Bush Mango (*Irvingia gabonensis*): New Potential Multipurpose Fruit Tree for India

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Bush mango (*Irvingia gabonensis*) is an African tree with edible yellow fruit resembling mangoes valued for its oil rich seed, fresh fruit, fuel, fibre, medicine, and hardy green termite resistant wood. Grows wildly in forest of tropical Africa. It offers considerable scope for enhancing the nutritional and economic security of subsistence farmers in India. In India, a large area is ideally suited to this tropical and subtropical fruit. In view of this, introduction of such plants from their centre of origin is necessary for enhancing the existing plant wealth. National Bureau of Plant Genetic Resources (NBPGR) New Delhi is nodal organization engaged in the various activities related to exchange of plant genetic resources in the country. Acquisition of germplasm has become a priority due to latest development under Convention on Biological Diversity and other International treaties and laws. Realizing the importance of tropical fruits trees and their future potential in India, an attempt was made to introduce Bush mango (*Irvingia gabonensis*), a new potential tropical fruit and sent to different research station for their preliminary evaluation. Multilocation testing, multiplication and distribution will be done in later stage.

Key Words: Bush mango, Multipurpose tree use, Variability and Tropical fruits

Introduction

Bush mango (*Irvingia gabonensis*) grows wild in forests of tropical Africa. It is truly a multipurpose tree as it provides food, fuel, fibre, medicines and timber. Fruits are edible having yellow pulp. Seeds contain oil used in different culinary purposes and wood is hardy and green having resistance to termites. Bark is used as medicine in arthritis, rheumatism, dropsy, swellings, oedema, gout, eye treatment, fabrifuges, stomach trouble and venereal diseases. This plant offers considerable scope for enhancing the nutritional and economic security of subsistence farmers in India. Formerly known as Simaroubaceae, the Irvingiaceae family has 3 genera (*Desbordesia*, *Irvingia*, *Klainedoxa*) and about 20 species (Oxafor, 1974). In African continent people used numerous local names – wild mango, Dika nut, Bush mango, egili (Igala), oghi (Etsako) and African mango are few of them (Onwuka, 1983).

Origin and Geographic Distribution

I. gabonensis is cohabitant of tropical Africa i.e. from Senegal to Angola often found near riverbanks and reaches its optimum in the dense evergreen rain forest. Commonly found in the forest of Cameroon, Congo, Gabon, Ivory Coast, Nigeria, Yoruba and Zaire. Southeast Nigeria is the centre of diversity of *I. gabonensis* (Atangana *et al.*, 2002).

Irvingia species collectively known as Bush mango or dika nut, are economically important fruit species, native to moist lowland tropical forest in central and west Africa, especially along the Gulf of Guinea. In Africa, *I. gabonenesis* is the commonest one. In Nigeria, two varieties of this species were identified in 1974, *I. gabonensis* var. *gabonensis* (with sweet edible fruit) and *I. gabonensis* var. *excelsa* (with bitter fruit). In a revision of the taxonomy of the Irvingiaceae family, Harris renamed the bitter variety *I. wombulu* Vermoesen and the sweet variety *I. gabonensis* Aubry-Lecomte ex O'Rorke. Other species of the same genera are *I. excelsa, I. robur, I. smithii*, and *I. grandifolia.*

The geographical range of *I. gabonensis* is from southern Nigeria to the Republic of Congo, the centre of concentration being southern Nigeria, southern Cameroon and central Gabon. While for *I. wombulu* the range of distribution is much greater and goes in principle from southern Senegal to the south western part of Uganda, its centre of concentration being southern Nigeria and southern Cameroon. This information is fundamental as a basis on which a farmer-oriented cultivar development process could be built, within the framework of a domestication program for the bush mango species. Found native in Angola, Cameroon, Central African Republic, Congo, Cote d'Ivoire, Democratic Republic of Congo, Equatorial Guinea, Gabon, Ghana, Guinea-Bissau, Liberia, Nigeria, Senegal, Sierra Leone, Sudan, Uganda and as exotic in Benin, Sao Tome.

Domestication

I. gabonensis and *I. wombolu*, the eating and the cooking types, respectively, of bush mango, have been identified by the International Centre for Research in Agroforestry as priority wild fruit tree species for domestication. With information on farmer trait preference, and in collaboration with national agricultural research systems, range wide germplasm collections have been made. The need for conservation, domestication and development of sustainable production systems, such as are possible through agroforestry, has been emphasized if the environment is to recover from this degradation process. The genetic benefits obtained from the domestication in the tropics has shown that large genetic gains are possible. The International Centre for Research in Agroforestry (ICRAF) has organized, with its national agricultural research system (NARS) partners, a systematic collection of good quality seeds from Ghana, Nigeria, Cameroon and Gabon, with emphasis on southeast Cameroon and northern Gabon, the centre of diversity of the trees *I. gabonensis* and *I. wombolu* (Ladipo, 1995).

Botany and Taxonomy

A deciduous tree reaching a height of 100 ft; bole usually straight and cylindrical slightly buttressed; trunk diameter 3 to 5 ft. glabrous in all its parts; ramuli usually sulcate when dries. Leaves coriarceous, shining above, elliptical or oblong-elliptical, shortly acuminate or apiculate, more or less acute, base cuneate or rounded in the broader-leaved forms, 7.5-11.5 cm long, 4-6.5 cm broad, petiole 0.6-0.8cm. Flowers in axillary panicles or loose subfasciculate, divaricate, few or several-flowered hermaphrodite racemes, usually much shorter than the leaves; pedicels 1-3 lines, often 2-5 together, calyx 5-occasionally 3-4-partite, with rotundate lobe petals broadly elliptical, style filiform. Fruit "edible" about 10 cm in diameter. With a fleshy epicarp and bony endocarp. Irvingaceae family comprises three genera viz. *Desboresia* (one species), *Klainedoxa* (two species) and *Irvingia* (six species). Genus *Irvingia* has six species (Table 1).

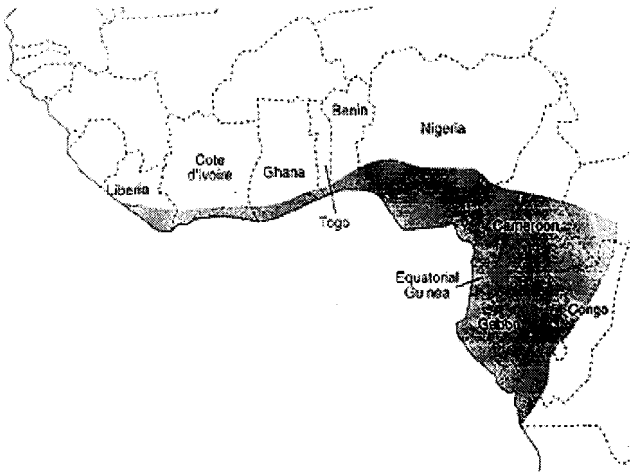

Fig. 1: *Distribution of Irvingia gabonensis in African sub continent (Ladipo et al., 1994)*

Variability in Fruit Shape and Quality

In the domestication of bush mango *I. gabonensis,* special attention needs to be placed on fruit shape and form. Spherical fruits are most common, but a range of other shapes has been recorded (Fig. 2). For example, in Cameroon, an unusual rectangular fruit shape was found, which was later also found to occur in Nigeria and Gabon. Pyriform fruits are also found frequently. This character was recorded for all mother trees. In Onne (Southeast Nigeria), fruit malformation or 'dimpling' was observed on some trees. In fact, it is important to identify this and other characteristics that can reduce the value or quality of *Irvingia* so that they can be eliminated early in the improvement programme for this species.

Variability in Fruit Sweetness

Chemical changes during ripening usually involve the conversion of starch to sucrose and reducing sugars. The extent of this conversion affects the sweetness of ripe and mature fruits as well as their retention on the tree. Fruits were divided into three categories: very sweet, sweet and not sweet. Most were assessed as sweet, but substantial variation in fruit sweetness between accessions was observed.

Table 1. Species and growing countries

Species	Countries
Irvingia gabonensis Bailln (Aubry-Lecomte ex O'Rorke)	Cameroon, Central Africa, Congo, Gabon, Ivory Coast, Nigeria, W. Africa, Yoruba and Zaire
Irvingia grandiflora (Engl.) Engl.	W. Africa, Cameroon, Central Africa, Gabon, Congo: Nigeria, and Zaire
Irvingia malayana Olivex AW Benn	Vietnam and Malaysia
Irvingia robur Mildbr	Congo, Cameroon and Gabon
Irvingia smithii Hook F.	Nigeria and Cameroon
Irvingia wombulu (Aubry-Lecomte ex O'Rorke)	Zaire

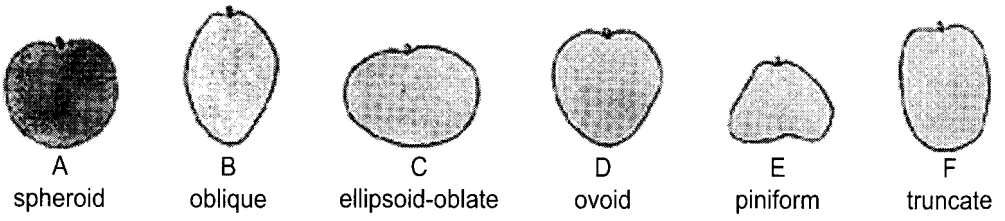

Fig. 2: Variation in fruit shapes of I. gabonensis

Variability in Fruit Colour

Irvingia fruits change from green to yellow as fruits ripen. The mature fruit colour has, however, been found to vary from tree to tree. Fruit pigmentation is a major attribute in fruit marketing. The major pigments responsible for fruit colours are chlorophyll, carotenoids and anthocyanins. The chloroplasts in green immature fruits generally lose chlorophyll on ripening and increase other pigments. This immense variability in colour is a resource that can be utilized for colour selection. The resulting consumer appeal should enhance the commercialization process of this wild fruit. *Irvingia* fruit has found in five colours as Green, Greenish yellow, Yellow, Brownish (cork) yellow and bright reddish yellow (Ladipo *et al.*, 1994).

Variability in Seed Cracking

The endocarp of *Irvingia* needs to be cracked open (shelled) to extract the cotyledons (kernels), which are used as thickening agents in soups and stews. People utilize different techniques to extract *Irvingia* kernels. They can be extracted from fruits in the fresh state, or fruits can be fermented and the kernels extracted wet. Alternatively, they can be fermented and sun dried before extracting, packaging or marketing. All these methods are difficult and hazardous. The whole operation also takes a lot of farmers' time. This useful trait is an early splitting of the hard endocarp, a process that usually takes place much later during germination.

Variability in Crown Shape

The form and shape of tree crowns can vary substantially and is probably due to genetic variation in apical dominance and apical control. Isolated mature (10-25 years) trees of *I. gabonensis* have been assessed for their crown characteristics over the last 4 years in Cameroon, Gabon and Nigeria. Considerable variation is apparent (Fig. 3). The genetic nature of these differences needs to be confirmed. Pruned and plantation trees were not included because of the possibility that their crown form results from competition in a forest type situation. It is not known, however, whether these assessed trees have been isolated throughout their life.

Variability in Leaves Colour

Colour change in the leaves of tropical trees is not uncommon as the leaves expand and mature. In *I. gabonensis* young leaves are usually pale green and sometimes pink. Field and nursery observations have shown that some trees of *I. gabonensis* have red leaves.

Agro Climatic Adaptation

I. gabonensis are very well adapted to the tropical rainforest. Thrives well in almost all-tropical rain forest soil but alluvial, equatorial brown loam soil, mud soils is suited best. Mineral composition of this soil is altisol and ultisol, rainfall should be in between 1250-2500 mm, shady conditions in the understory of water demands are high and there is a good adaptability to dry conditions. *I. gabonensis* is distinguished by a high productivity, which is conforming to the high nutrient and water demands.

Propagation

Propagate through direct seeding/seedling and vegetative methods like cutting, budding and grafting. Because of the plant's allogamy, multiplication by seed involves a large genetic heterogeneity. The techniques of traditional vegetative multiplication give a low propagation rate. *In vitro* technique for cloning of selected individuals open a new way for the consistent production of *I. gabonensis* plantlets, which could be used for the species propagation and domestication. Germination is a major problem owing

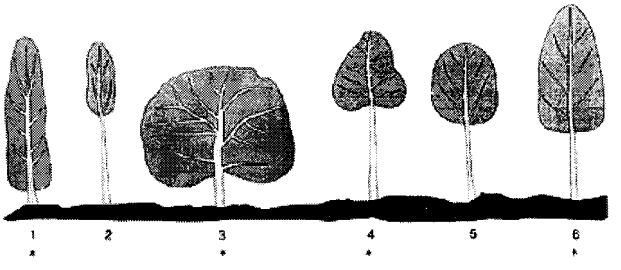

Fig. 3: Variation in crown shape of I. gabonensis

to strong shell and may take on an average about 3-4 weeks time to germinate coupled with low germibility.

Cultivars

Very little work had been carried out in past on improvement of this crop, as a result this is still under domestication and grown in forest, agroforestry system and in kitchen garden only. Now emphasis is given on exploration for selection and collection of superior genotype for systemic breeding programme. Excelsa and Dulices are main cultivars/ varieties but basically these are varieties of *I. gabonensis i.e. I. gabonensis* var. *excelsa and I. gabonensis dulices.*

Cropping System

I. gabonensis can be well accommodated in agroforestry system and silviculture, in kitchen gardens as well as in social forestry system. Inter cropping of food crops, such as maize and cassava takes place with the planting of additional multi-purpose fruit trees.

Nutrient Management

Arbuscular mycorrhizal inoculation as experience points not only to increased growth and nutrient uptake but also to improved water supply (as indicated, for example, by higher SLA). This would stimulate even further the above-mentioned high adaptability to dry conditions.

Training and Pruning

Domesticated *I. gabonensis* acceptable for both agroforestry and intensive orchard management may eventually be required. This might involve the need for different crown and bole forms manipulation of tree to promote flowering and improve fruit yields. Branching and form traits are incorporated into breeding and selection programmes, as they can be of substantial value for orchard development.

Fruiting Age

Precocity in plants is known to be under some degree of genetic control, with considerable variation in the time taken for trees to reach maturity and start fruiting. *I. gabonensis* is generally said to commence flowering after 10-15 years, but it has also reported variation in the commencement of flowering in young *I. gabonensis* in southeast Nigeria, that fruiting could commence much earlier in a precocious tree genotype i.e. it can start from the age of 4 year onwards.

Fruit Production

The flowering and fruiting process consists of a series of sequential stages, the key steps are floral initiation, flower development, pollination, fruit set, fruit development and seed set. Fruit set may depend on the availability of pollen and the efficiency of pollinators, but seed set that is the development of viable seeds from the ovules of pollinated flowers depends on endogenous factors and their interaction with the environment.

Flowering

The flower is hermaphrodite, like other tropical trees, is highly heterozygous. The first stage in the flowering process is floral induction or evocation. It is not known what triggers this process in *Irvingia* species, but a substantial variation was observed in the number of floral flushes within the population, with most trees not flowering at the age of 4-5 year or flowering only once a year, twice a year and few flowering 3-4 times a year.

Harvesting

Maturity of fruits was early in the southwest and littoral regions, while fruiting was late in the central, eastern and southern regions of the humid lowlands of Cameroon. Fruiting can be observed in July-August (early); and August-September (late). However, some out-of-season fruiting seems to occur. In Onne (southeast of Nigeria) few trees fruited in February (4 months before general fruiting). Southeast Nigeria, Research is therefore, needed to understand the genetic basis of this characteristic, so it can be effectively utilized.

Post Harvest Management

Irvingia fruits follow climacteric pattern for its ripening, fruit after harvesting faces several physiochemical change which cut short shelf life of fruit, changes occurred mainly in fruit weight, texture, colour, starch, fermentation of sugar and increase in total carotenoids. Dipping of perclimateric mature green fruits in 0.5% NaS_2O_5 at 55°C, followed by wax packing in wooden boxes overlapped with stretch polyvinyl chloride (PVC) film, delayed ripening, controlled decay, minimized weight losses and extended the shelf life of fruits kept at 22-35°C and 70-95% RH.

Disease and Pest Management

Major diseases pest is *Phytophthora* root rot, root knot nematode (*Helicotylenchus limatus* sp.*nov)* stored pest *(Oryzaephilus mercator)* of nuts and bark eating caterpillar, which can be managed with help of fungicide/ pesticide application coupled with proper crop management techniques.

Fruits Characteristics

Bush mango fruit had variability in all respect of its fruits viz. size, shape and weight which is reflected by fruit mass, flesh nut mass, shell mass, kernel mass, length, width, flesh depth, extent of variability is shown in Table 2.

Table 2. Fruit characteristics

Parameter	Range
Fruit Weight	69.0-419.8 g
Flesh Weight	59.5-388.8 g
Nut Weight	9.5-40.6 g
Shell Weight	4.9-30.9 g
Kernel Weight	0.41-7.58 g
Length	49.2-89.3 mm
Width	46.2-100.5 mm
Flesh depth	12.9-31.4 mm
Fruit Share	
Particular	Share (%)
Mesocarp	89%
Endocarp	8%
Seed	3%

Nutritive Value of Fruit and Kernel Seed

Bush mango has good nutritive valve. It is good source of energy, vitamin A and C, protein, fibre, fat, minerals and essential oils. Composition of fruit pulp and seed (kernel) are given in Table 3.

Fat produced form nuts of bush mango are used in various purposes (Eyo, 1979), physicochemical properties mentioned in Table 4 reflects the potential to use it in different pharmaceuticals confectionery and cosmetic uses.

Aroma Content

More than 35 compound (essential oils) were identified mainly benzoic, cinnamic and methyl-butyric acid derivatives as well as the sesquiterpens, a *Curcumene* and *Zingerberrine* in ripe and unripe fruits (peel and fruit pulp). Study suggested that this could be used as flavoring agent in food (Van Buren, 1970).

General Characteristics Timber Wood

Heartwood pale green brown or orange yellow, fading on exposure to a grey brown, sometimes with dark grey streaks; sapwood lighter, not always differentiated. Texture is fine to medium; grain straight to interlocked and without luster.

Mechanical Properties: (2-cm standard)

- Moisture content, Bending strength Modulus of elasticity, Maximum crushing strength (%) (Psi) (1000psi) (Psi) 12% (47) 23,600 2,710 11,400.
- Amsler toughness 288 in.-Ib at 12% moisture content (2-cm specimen). Growth ring boundaries indistinct or absent. Heartwood basically light brown yellow to white or grey, without streaks. Sapwood colour similar to heartwood colour. Odour indistinct or absent. Basic specific gravity 0.64-0.75 g/cm^3.

Table 3. Nutritive value of fruit pulp and kernel seed

Parameter	Value
Moisture	46.5%
Dry matter	43.5%
Carbohydrate	19.2%
Protein	10.9%
Fiber	8.2%
Ash	1.8%
Vitamin A	67 mg/gm
Vitamin C	65.3 mg/gm
Minerals	Mg, Ca, P, Na, K, Cu, Zn, Ni, Fe and Co
Kernel Seed	
Crude fat	68-75%
Fat	54%
Gum content	67%
Preteen	8-9%
β-Carotene	0.7 mg/gm
Plant sterols	8.08 mg/gm
Phospholipid	14.8 mg/gm
Myristic	21.2%
Palmitic	33.9%
Oleic acid	25.4%
Unsaturated fatty acid	23%
Saturated fatty acid	77%
Minerals	Mg, Ca, P Zn, Ni, Fe and Co

Table 4. Physicochemical properties of Bush mango fat (Omogbai, 1990)

Melting point	**39-40 °C**
Saponification value	212-220 °C
Smoking point	213-210 °C
Free fatty acid value	0.25-0.30%
Iodine Value	3.5-4.2
Peroxide value	1.95-1.99mg/gm
Acid value	13.6
Total Lipid content	71%

Wood Anatomy

Wood type is diffuse-porous. Vessels are arranged in no specific pattern, in multiples, commonly short (2-3 vessels) radial rows. Average tangential vessel diameter 145-220-300 flm; diameter of vessel lumina varies from large to very large. Average number of vessels/mm^2 (2-) 3-5(-7); vessels per square millimeter very few to few. Average vessel element length 400-650(-800) flm.

Average vessel element length medium. Perforation plate's simple. Intervessel pits alternate. Intervessel pits average diameter (vertical) 7-10 flm, medium. Intervessel pits not vestured. Vessel-ray pits with reduced borders or apparently simple, rounded or angular or horizontal to vertical, of uniform size or type or of two distinct sizes or types in the same ray cell, of the same type in adjacent elements or unilaterally compound and coarse. Helical thickenings absent. Tyloses in vessels present. Other deposits in heartwood vessels not observed.

Tracheids and Fibres

Vascular or vasicentric tracheids sporadic to absent. Fibres of medium wall thickness to very thick-walled. Average fibre length 1650-2200 flm. Fibre pits mainly restricted to radial walls, simple to minutely bordered. Helical thickenings absent. Fibres non-septate.

Axial Parenchyma

Axial parenchyma banded. Axial parenchyma bands not marginal (or seemingly marginal), bands much wider than rays, coarse, more than three cells wide. Axial parenchyma as strands. Average number of cells per axial parenchyma strand 6-13. Rays 7-11 per tangential mm, multiseriate (also if only few), 2-4 cells wide, narrow (2-3 seriate) to of medium width (3-5 seriate). Height of large rays up to 500 /lm to commonly 500 to 1000 /lm. Rays composed of a single cell type (homocellular). Homocellular ray cells procumbent. Sheath cells absent. Perforated ray cells absent

Secretory Structures

Intercellular canals absent. Laticifers or tanniniferous tubes absent.

Mineral Inclusions

Crystals present, prismatic, located in ray cells or axial parenchyma cells or tyloses. Crystal-containing ray cells procumbent. Crystal-containing axial parenchyma cells chambered, or not chambered. Number of crystals per cell or chamber one. Silica not observed.

Uses

Bush mango is multipurpose tree, beside it is excellent timber wood it has quality fruit and oil in its kernel is used for (i) Bakery and cosmetic purpose for preparation of dikka fat, chocolate and soap; (ii) Pharmaceutical purposes for preparation of anti ulcer and analgesic medicine;(iii) Bark of this tree has sown ant fungal activities. Polyphenols tannin or saponins could be responsible and (iv) the wood of Bush mango split in to chewing stick approximate 12x2.5x0.5cm is very commonly used for personal dental hygiene in sub Sahara Africa.

Summary

Bush mango, being truly fruit based multipurpose tree if adopted well in tropical and subtropical regions of India has the potential to change the fruit culture scenario as well as living standard of small and marginal framers. Owing to its immense potential to perform well under adverse agro climatic condition and poor and marginal soil as well it proves to be potential multipurpose fruit tree for farming community.

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