turned brown. The husks are removed and the nuts are dried within 24 hours of harvest. Failure to do so initiates undesirable physiological activity which causes fermentation and spoilage.

For the production of edible nuts it is important to dry the nuts from an initial moisture content of 45% to between 5% - 1.5%. This is done by passing air through the nuts for a week, followed by an application of low heat (38 deg C - 54 deg C), for an additional 7-10 days (Cavaletto). At a smaller scale nuts are placed 2-3 deep in trays which have good air circulation and these are left to dry for about 2-3 weeks (Rosengarten).

If stored in bulk, respiratory activity results in increased temperatures and creates high relative humidity. In such conditions lipolysis and moulds become storage problems. The nuts should be stored in a rainproof shelter or drying shed (Rosengerten). Simple drying racks can be made from meshed wire.

### **Market analysis:**

The Kenya macadamia nut industry is currently made of approximately 900,000 trees of varying ages from one year to 20 years, grown by over 100,000 small scale farmers with an average of 6 -12 trees per grower. Annual production is about 4,000 metric tons of nuts-in-shell. These produce about 800

metric tons of marketable kernels, making the main commercial product. Other by products such as oil, are minimal. Producers get from nuts-in-shell Shillings 92 million per year.

Kenya is the third largest macadamia producer and the second largest exporter of macadamias. Many Kenyan farmers are integrating macadamia trees into their coffee and tea plantations. They view macadamia output as insurance against the uncertainties of weather which affect coffee and tea.

Japan and the United States are the 2 largest markets, together accounting for almost 84 percent of Kenya's total exports

### Macadamia Production and Value for 2005-2007

Province	Area (Ha)		Production (MT)		Value (Kshs.'000')	
	2005	2006	2005	2006	2005	2006
Central	947	1,158	6,629	8,106	397,740	486,360
Rift Valley	344	310	2,408	2,170	144,480	130,200
Eastern	1,300	1,407	9,100	9,849	546,000	590,940
<b>Total</b>	<b>2,591</b>	<b>2,875</b>	<b>18,137</b>	<b>20,125</b>	<b>1,088,220</b>	<b>1,207,500</b>

HCDA, 2008.

## Nutritional Value

It has tough thick shell which encloses a cream-colored oil-rich nut. The macadamia nuts are rich in oil (60-72%), Proteins and Carbohydrates. It is also a good source of Vitamin B1, B2, E, Fibre, Calcium, Phosphorous, Magnesium, Iron, Potassium and Niacin. The nuts can be eaten raw or used to make edible oils or confectionery or baking Macadamia is a good source of calcium. phosphorus, iron, vitamins B and niacin.

*Nutritional composition of raw edible portion Per100g of macadamia nut*

Energy	2,9936kj
Protein	8.30 grams
Carbohydrates	4.43 grams
Fibre	9.30 grams
Vitamin B <sub>1</sub>	0.350 milligrams
Vitamin B <sub>2</sub>	0.110 milligrams
Niacin	5.69 milligrams
Vitamin B <sub>6</sub>	0.196 milligrams
Vitamin E	0.410 milligrams
Calcium	70.0 milligrams
Phosphorous	136 milligrams
Magnesium	116 milligrams
Iron	2.41 milligrams
Potassium	368 milligrams
Magnesium	116 milligrams
Zinc	1.71 milligrams
Saturated Fat	11.0 milligrams
Sodium	5.00 milligrams

## **Economic importance**

The importance of macadamia nut as a tree for inclusion in agro-forestry products lies in the fact that the tree can be inter-planted with other cash crops and once established, it needs minimal care in comparison to other tropical tree crops such as the cashew nuts which is confined to the coastal region only. The macadamia tree has a wider ecological suitability.

The main uses for macadamia nut still remain as the kernel which is eaten as a dessert nut, in raw or roasted form, but also for making confectionery products. Soaps and cosmetics industries use the oil as a raw material.

The oil press cake can be used as a livestock feed additive, the shells can be used to make charcoal while the wood also has the potential for production of hard timbers for the furniture or building.

*Apiculture:* Macadamia pollen is very attractive to bees, providing necessary forage for honey production.

*Fuel:* Macadamia shells may be used as fuel, generating sufficient energy to dry wet, in-shell nuts.

*Tannin or dyestuff:* The hulls, the green covering of the nuts, contain approximately 14% of substances suitable for tanning leather.

*Lipids:* Macadamia is the richest oil-yielding nut known. The kernel contains more than 75% oil, suitable for human consumption.



*Essential oil:* The characteristic, subtle macadamia flavour is probably due to volatile compounds, the major ones being similar to those in other roasted nuts

### **Services**

*Shade or shelter:* *M. integrifolia/ tetraphylla* makes an excellent evergreen shade and shelter due to its thick crown of leaves.

*Soil improver:* The decomposed husk is commonly used in potting soil.

*Ornamental:* As well as being an evergreen nut-bearing tree, *M. integrifolia/ tetraphylla* has good symmetrical shape and when in full bloom is covered with creamy-white and pinkish flowers. These make it a popular ornamental tree.

*Intercropping:* Inter-row cropping can be practised with trees such as citrus or coffee or maize.

*Health aspect:* Macadamia fats helps lower cholesterol and Improves blood circulation they provide antioxidants that prevent arteriosclerosis

### **Challenges**

The development of macadamia nuts as commercial tree crops will be largely determined by local research to identify suitable cultivars for planting. Each different climatic situation will require different cultivars. Trials of selections from Hawaii and Australia in Kenya have not resulted in very suitable selections and researchers had to go to seedlings populations planted during 1969-1975 to select the few that are currently being propagated. All aspects of physiology, flowering and

pollination habits fruit development and maturation are greatly influenced by local environments in terms of weather and edaphic factors

Macadamia trees appear sensitive to nutrient deficiencies or imbalances the main constraints include lack of drought resistant, high yielding and early Maturing Varieties; along with the presence of powdery mildew disease, red ants and Anthracnose.

The species is also not easy to graft since the success rate of grafted seedlings is lower than that of Avocado or Mangoes. Farmers needs for planting materials, husbandry knowledge and crop management on the farm are not being met fully because Kenya Nut Company has very limited resources for these aspects. Pests and diseases: There are a number of economically important pests attacking flowers, fruits, foliage and twigs. Fungal diseases include Phytophthora cinamomi, husk spot, blossom blight and husk rot. Leaf miners may damage the leaves, resulting in reduced yields. Stench bugs may become evident during the dry season when they attack immature nuts, leading to premature drop of nuts. Rats are fond of macadamia nuts. Macadamia trunk canker is a fungal disease that may affect the tree trunk, which becomes distorted, and often with exuding gum. Affected plants look stunted, chlorotic and partially defoliated.

### **Way forward**

- a. The most effective grafting method need to be researched on, to increase the production of grafted or high quality seedlings
- b. Continued work needs to be done in cultivation practices and methods of propagation. These differences are reflected

in the dominance of *Macadamia tetraphylla* x *integrifolia* hybrid cultivars in Kenya.

- c. A research program is needed to ascertain optimum and the most economical cultivation practices.
- d. Studies should be undertaken to ascertain differences between harvesting methods in nut quality and efficiency.
- e. Structuring the production and marketing system may be necessary to accelerate industry growth.
- f. Formation of a growers/marketing association to structure the industry may be necessary to avoid theft, purchasing of nuts with high moisture content and harvesting of immature nuts.
- g. Collaboration between key GOK ministries and other stakeholders is necessary as a way forward for the industry
- h. Development of a wide genetic base at local level is necessary in order to create a wide range of selections of cultivars suitable in various parts of Kenya or any other East Africa country.

### **Further reading**

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## Passion Fruit (*Passiflora Edulis*) Farming



*Immature Green passion fruits still attached to the vines in a farm in Central Kenya*

### **Introduction**

Passion fruit is a climbing plant of the Passifloraceae family. It is the size of an egg and is yellow or purple. Purple passion fruit (*Passiflora edulis*) is subtropical, important in some countries, while the more tropical yellow passion fruit excels in others. Both yield delicious juice. The passion fruit vine is a shallow-rooted, woody, perennial, and climbing by means of tendrils. The alternate, evergreen leaves, deeply 3-lobed when mature, are finely toothed, 3 to 8 in (7.5-20 cm) long, deep-green and glossy above, paler and dull beneath, and the fruit is purple in color when mature. Commercial farming of purple passion fruit begun in Kenya in 1933 and was expanded in 1960, when the crop was also introduced into Uganda for

commercial production. In both countries, the large plantations were devastated several times by easily-spread diseases and pests. The purple passion fruit (*passiflora edulis*) is the most commonly grown passion for commercial purpose in Kenya. It is mainly grown for fresh and juice extraction.

Passion fruit grows in warm to cool climates within altitude ranging from 1200-2000m. above sea level and minimum rainfall of 900mm per annum. The most suitable soil is medium texture (loamy), which are deep and well drained, with PH ranging from 5.5-7.5.

### **Distribution**

**Native Range:** Australia, Argentina, Brazil, Kenya, South Africa, Paraguay, India, Java, Western Samoa

**Exotic Range:** Hawaii, Jamaica, Israel, Florida

In Kenya, it grows in high potential or cool areas of Central, Coast, Eastern, Western, Rift valley and Nyanza

### **Propagation**

**Pollination:** yellow passion fruit flowers are perfect but self-sterile. Yellow passion fruit is pollinated by Carpenter bees (*Xylocopa megaxylocopa frontalis* and *X. neoxylocopa*) or Honey bees (*Apis mellifera adansonii*).

In crossing the yellow and purple passion fruits, it is necessary to use the purple as the seed parent (root stock) because the flowers of the yellow are not receptive to the pollen of the purple. The yellow form has a more vigorous vine and generally larger fruit than the purple, but the pulp of the purple is less acid, richer in aroma and flavor, and has a higher proportion of juice-35-38%. The purple form has black seeds,

the yellow, brown seeds KARI in Kenya is already developed a highbred by grafting the yellow in to purple Varieties.

The following are some of the older cultivars and more recent cultivars grown in various countries: 'Australian Purple', or 'Nelly Kelly'—a purple selection of mild, sweet flavor, grown in Australia and Hawaii. 'Common Purple'—the form growing naturalized in Hawaii; thick-skinned, with small seed cavity, but of fine flavor and low acidity. 'Kapoho Selection'—a cross of 'Sevcik' and other yellow strains in Hawaii. A heavy bearer of large fruits but subject to brown rot; many fruits contain little or no pulp and the juice has the off-flavor of 'Sevcik' though not as pronounced.

'Pratt Hybrid'—apparently a natural cross between the 'Common Purple' and a yellow strain; subject to rot, but juice is of fine color and flavor, low in acid.

'Sevcik Selection'—a golden form of the yellow selected in Hawaii; a heavy bearer, but subject to brown rot and the juice have a peculiar woody flavor. 'University Round Selection'—Hawaiian crosses of 'Waimanalo' and 'Yee'—fruit smaller than 'Yee'; not as attractive but yields 10% more juice of very good flavor. 'University Selection No. B-74'—a Hawaiian hybrid between 'Pratt' and 'C-77', usually yellow, occasionally with red tinges; resembles 'Waimanalo'; has good juice yield and very good flavor. 'Waimanalo Selection'—consists of 4 strains: 'C-54', 'C-77', 'C-80', of similar size, shape, color and very good flavor, and 'C-39' as pollinator. 'Yee Selection'—yellow, round, very attractive, highly disease-resistant, but fruit has thick rind and low yield of juice which is of very good flavor. Commercial cultivars of the purple form in Brazil include 'Ouropretano', 'Muico', 'Peroba', and 'Pintado'; of the yellow form, 'Mirim' or 'Redondo', and 'Guassu' or

‘Grande’. In the Cauca Valley of Colombia, the best-performing yellow passion fruit is the ‘Hawaiiana’. Venezuelan growers favor the ‘Hawaiiana’, ‘Brasilera amarilla’, and the purple-fruited ‘Brasilera rosada’.

Passion fruit vines are usually grown from seeds. With the yellow form, seedling variation provides cross-pollination and helps overcome the problem of self-sterility. If planted soon after removal from the fruit, seeds will germinate in 2 to 3 weeks. Cleaned and stored seeds have a lower and slower rate of germination, thus it’s important to use fresh seeds. Sprouting may be hastened by allowing the pulp to ferment for a few days before separating the seeds, or by chipping the seeds or rubbing them with fine sandpaper. Seeds are planted 1.25 cm deep in beds, and seedlings may be transplanted when 25-30 cm high. Some growers prefer layers or cuttings of matured wood with 3 to 4 nodes. Cuttings should be well rooted and ready for setting out in 90 days. Rooting may be hastened by hormone treatment. Scions from healthy young vines are preferred to those from mature plants. The diameter of the selected scion should match that of the rootstock. Either a cleft graft, whip graft, or side-wedge graft may be made.

Field establishment: Grafted vines must be planted with the union well above ground, not covered by soil or mulch; otherwise the disease resistance will be lost. Mounding of the rows greatly facilitates fruit collection.

In plantations or Orchard establishment, the vines are set at various distances. In Kenya the spacing normally used is 2m x 3m or 3m x 3m to allow easy movement when collecting fruits. Dig holes of 45 cm x 45 cm. mix the topsoil with farm yard manure and 125g of Double Super Phosphate (46 % P<sub>2</sub>O<sub>5</sub>) if

available; fill the hole with this mixture at least 3 weeks before transplanting. Plant at the onset of rain.

**Staking and Trellising**-the common system of support is by use of plain wires strung on post referred to as trellises. Post for trellising should be about 3 m long and have a diameter of 15 cm. These posts should be put 60cm deep in the ground at a spacing of 6m apart in a row. A single strand of wire is tightly stretched over each row of posts and fixed firmly to the end posts.

**Training**-A light stick is driven into the ground close to the plant or a piece of sisal twine tied to the wire from the base of the young plant to the wire above. Two healthy shoots at the base of the plant are then selected and trained up to the stick or the sisal strands by twining them regularly. The laterals bearing the fruit should hang down once from the wire. Inter crop the fruit with vegetables such as beans, cabbage and tomatoes during the first year.

### **Production**

The purple fruit is fast growing as it bears fruits within 7-9 months after transplanting and has two peak harvesting seasons in Kenya-July to August and December to January; however the yellow begin to bear in 1 to 3 years. Ripening occurs 70 to 80 days after pollination.

### **Harvesting**

For fresh markets-ripe fruits should be picked when they turn Purple in case of purple passion and yellow color for yellow passion. Ripe fruits naturally fall to the ground and will roll in between mounded rows. They do not attract flies or ants but should be collected daily to avoid spoilage from soil



organisms. Harvest early in the morning when it is cool to prevent them from sunburn, sort and grade in the shade.

Harvest period is 2 to 3 times a week for 2 to 3 months. For juice processing, the fruit is allowed to attain a deep-purple colour. In India and Israel the fruits are always picked from the vine rather than being allowed to fall. It has been found that fallen fruits are lower in soluble solids, sugar content, acidity and ascorbic acid content. The fruits should be collected in cartons or boxes, not in bags which will cause “sweating”. If not sent immediately to processing plants, the fruits should be spread out on wire racks where there will be good air circulation.

**Yield**-many factors influence the yield of passion fruit vines. In general, yields of commercial plantations range from 9 tons to 15 tons per 1.0 ha.

**Shelf Life:** Fruits can be stored for 1-2 weeks at ambient temperature or for 4-5 weeks at 7°C. If stored below 4.4°C, the fruits get fungus attack while high temperature leads to mouldiness. If the fruits are waxed, they can be stored for 2-3 months at optimum temperatures.

### **Market Analysis**

Passion fruits are grown for both the export and domestic markets. It is a very popular fruit in the domestic market either used as fresh fruit or for processing into juices. The major challenge in passion fruit production is lack of clean planting materials free from *Fusarium wilt* which is rampant in the country. Kenya Agriculture Research Institute (KARI) has been researching and has established a screening lab to facilitate production of clean planting materials.

Other efforts have been through the PSDA/ GTZ who in collaboration with the Ministry of Agriculture, HCDA and KHDP especially in Rift valley province. Thika District HCDA is also assisting farmers groups in enhancing production of clean planting materials. The leading passion fruit processors include Kevian Ltd, Milly processors and FIPS Ltd, Ruaraka. Extensive juice extraction is carried out at household and cottage industries.

The adopted values are 12.5 tons/ha as national yield and Kenya shillings 30.00/kg as national price notwithstanding higher yields have been reported in the Rift valley.

**Passion Fruits Production and value for 2005-2007**

	Hectare (Ha)		Production (MT)		Value (Kshs'000')				
	2005	2006	2005	2006	2005	2006	2007		
Province	2005	2006	2007	2005	2006	2007	2005	2006	2007
Eastern	550	1,098	1,311	7,425	14,823	16,388	222,750	444,690	491,625
Central	1,018	967	967	13,743	13,054	13,054	412,290	391,635	391,635
Western	218	211	235	2,725	2,638	2,938	81,750	79,125	88,125
Rift									
Valley	988	1,027	1,180	13,338	13,864	14,750	400,140	415,935	442,500
Nyanza	1,109	1,054	1,054	13,863	13,175	13,175	415,875	395,250	395,250
Coast	61	63	80	763	788	1,000	22,875	23,625	30,000
<b>Total</b>	<b>3,944</b>	<b>4,420</b>	<b>4,827</b>	<b>51,857</b>	<b>58,342</b>	<b>61,305</b>	<b>1,555,680</b>	<b>1,750,260</b>	<b>1,839,135</b>

HCDA, 2008.

## **Nutritional Value**

*Nutritional composition per 100 g of raw edible Portion  
(Purple passion fruit, pulp)*

Energy	408kj
Protein	2.20 grams
Carbohydrates	13.0 grams
Fibre	10.4 grams
Vitamin A	70.0µg
Vitamin B <sub>2</sub>	0.130 milligrams
Niacin	1.50 milligrams
Vitamin B <sub>6</sub>	0.100 milligrams
Vitamin C	30.0 milligrams
Vitamin E	1.12 milligrams
Calcium	12.0 milligrams
Phosphorous	68.0 milligrams
Magnesium	29.00 milligrams
Iron	1.60 milligrams
Potassium	348 milligrams
Zinc	0.100 milligrams
Total Fat	0.700 grams
Saturated fat	0.059grams
Sodium	28.00 milligrams

Note: Yellow passion fruit has somewhat less ascorbic acid than the purple but is richer in total acid (mainly citric) and in carotene content.

## **Economic Importance:**

Commercial processing of the passion fruit may yields 36% juice, 51% rinds, and 11% seeds. Passion fruit is used as food, which has high content of iron and vitamin C

Health Aspect: Passion reduces Iron deficiency anemia since it has high content of iron and vitamin C.

Constipation- the pulp and juice act as a mild laxative and protects the stomach lining.

Nervousness & Anxiety-passion fruit juice is appropriate for those wishing to relax the nervous system. In Madeira, the juice of passion fruits is given as a digestive stimulant and treatment for gastric cancer.

**Seeds:** The seeds yield 23% oil which is similar to sunflower and soybean oil and accordingly has edible as well as industrial uses. The juice but mainly the leaves of passion fruit contain the alkaloids, including Harman, which has blood pressure lowering, sedative and antispasmodic action. The passion fruit leaves are used in many countries as medicines.

The flower of passion fruit has a mild sedative and can help to induce sleep. Passion flower has been used in the treatment of nervous and easily excited children, bronchial asthma, insomnia, nervous gastrointestinal disorders and menopausal problems. Passion flower is sometimes used as a mild hallucinogen.

Anti-cancer effect: Researchers at the University of Florida have found that yellow [passion fruit extracts](#) can kill cancer cells in vitro. The phytochemicals which are responsible for this [anti-cancer](#) effect are carotenoids and polyphenols.

Reduction of asthma symptoms: A study by Watson and his co-workers showed that the consumption of purple passion fruit peel extract can reduce [asthma](#) symptoms. They selected 42

patients received an oral administration of purple passion fruit extract. The passion fruit extract supplementation reduced the wheezing by 75 percent and increased forced vital capacity

### **Services**

Passion can be used as hedge and also for soil improvement

### **Challenges**

- a. Limited clean planting materials
- b. Producers have limited knowledge in adding value to the fruit products.
- c. Poor pollination can be due to bees not working on the flowers, temperatures being too low or too high for pollination or rain directly reducing the viability of the pollen.
- d. Many pests and diseases affecting passion fruit-**Coried Bugs, Green stinkbug, The Kenya Mealybug, Brown Spot Disease, Fusarium wilt Disease: Phytophthora Root Crown rots, Woodiness virus.**

### **Way forward**

Improve propagation methods and avail more clean planting materials

Linking the markets with producers and training producers on value adding.

Use effective pesticides to control pests and diseases- Atom 2 SEC. Asstaf 755p. Agrinate 90sp or carbaryl to the plant base and stems where pests suck plant sap or apply chemicals such

as Cyclone 50SEC, Sulban 48EC, Ogor 40EC or Oshothion 50EC In root infestations, drenching with dimethoate (Ogor 40 EC) OR Tata MIDA 200SL

Use of fungicides like Oshothane 80WP, Manco Fio 455sc, Tata MASTER 72WP, Cotal SE and Sulcop 50DF.

Plant or use of a resistant variety (yellow passion fruit-*passiflorae edulis f. flavicarpa*) as rootstock for purple passion fruit. The graft union should be at least 60cm above soil line. Use drip irrigation to avoid movement of fungus from infected to clean areas. Pesticides; Bio-Cure B; Benovap 50WP

### **Further reading**

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Patrick M. Maundu, Grace W. Ngugi & Christine H.S. Kabuye. 1999. Traditional Food Plants of Kenya. NMK

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## Growing Tamarind (*Tamarindus indica*) in Kenya



*Mature pods of tamarind-Trade winds fruit*

### **Introduction**

Tamarind grows from altitudes of 0-2000m., mean annual temperature of 20-23 deg. C and in areas with 250-4000mm mean annual rainfall. It can also grow to a height of up to 30m. It grows in most soils, but prefers well-drained deep alluvial soil. Tamarind (*Tamarindus indica* L.), is a multipurpose tropical fruit tree used primarily for its fruits, which are eaten



fresh or processed for non-food uses, The species has a wide geographical distribution in the subtropics and semi-arid tropics and is cultivated in numerous regions.

Tamarind belongs to the dicotyledonous family leguminosae which is the third largest family of flowering plants with a total of 727 genera recognized. The number of species is estimated at 19,327.

The main objective of this booklet is to provide simple information in a readily available form to extension agents, NGOs, Students, nutritionist, farmers growing tamarind and policy makers on different aspects of tamarind and to highlight its importance as a fruit tree.

The opinions in this booklet are those experienced by the first author during her work with Tamarind in Western, Eastern, Rift valley and costal areas of Kenya and literature review

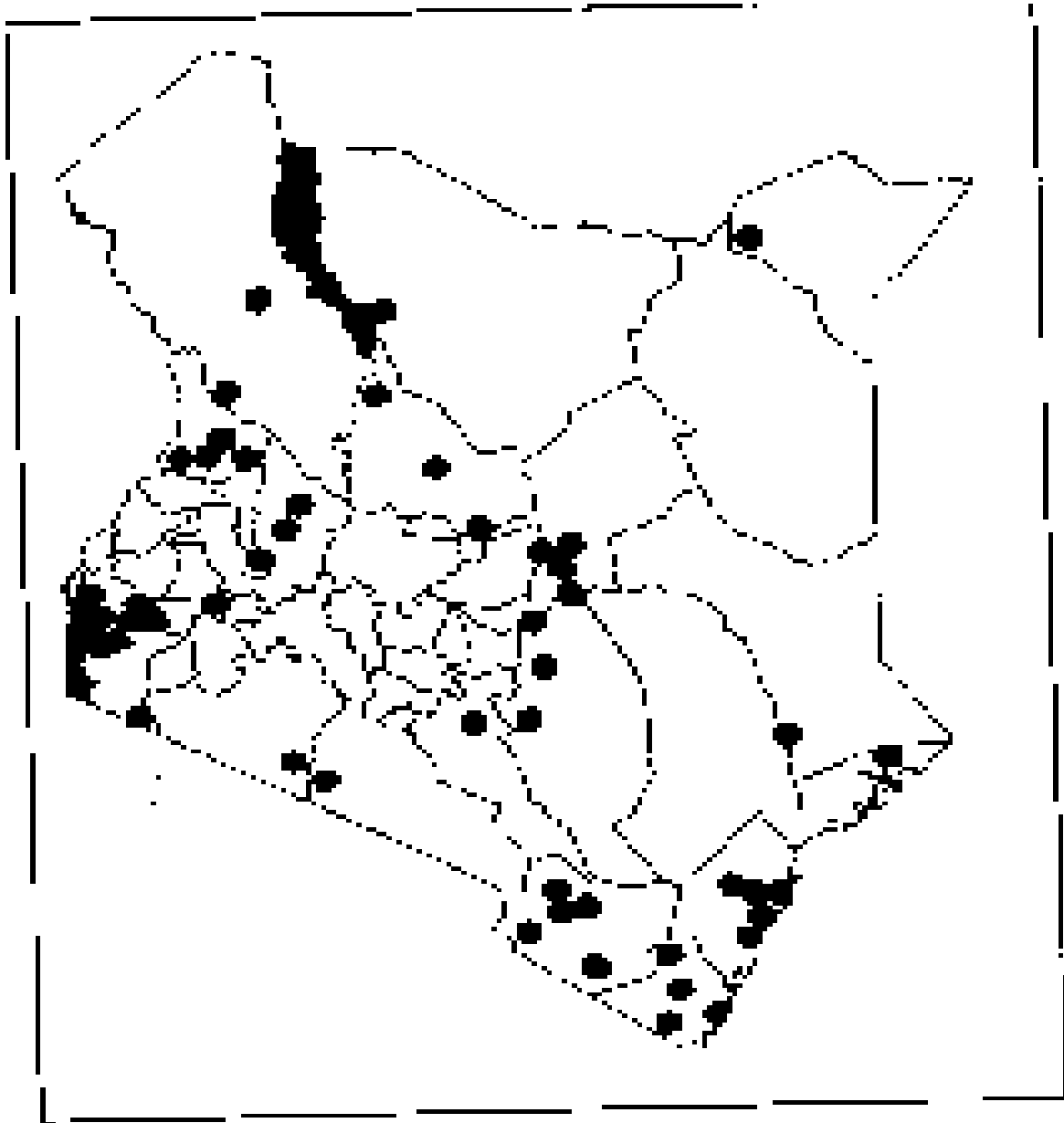
## **Distribution**

Native Range: Burkina Faso, Central African Republic, Chad, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Kenya, Madagascar, Mali, Mozambique, Niger, Nigeria, Senegal, Sudan, Tanzania, Uganda, Zimbabwe

Exotic Range: Afghanistan, Australia, Bangladesh, Brazil, Brunei, Cambodia, China, Colombia, Cote d'Ivoire, Cuba, Dominican Republic, Egypt, Ghana, Guatemala, Haiti, Honduras, India, Indonesia, Iran, Jamaica, Laos, Liberia, Malaysia, Mauritania, Mexico, Myanmar, Nepal, Nicaragua, Pakistan, Panama, Papua New Guinea, Philippines, Puerto Rico, Sri Lanka, Thailand, Togo, United States of America, Vietnam, Zambia

In Kenya, tamarind is found in Coast, Southern, Northern,

Eastern and Nyanza provinces. Specific planting areas are Gede, Kitui, Kibwezi, Kwale, Tot, Sigor, Turkana, Migori, Mbeere, Tharaka, Taita-Taveta, Samburu, Siaya and Mwingi



*Tamarind distribution in Kenya*

## **Propagation**

Tamarind may be propagated by using seeds or by grafting (cleft/whip grafting), shield and patch budding, stem cuttings, air-layering or marcotting (a branch is selected and a 2.5 cm length of the bark is removed. This area is covered with a moist soil mixture or a moist porous material, such as coir fibre dust and kept in position by wrapping with polyethylene film. It is kept moist for 2-3 months. When large quantities of roots are observed through the polyethylene film, the branch with its roots is severed from the parent tree and potted up for later planting). In case one intends to use seeds for propagation then it's important to note that seed pretreatment is required to speed up germination. This Pretreatment involves pouring hot water over the seeds and soaking them for 24 hours in the cooling water or nicking the seed; germination is epigeous, after 40-50 days one may get up to 90% seed germination. Germination is best when seeds are covered by 1.5 cm loose, sandy loam or by a mixture of loam and sand. Seedlings should attain at least 80 cm before being transplanted to their final location (field) at the beginning of the rainy season.

Tamarind Genetic improvement: Genetic improvement through use of superior clones is one of the improvement options (Kulkarni et al. 1993). Provenance trials need to be conducted in many parts of the tropics to select the best germplasm for further improvement. More trait specific research and combining desirable characters together are needed to develop cultivars. The selection of elite trees is an important step. Trees should be selected using the following characterises: acidity of the pulp, content of tartaric, acid and composition), superior appearance and tolerance or resistance to the major pests and diseases. The genetic improvement step to be undertaken are straightforward based on the available material. This are: faster

growth and higher yielding lines for selection for different uses. Since normal crossing is not an option, more trait specific work is needed so that provenance trials can lead to selections which combine desirable characters, and cultivars developed from them. These should be developed with reference to land-use systems of agro forestry, orchards/plantations. Specific sweet and sour cultivars exist in Eastern, coast, Western and Northern parts of Kenya

### **Production**

When establishing a pure plantation, the final spacing should be at least 13 x 13 m to allow inter-cropping. Distance can be reduced when using vegetative propagated plants (spacing of 8-10m), as they do not attain the same size as seeded trees. This allows some further selection in the field where by thinning is carried out two or three times. Propagation by Grafting is important since the smaller trees produced are easier to harvest.

From Tharaka, Mwingi, Kitui to Taita-Taveta, flowering can be observed from December to February while the fruits mature from July –October. Around Gede, Kwale, Kibwezi, Tot, Turkana, Samburu, Sogor, flowering occurs between April and June, followed by fruit maturity period from September to February.

A grafted tree bears fruit from the fourth year. The pod yield at this time is 40 kg/tree but when it reaches 10 years, it can yield 100kg/tree. The tree may remain productive until it reaches old age, yielding up to 150 kg/tree or over 2 tones /ha a year.

**Processing and Storage of Pulp:** In Kenya extraction of pulp from the pods is carried out by, removing the cracking dry ripe pods and separating the pulp and fibres from the broken shells.

The pulp is then processed by peeling and removing the fibre strands from the pulp using hands, some times this is sold as grade 3, fetching less money per kg. After separating the pulp from the fibres, the seeds and shells, the pulp is then compressed and packed in plastic bags for storage and marketing as grade 2.

The most marketable pulp is grade 2 (which goes further processing by removing seeds in it-seedless)

### **Market Analysis**

The fruit pulp, mixed with a little salt, is a favourite ingredient of the curries and chutneys popular throughout India, though most of the tamarind imported into Europe today comes from the West Indies, where sugar is added as a preservative. Fruit is marketed worldwide in sauces, syrups and processed foods.

In Kenya, much of the tamarind trade is local; however some tamarind is exported to Yemen, Zanzibar, Saudi Arabia and Somalia. The exported fruit pulp has to be taken to Mombassa or coast. The farmers or traders contact the exporters and partners at the coast by telephone. Markets are used as collection points. Most of the market outlets in Kenya are- Kitui, Tharaka, Mwingi, Kibwezi, Coastal towns, Siaya, Lodwar, West Pokot, Baringo, Lodwar, Mariment, Mwingi, etc Grade 2 (seedless) tamarind appears to be preferred domestically and internationally to Grade 3 (seeded) tamarind, thus farmers are able to obtain more money for grade 2 tamarind than for grade 3.

### **Nutritional value**

The fruit pulp contains high level of vitamin C (44mg/100g), carbohydrates (41.1-61.4 g/100g), protein (2-3g/100g), calcium (43.94mg/100g), phosphorus (34.78/100g), fibre (0.6g/100g) and little iron, vitamin B2. The seed is also rich in protein, fibre, carbohydrate and calcium. The fruit is eaten raw or used to make juice (the pulp is put in warm water and pressed to get juice), jam, syrup, candy, tamarind balls (made by mixing ripe pulp, sugar and sweet potatoes) , curries, salads, seasoning boiled rice, fish and meat and also in preparing tamarind sauce.

*Nutritional composition per 100g of raw edible tamarind pulp portion*

protein	2.3grams
Fat	0.6g grams
Carbohydrates	41-61.4 grams
Fibre	0.6-2.9 g/100g
Calcium	34-94 milligrams
Phosphorus	34-78 milligrams
Iron	0.2-0.9 milligrams
Vitamin C	44 milligrams
Niacin	1.0 milligrams
Vitamin B2	0.43 milligrams

**Economic Importance:**

*Food:* The ripe fruit of the sweet type is usually eaten fresh, whereas the fruits of sour types are made into juice, jam, syrup and candy. The flowers, leaves and seeds can be eaten and are prepared in a variety of dishes. Tamarind seeds are also edible after soaking in water and boiling to remove the seed coat. Flour from the seed may be made into cake and bread. Roasted seeds are claimed to be superior to groundnuts in flavour.

*Fodder:* The foliage has a high forage value, though rarely lopped for this purpose because it affects fruit yields. In the southern states of India cooked seeds of Tamarind tree are fed to draught animals regularly.

*Apiculture:* Flowers are reportedly a good source for honey production. The second grade honey is dark-coloured.

*Fuel:* Provides good firewood with calorific value of 4 850 kcal/kg, it also produces an excellent charcoal.

*Timber:* Sapwood is light yellow, heartwood is dark purplish brown; very hard, durable and strong (specific gravity 0.8-0.9g/cubic m), and takes a fine polish. It is used for general carpentry, sugar mills, wheels, hubs, wooden utensils, agricultural tools, mortars, boat planks, toys, panels and furniture. In North America, tamarind wood has been traded under the name of 'madeira mahogany'.

*Lipids:* coloured seed oil - which resembles linseed oil - is suitable for making paints and varnishes or for burning in lamps.

*Tannin or dyestuff:* Both leaves and bark are rich in tannin. The bark tannins can be used in ink or for fixing dyes. Leaves yield a red dye, which is used to give a yellow tint to clothe previously dyed with indigo. Ashes from the wood are used in removing hair from animal hides.

*Medicinal:* Boiled or pounded leaves then made to a solution is drunk or applied to the body for treatment of measles or chickenpox (kamba people) Infusion made from dried pounded leaves is taken for stomach-ache (in Siaya) Leaf extract is applied to inflamed eyes (Giriama people) in Kenya

### **Services**

*Shade or shelter:* The extended crown of the tamarind offers shade so that it is used as a ‘rest and consultation tree’ in villages. Because of its resistance to storms it can also be used as a windbreak. It should be considered, however, that *T. indica* is not very compatible with other plants because of its dense shade, broad spreading crown and allelopathic effects. It is thus more commonly used for firebreaks, as no grass will grow under the trees.

*Boundary or barrier or support:* *T. indica* could be inserted into a live fence.

*Ornamental:* The evergreen habit and the beautiful flowers make it suitable for ornamental planting in parks, along roads and riverbanks.

In Africa, tamarind is a host of one of the wild silkworms (*Hypsoides vuillitii*).



## **Challenges**

Lack of information on the basic biology (information on flowering fruiting phenology, pollination mode, breeding system, fertilization, seed dispersal mechanisms and regeneration potential etc) of the species

Pest attack is very serious in seeds

Processing technology at producer level is lacking and heavy losses are reported.

Destruction of the pulp by insects and fungi during storage is a big problem

Slow growth and low quality of indigenous fruit species compared with exotic fruits, which are already improved.

Planting material-seedlings of indigenous fruit trees often unavailable in local tree nurseries.

Poor marketing outlets and low pricing of products

## **Way forward**

- a. Research use of hormones to enhance fruit set and fruit production throughout the year, particularly in the case of sweet tamarind varieties, should be given priority
- b. Simple improved methods for processing, storage and value addition should be developed.
- c. Development of a more efficient method of removing seeds from tamarind pulp.
- d. Local market surveys should be carried out to identify potential markets for various products of tamarind.

- e. Studies of domestic and international trade should be carried out to popularize tamarind as a crop species among the farmers
- f. Research on identification of suitable rhizobia should be carried out to enhance faster growth in tamarind tree species

### **Further reading**

Gunasena, H. P. M. and Hughes, A. (2000) Tamarind. International Center for Underutilised Crops, Southampton, UK

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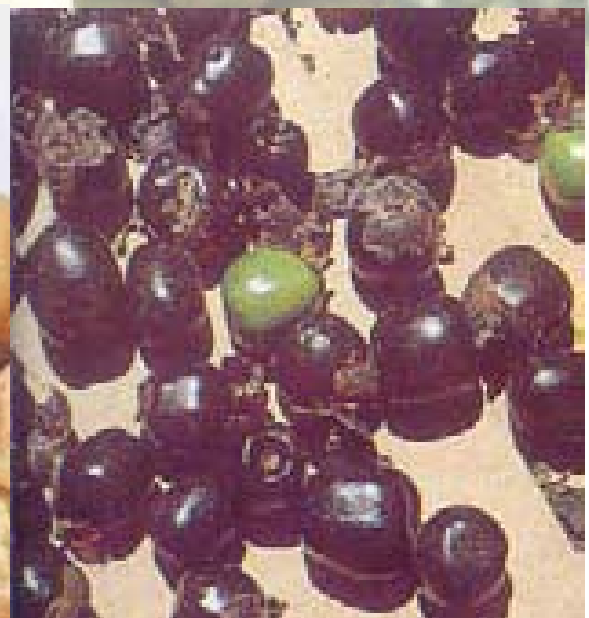
J. Albrecht (ed.) 1993. Tree Seed Handbook of Kenya, GTZ Forestry Centre Muguga

The World Agroforestry Centre publishes a range of other resources that may be useful to the readers of this guide. These include the following:

The **Tree Seed Suppliers Directory** is an online database that provides information on the different suppliers of tree planting material. The database lists several thousand tree species, including fruits and nuts, and indicates where germplasm of these trees can be obtained. It also provides information on the quality of different germplasm sources. The Directory allows users to make more informed choices about the trees that they plant, and is available at ICRAF's website ([www.worldagroforestry.org](http://www.worldagroforestry.org)).

An ICRAF training manual, titled **Vegetative Tree Propagation in Agroforestry**, explains the different methods by which fruit other trees may be propagated. It is also available through ICRAF's website.

**Avocado growing in Kenya (2005)**, **Mango Growing in Kenya (2003)**, **Fruits and nuts species with potential for Tanzania (2005)** and **Growing temperate fruit trees in Kenya (2007)** are some of the publications available from ICRAF that provide information on the production of other fruit species and indicate suitable varieties for cultivation.'



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