Conservation and Sustainable Use of Genetic Resources
of Priority Food Tree Species in sub-Saharan Africa

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Irvingia gabonensis / I. wombolu

Bush mango

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Flour from bush mango kernels in a Beninese market

Common name	Scientific name	Synonyms	Family
Sweet bush mango, bitter bush mango, wild mango (English) Mangue sauvage, pommier sauvage (French)	*Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke) Baill *Irvingia wombolu* Vermoesen	***I. gabonensis***: *Mangifera gabonensis* (Aubry-Lecomte ex O'Rorke) var. *gabonensis* Okafor; *Mangifera gabonensis*; *I. barteri* Hook; *I. caerula*; *I. duparquetii*; *I. erecta*; *I. griffoni*; *I. hookeriana*; *I. tenuifolia*; *I. velutina*; *I. gabonensis* var. *gabonensis* ***I. wombolu***: *Irvingia gabonensis* var. *excelsa*; *Irvingia gabonensis* var. *wombolu*	Irvingiaceae

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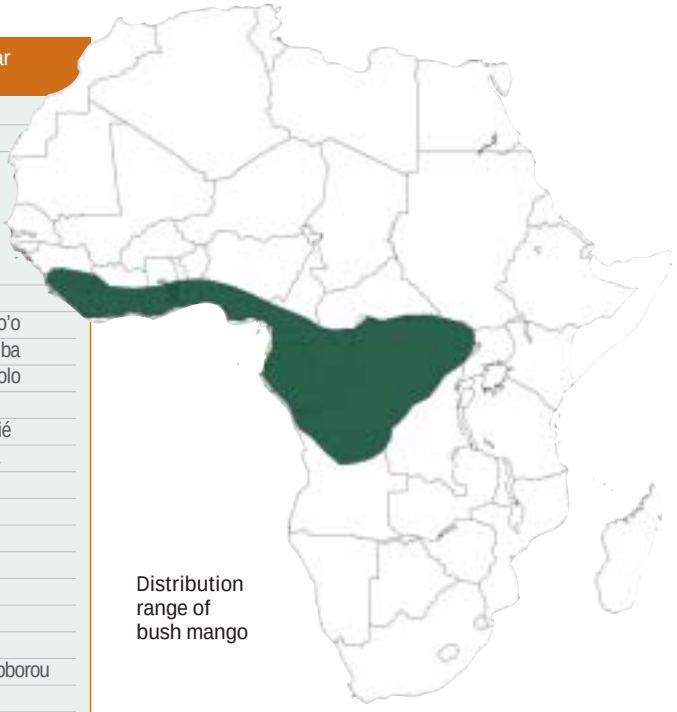
This leaflet highlights the nutritional and socio-economic potential of bush mango and provides information to assist those working with the species. The focus is on conserving genetic diversity and promoting sustainable use of bush mango. The leaflet presents a synthesis of current knowledge about the species. The recommendations provided should be regarded as a starting point, to be further developed according to local or regional conditions. These guidelines will be updated as new information becomes available.

Socio-cultural group	Country	Vernacular name
Adja	Benin	Atoo
Goun	Benin	Asiotin
Yoruba, Nagot	Benin	Anpom, igi oro, oro wewe, oro oyibo, oro nbèdjè
Ewondo	Cameroon	Andok
Boulou	Cameroon	Endoé, ando'o
Bassa	Cameroon	Ndoka, mwiba
Bagangte	Cameroon	Bush mangolo
Bibaya Pygmies	Cameroon	Pékié
Maka	Cameroon	Nouak, pékié
Douala	Cameroon	Miba, njaka
Bayang	Cameroon	Besay
Ombaba	Congo	Ondimba
Pounou, Tsaaya	Congo	Muiba
Pounou, Tsangui	Congo	Muiba
Téké, Tsaaya	Congo	Muwiki
Ombamba	Congo	Ondimba
Yaka	Congo	Muyii
Abé	Côte d'Ivoire	Boborou, poborou
Attié	Côte d'Ivoire	Bé
Fang	Gabon	Andok
Mpongwe	Gabon	Oba
Nzebi	Gabon	Mudjiku
Bojep	Nigeria	Boki
Igala	Nigeria	Egili
Etsako	Nigeria	Oghi
Yoruba	Nigeria	Oro, oroapon
Igbo	Nigeria	Ororgbije, ugiri, upupo, obono



Distribution range of bush mango

Geographical distribution

Sweet bush mango (*I. gabonensis*), so called because of its sweet fruit pulp, and bitter bush mango (*I. wombolu*), which has bitter-tasting fruit, are found throughout their natural range in the humid forest zone of West and Central Africa, including in Angola, Cameroon, the Central African Republic, Congo, Côte d'Ivoire, the Democratic Republic of Congo, Equatorial Guinea, Gabon, Ghana, Guinea-Bissau, Liberia, Nigeria, Senegal and Sierra Leone. Bitter bush mango is also found in southern Sudan and Uganda. Bush mango has been introduced to Sao Tome and Principe and it is unclear whether populations in southern Benin are native or introduced.

Importance and use

Bush mango is both cultivated and harvested from the wild. The tree has a wide range of uses. The most important product of both species is processed seed cake, which is widely used in soups and stews. The nut is cracked open to release the kernel. The kernels—fresh, sun-dried

Uses	Part of plant
Food	Fruit pulp, kernels, kernel oil, kernel paste, defatted kernel paste
Fodder	Fruit, kernels, kernel paste
Fuel wood or wood production	Branches, stem, wood
Medicines	Bark, fruit, leaf, kernel
Recreation and soil protection	Whole tree
Ship' decks, paving block, panting	Wood

or smoke-dried depending on the end product—can then be ground and crushed to make paste (fresh kernels) or cake (dry kernels) both used to add consistency to soups and stews. Bush mango is also fed to cattle.

Kernel oil is used in cooking while the defatted paste is added to soups as a condiment to produce a desirable sticky consistency. It constitutes an alternative condiment to okra (*Hibiscus esculentus*), groundnut (*Arachis hypogea*) and egusi seeds (*Cucurbita* sp.), all three widely used in traditional cuisine in West and Central Africa.

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Bush mango kernels sold in a market

Sweet bush mango fruit pulp is consumed fresh and the juice can be used to make jam, jellies and wine. In Nigeria, a wine made from the fruit's pulp juice had attributes comparable to those of a German reference wine.

Bush mango fruit pulp is a major source of vitamin C and beta-carotene. Fresh bark can be used to confer a bitter taste to palm wine if pieces are kept in the wine containers during tapping.

Medicinal uses of bush mango continue to grow in the subregion. Leaf, seed and bark extracts are used to treat a variety of illnesses and to relieve pain.

Bush mango trees produce very hard dense wood used locally for specialty construction such as ships' decks, planks and paving blocks.

Socio-economic value

Bush mango trees provide a valuable source of income for farmers and traders in Cameroon. The fruit is traded locally. The kernels, which fetch a higher price than the fruit, are traded regionally and internationally, mainly within West Africa. Small quantities of kernels are also shipped to consumers of West and Central African origin in Western Europe. Distribution is limited generally to African food markets. The development of an international market for bush mango will depend on growing demand from Africans in the diaspora and from Europeans and North Americans who consume ethnic foods.

Expanding the trade in bush mango kernels would benefit both producers and traders and could lead to conservation through the domestication and sustainable use of the two species. However, seed extraction is time-consuming and post-harvest losses are high, and this limits the potential to increase financial returns.

Ecology and biology

Both bush mango species occur at altitudes between 200-500 m, with mean annual temperature of 25-32ºC. Sweet bush mango grows best in a dense moist forest on well-drained acidic soils, with mean annual rainfall of 1500–3000 mm. Bitter bush mango can tolerate a wider range of soils, growing in swamps and seasonally flooded forest as well as dry land forest, where annual rainfall is 1500-2500 mm. Sweet bush mango can reach 40 m in height under good conditions while bitter bush mango can reach 25 m in height.

Reproductive biology

Bush mango flowers are hermaphroditic, meaning that each flower is both male and female. They are pollinated by beetles, flies, wasps, bees and one known moth species.

Seeds are known to be dispersed by humans,

Fruit, pulp and kernels of sweet bush mango

elephants and monkeys. Bitter bush mango seed is recalcitrant

Phenology

The two bush mango species have different flowering and fruiting phenology. Depending on the location, sweet bush mango flowers in February to June and there are two fruiting seasons, from April to July and Sepember to October. Bitter bush mango flowers in October and November and fruit develops from February to April.

Related species

Irvingia gabonensis and *I. wombolu* were once considered varieties of the same species. However, DNA analyses indicate that the two are genetically distinct. The genus *Irvingia* is made up of seven species, of which six occur in tropical Africa and one in South-East Asia.

Morphological traits and their variation

The two species are very similar in their morphological traits, except that sweet bush mango is taller and has a more elongated crown than bitter bush mango. The crown is dense and compact. The bark is grey and smooth or very slightly scaly. Leaves are green, simple and elliptic. They are placed alternately along the twigs. Petiole length is 5-10 cm.

Flowers are yellowish to greenish-white, and grow in slender, clustered racemes or small panicles above the leaves. Individual flower stalks are slender, about 6 mm long and petals bend right back. Fruit is yellow when ripe, broadly ellipsoid and varies in size from 5 to 20 cm long, and 4 to 11 cm wide. Fruit consists of yellow, fibrous pulp surrounding a large seed.

Variation has been noted in flowering and fruiting phenology, crown shape, flower colour, fruit production, precocity, fruit characteristics (shape, quality, colour, size, pulp colour, sweetness, fibrousnesses) and seed hardness. Many of these traits are important to farmers. Depending on the degree to which the variation in these traits is inherited, there may be opportunities for substantial improvement in a breeding and domestication programme.

Genetic knowledge

The two bush mango species have been subjects of several genetic studies but information useful for assessing the genetic status of the species and developing genetic conservation guidelines is limited. Knowledge of amount and pattern of diversity at the DNA level and quantitative trait variation are both important for informed genetic management. Two studies have been conducted in the western part of the species' ranges using DNA markers and a common garden experiment was established in 1995 using seed from individual trees and planted in Nigeria and Cameroon. The two sites are intended to fulfil the functions of genebank and progeny test.

Irvingia species found in tropical Africa

Species	Description and distribution
I. gabonensis	Medium-sized evergreen tree up to 40 m tall found across West and Central Africa. Fruit pulp is edible.
I. wombolu	Medium-sized evergreen tree up to 25 m tall found across West and Central Africa. Fruit pulp is inedible.
I. excelsa	Large tree found in Central Africa. Fruit pulp is inedible, seed is edible,
I. grandiflora	Large forest tree with edible seeds found in West and Central Africa.
I. robur	Large tree found from Sierra Leone to DR Congo. Fruiting occurs all year round.
I. smithii	Deciduous tree up to 28 m tall found in West and Central Africa. Fruit pulp and kernels are edible.

Questions have been raised about the potential for hybridization between the two species and the possibility of negative consequences of planting one species near natural populations of the other. However, the DNA analyses showed no evidence of hybridization between the two bush mango species, even where they are found in close proximity. For both species there is a trend for genetic isolation with distance, meaning that genetic differentiation between trees increases with geographic distance between them. There is very little evidence of inbreeding in either species.

On the basis of genetic evaluation of part of the species range, southern Nigeria and southern Cameroon were found to be centres of diversity for both species. Central Gabon is thought to be an additional centre of diversity for sweet bush mango. Genetic diversity of sweet bush mango is greater in Cameroon than in Nigeria and Gabon.

A study of 100 *I. gabonensis* trees from south-eastern Nigeria reported significant tree-to-tree variation in fruit mass, flesh mass, nut mass, shell mass, kernel mass, fruit length and width, and flesh depth.

An assessment of genetic diversity and relationships among 15 accessions of *I. gabonensis* from Cameroon, Gabon and Nigeria using amplified fragment length polymorphism (AFLP) indicated greater genetic diversity among accessions from Cameroon than among those from Gabon and Nigeria. These molecular studies are critical to the preservation of the genetic diversity in *Irvingia* spp. in the subregion.

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Differences in tree shape

Local practices

People usually select the trees to be left in farmers' fields based on the fruiting seasons (early, regular or late season fruiting trees). Other local selection criteria include fruit size, fruit taste and sliminess of the kernel paste. Sweet bush mango is selected for both the sweetness of their fruit pulp and the sliminess of its kernels, while bitter bush mango is selected for the sliminess of its their kernels alone. Kernel quality outweighs the taste of the fruit pulp in selecting sweet bush mango.

Different regions have different traditional rules of ownership and harvesting. For example, women in the humid lowlands of Cameroon have the right to plant bush mango trees even though the planted tree then belongs to the head of the household, in most cases a man.

In Benin, all family members harvest bush mango products. Men are particularly involved in collecting the bark for use as medicine and wood for construction. Women and girls collect fruits, extract the kernels and market them. Boys collect fruits for immediate consumption and sometimes sell them in the local markets. All family members are beneficiaries of the revenues from the sales of bush mango products.

In Nigeria, children and women harvest bush mango products in compound farms near their villages. Men collect bush mango deep into the forest, extracting the seed on site to reduce the load they have to transport to their villages. Processing fruits collected in compounds farms is carried out by women and children.

Threats

Bush mango populations are threatened in some areas by deforestation, especially in Nigeria where genetic variability is also high, and by pressures to convert land to monocrop mechanised culture. Sweet bush mango may also be threatened by climate change, especially reduced rainfall.

Sweet bush mango is listed as lower risk/near threatened in the 2008 IUCN Red List. Farmers usually protect bush mango trees when they clear the forest for slash-and-burn agriculture.

In some cases, forest legislation hinders conservation and sustainable use. For example, the government of Cameroon controls forest land throughout the country. This situation does not encourage rural communities to participate in tree management, agroforestry and regeneration programmes, and often results to conflicting rules in place for local communities.

Conservation status

Bush mango seeds are recalcitrant or intermediate, which means that they cannot be stored for more than a few weeks under conventional storage conditions. Thus, *ex situ* conservation in seed banks is not possible. Field genebanks are currently maintained in Mbalmayo (southern Cameroon), Onne (south-western Nigeria) and central Gabon with trees grown from seed collected from Cameroon, Gabon, Ghana and Nigeria.

It is not known whether bush mango occurs within any protected natural area such as a national park.

Management and improvement

The World Agroforestry Centre (ICRAF) has been promoting the domestication of bush mango for more than 15 years. It is considered to be cultivated in Cameroon and Nigeria and semi-domesticated in Benin. In Nigeria, as of 2000, less than 10 percent of the total annual fruit and kernel crop was harvested from planted trees. However, this percentage is increasing slowly in Nigeria as trees continue to be planted. Few trees have been planted in other countries.

Farmers in Cameroon manage their trees, applying fertilizer and pruning them.


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A young bush mango seedling

Propagation from seed

Planting depulped bush mango fruit in a 1:1 mixture of sawdust and forest top soil can give good levels of seed germination and can allow mass production of uniform seedlings.

Vegetative propagation

Vegetative propagation should be recommended to farmers because it is quicker than propagation from seed and results in earlier fruit production.

The simplest and quickest approach is to use rooted cuttings, but success rates are highest using young stems, i.e. from trees that are yet to set fruit and are thus unknown in terms of their fruit production. Grafting and air layering give the best results but are time-consuming, and failure rates for air layering are high (about 60 %). Micropropagation studies are underway at several centres.

Guidelines for conservation and use

Conservation relies on field genebanks, *in situ* conservation or conservation through sustainable use.

Seed should be collected from populations under particular threat and additional field genebanks established.

Conservation through sustainable use, including domestication, may be the best option in Nigeria where the rate of deforestation puts *in situ* conservation areas at risk. Areas of southern Nigeria are probably the most threatened and have high genetic diversity, so they should be given the highest priority for conservation efforts. Farmers in Nigeria already plant the two species to a limited extent, and they should be encouraged to plant more, for example on field borders or for shade in coffee and cocoa plantations.

In other areas, where the forest is less disturbed, populations should be identified for *in situ* protection. Quantitative trait analyses should be carried out to inform the location of the sites.

Research needs

- Determine the number of viable populations in protected natural areas such as national parks
- Identify seed handling methods to enhance potential for ex situ conservation
- Expand genetic diversity studies to full range of each species
- Determine genetic variation in drought tolerance and location of important sources of variability
- Determine genetic variation in tree growth and fruit production
- Identify pollinator species, investigate effective pollen flow and determine threats to pollinator species
- Investigate effectiveness of seed dispersal and degree of dependence on fauna that are rare or threatened
- Determine effective population sizes in semi-natural farmland populations and minimum viable populations for conservation and long-term sustainable use. ■

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This leaflet was produced by members of the SAFORGEN Food Tree Species Working Group. The objective of the working group is to encourage collaboration among experts and researchers in order to promote sustainable use and conservation of the valuable food tree species of sub-Saharan Africa.

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