

## Baobab (*Adansonia digitata* L.): a Review on a Multipurpose Tree with Promising Future in the Sudan

### Baobab (*Adansonia digitata* L.): Ein Überblick über eine vielseitig verwendbare Baumart mit guten Zukunftsaussichten für den Sudan

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#### Summary

Africa has abundant wild plants and cultivated native species with great agronomic and commercial potential as food crops. However, many of these species, particularly the fruits and nuts, have not been promoted or researched and therefore remain under-utilized. Moreover, many of these species face the danger of loss due to increasing human impact on ecosystems.

Sudan, as in many other African countries, is endowed with a range of edapho-climatic conditions that favor the establishment of many plant species, most of which are adapted to specific ecological zones. Among these plants is the baobab (*Adansonia digitata* L.) which is a fruit-producing tree belonging to the family Bombacaceae. The baobab has an exceedingly wide range of uses ranging from food and beverages to medicinal uses. Despite its potential, which is well recognized, very little is known about the tree phenology, floral biology, husbandry or genetic diversity.

In this article, we have aimed to bring out detailed information on various aspects of its botany, ecology, origin, propagation, main uses, genetic improvement and especially its importance for nutrition and poverty alleviation in the Sudan.

#### Zusammenfassung

In Afrika gibt es eine Fülle von Wildpflanzen und kultivierte einheimische Arten als Nutzpflanzen, die ein großes agronomisches und kommerzielles Potenzial besitzen. Viele dieser Arten, insbesondere die Obst- und Nussbäume, finden bis heute wenig Beachtung und sind wissenschaftlich kaum untersucht. Ihr Nahrungspotenzial wird bei weitem nicht ausgeschöpft. Aufgrund des zunehmenden Einflusses der Menschen auf die Ökosysteme sind viele dieser Arten vom Aussterben bedroht.

Der Sudan ist, wie viele andere afrikanische Länder, mit einem Spektrum an edapho-klimatischen Bedingungen ausgestattet, die eine Etablierung vieler Pflanzenarten ermöglichen, die an die spezifischen ökologischen Zonen angepasst sind. Zu diesen Pflanzen zählt der Baobab (*Adansonia digitata* L.), der zur Familie der Bombacaceae gehört und Früchte produziert. Dieser Baum bietet eine Vielzahl von Verwendungsmöglichkeiten als Nahrungs- und Heilmittel, trotzdem ist er

staunlich wenig über die Baumphenologie, Blütenbiologie, den Anbau sowie die Diversität bekannt.

In diesem Artikel werden unterschiedliche Aspekte wie Botanik, Ökologie, Herkunft, Vermehrung, Nutzungsmöglichkeiten, Auslese wertvoller Herkünfte sowie besonders seine Bedeutung für Ernährung und Armutslinderung im Sudan diskutiert.

#### Introduction

Arid and semi-arid Africa is blessed with various tree, palm and shrub species which provide shade, give an aesthetic sight, or offer fruits, tannins, gums, resins, oils or extracts and pharmaceutical products (STEPLER and NAIR 1987; GLEW et al. 1997; NOWAK and SCHULZ 1998; MUOK et al. 2001;). The baobab (*Adansonia digitata* L.) is important to the livelihood of the people in arid zones (BECKER 1983). Because of their great size and bizarre shapes, baobabs are often the most prominent tree species where they occur (Fig. 1). They are the subject of many local legends (FENNER 1980). The tree provides food, shelter, clothing and medicine as well as material for hunting and fishing (VENTER and VENTER 1996). Tubers, twigs, fruits, seeds, leaves and flowers of this plant are identified as common ingredients in traditional dishes in rural and urban areas (NORDEIDE et al. 1996). Many of the products sold in markets are an important source of income for the people (BONKOUNGOU et al. 1999).

Monkey bread is one of the common English names. This name is generally assumed to be derived from the fact that monkeys eat the baobab's fruit (RASHFORD 1994). Vernacular names for the baobab tree in the Sudan are: 'Humar', 'Homeira', or 'Tebeldi'. The fruits are named 'gunguleiz'.

#### Botanical Description

*Adansonia digitata* is a deciduous, massive, majestic tree up to 25 m high, which may live for hundreds of years. It has thick, angular, wide spreading branches and a short, stout trunk which attains 10–14 m or more in girth and often becomes deeply fluted. The form of the trunk varies. In young trees it is conical; in mature trees it may be cylindrical, bottle shaped, or tapering with branching near the base.



Fig. 1. Baobab tree in the Ed Damazin area (Eastern part of Sudan).

*Baobabbaum im Gebiet von Ed Damazin (östlich im Sudan).*

The tree structure has the following characteristics:

- Bark: smooth, reddish brown or greyish with a purplish tinge or rough and wrinkled like an elephant's skin.
- Leaves: alternate and hand-shaped with 3–9 subsessile tapering leaflets, about 10x5 cm at the ends of branches; digitally foliate, simple leaves on young plants (Fig. 2).
- Inflorescences: axially, large, white, 12 cm across; sepals cup-shaped, 5-cleft, hairy; petals 5, leathery and ultimately reflexed, hairy inside; stamens many staminal columns dividing into many filaments of 1-celled anthers; styles long 7–10-rayed; life span of the flowers is not more than 24 hours.
- Fruit: the capsule hangs singly on a long stalk. It has an ovoid, woody shell 20–30 cm long and is up to 10 cm in diameter, which is covered on the outside with greenish-brown felted hair (Fig. 3). This shell contains numerous hard, brownish seeds, round or ovoid, up to 15 mm long, which are embedded in a yellowish-white, floury acidic pulp (Fig. 4).

### Ecology and Distribution

The baobabs are comprised of eight species with large, spectacular, nocturnal flowers (BAUM 1995). One of these species, *A. digitata*, occurs throughout the drier parts of Africa. A second species is restricted to North-Western Australia (*A. gibbosa*), and the remaining six species are endemic to Madagascar (BAUM et al. 1998).

*A. digitata* is widespread throughout the hot, drier regions of tropical Africa. It extends from northern Transvaal and Namibia to Ethiopia, Sudan and the southern fringes of the Sahara. In Sudan, the baobab is most frequently found on sandy soils and by seasonal streams 'khors' in short grass savannas. It forms belts in Central Sudan, in Kordofan, Darfur, Blue Nile, Upper Nile and Bahr El Ghazal (EL AMIN 1990). It is often found associated with the tamarind, *Tamarindus indica* L. (PURSEGLOVE 1982).

Areas where the baobab can be grown are restricted to those with not more than one day of frost per year (VENTER and VENTER 1996). The baobab trees can reach an age of several hundred or thousand years under suitable conditions (SWART 1963, VON BREITENBACH 1985).

The baobab has an extensive root system and high water holding capacity. It survives well in dry climates and is resistant to fire. This adaptation allows it to grow in zones with 100–1000 mm annual rainfall, but trees are often stunted in the lower rainfall areas. It characteristically occurs on free-draining sandy-textured soils but not on deep sand, where it is unable to get enough moisture or anchorage. It is insensitive to soil pH and tolerates shallow lateritic soils. It is also found on rocky hillsides, in calcareous soils, on sites receiving run-off, or where water accumulates (FAO 1988). Measurements on exposed roots show that they are relatively shallow (<1.8 m) but spread out to a distance greater than the height of the trees (FENNER 1980). Such an extensive shallow root system is probably the best adaptation to exploiting the low annual rainfall, most of which falls in the form of infrequent heavy showers.

The baobab spends only four months of the year in leaf. This is possible because some photosynthesis takes place in the trunk and branches during the eight-month leafless period, using water stored in the trunk. Many of the larger baobabs have hollow centers due to natural causes or as a result of human intervention (PALGRAVE 1957).

The baobab was found to be among the most effective at controlling its water loss. Daily shrinkage of the trunks was measured, giving a daily estimate of approximately 400 litres water deficit when they are in leaf. Seasonal shrinkage indicates a loss of up to 1500 litres of water during dry periods (FENNER 1980).



Fig. 2. Different leaf types of the baobab tree.  
*Unterschiedliche Blattpen des Baobab.*



Fig. 3. Baobab fruit.  
*Baobabfrucht.*

VON BREITENBACH (1985) distinguished four principal growth phases in the development of *A. digitata*: sapling phase (up to 10–15 years), cone phase (up to 60–70 years), bottle phase (up to 200–300 years) and an old age phase (up to 500–800 years). Initially the trees grow extremely fast, especially in the cone phase, but very slowly during the greater part of their life.

In Sudan, flowering was found to occur between May and July and fruiting extends from August to October (EL AMIN 1990). The baobab is pollinated by bats (*Galago crassicaudatus*) and insects but is also adapted for wind pollination (FAO 1988).

Although the baobab is one of the most familiar trees in the drier parts of Africa, very little work has been done on its ecology or physiology (FENNER 1980).

### Propagation and Cultivation

In Sudan propagation is basically accomplished by seeds. Seeds can be collected from picked or fallen fruit. After crushing the hard woody shell of the fruit, the seeds can be extracted from the dry acidic pulp. Baobab seeds have very hard seed coats and germination is usually less than 20% (DANTHU et al. 1995).

In nature, dormancy is broken by passage through the digestive system of large mammals. In cultivation, dormancy may be broken by immersing the seed in hot water for several minutes or by chopping the seed coat (ESENOWO 1991). According to DANTHU et al. (1995) acid scarification for 6 or 12 hours is the optimal pre-

treatment method for breaking the baobab seed coat inhibition. Vegetative propagation by root cuttings or by grafting or budding can also be practiced (SIDIBE et al. 1996).

Seedlings have big, flat and paired cotyledons, and the first leaves are petiolate (with a leaf stalk), generally narrow, simple and linear. Effective protection against livestock is essential after planting the seedlings. Under good conditions, rapid growth in diameter and height is possible, reaching 2 m in two years and up to 15 m in twelve years (FAO 1988). Time required to produce fruits varies from 8 to 23 years. Each matured plant produces more than an average of 250 capsules which may provide at least 30 kg of the fruit (IBIYEMI et al. 1988).

Although the trees seem to be protected by those who know its value, a major factor in Central Sudan which contributes to low numbers in the field is uncontrolled bush burning, common in dry seasons, which destroys the seedlings. Other factors include cattle grazing on seedlings and diseases which render the seeds nonviable after planting (DANTHU et al. 1995). The tree is often planted near villages, but there is limited information on local tree husbandry practices.

### Food Value

The fruit pulp has a very high vitamin C content, almost ten times that of oranges. It contains sugars but no starch and is rich in pectins. However the vitamin C content of the bulk fruit pulp varied from 1623 mg kg<sup>-1</sup> in one tree to 4991 mg kg<sup>-1</sup> in another (SIDIBE et al. 1998a). The chemical composition of the fruit pulp is shown in Table 1.

Fresh young leaves have a protein content of 4%, and they are rich in vitamins A and C. In terms of mineral content, baobab leaf is an excellent source of calcium, iron, potassium, magnesium, manganese, molybdenum, phosphorus, and zinc (YAZZIE et al. 1994). This indicates that in terms of both quality and quantity, baobab leaf can serve as a significant protein and mineral source for those populations for whom it is a staple food.

Tab.1: Chemical composition of baobab fruit pulp (NOUR et al. 1980).

*Chemische Zusammensetzung der Baobabfruchtpulpe (NOUR et al. 1980).*

Constituents (dry weight basis)	
Total soluble solids (%)	79.3
Alcohol insoluble solids (%)	57.3
Total sugars (%)	23.2
Reducing sugars (%)	19.9
Total pectin (% galacturonic acid)	56.2
Starch (%)	–
Protein (% N)	2.6
Fat (%)	0.2
Crude fibre (%)	5.7
Ash (%)	5.3
Ascorbic acid (mg/100 g)	300.0
Iron (mg/100 g)	8.6
Calcium (mg/100 g)	655.0
Phosphorus (mg/100 g)	50.8
Moisture	6.7
pH	3.3

According to ADDY and ESTESHOLA (1984) and IGBOELI et al. (1997), the seed can be classified as both protein- and oil-rich. It is also a very rich source of energy and has a relatively low fat value.



Fig. 4. Seeds of the baobab tree, with and without fruit pulp. *Samen des Baobab mit und ohne Fruchtpulpe.*

### Main Uses

The plant has numerous medicinal and non-medicinal uses in Africa (VON MAYDELL 1990, WYK and GERICKE 2000). Every part of the baobab tree is reported to be useful (OWEN 1970).

Villagers often plant baobabs within their own courtyards and nurture them until they are 2–3 m tall, before transplanting them along the edges of cultivated fields. It is used as a boundary marker to make the dividing line between plots (ROCHELEAU et al. 1988).

The fruit pulp is used in preparing cool and hot drinks in rural areas and has recently become a popular ingredient in ice products in urban areas (SIDIBE et al. 1998b). The pulp is never cooked as the hot drinks are being prepared. Rather the pulp is added at the end of the preparation process after the drinks are allowed to cool (SIDIBE et al. 1996). In some areas the use of the 'baobab milk' is very common. The dried pulp is scraped from baobab fruits and made into a solution. The milk is a highly nutritious drink (OBIZOBA and ANYIKA 1994). *A. digitata* fruit pulp is processed locally to obtain sweets (IBIYEMI et al. 1988). The pulp is also eaten fresh in Sudan. Whole fruits or just the fruit pulp can be stored for months under dry conditions. The pulp powder is extracted and stored in polyethylene bags which protect it against ambient moisture (SIDIBE et al. 1996).

The leaves of the baobab tree are a staple food source for rural populations in many parts of Africa, especially the central region of the continent (YAZZIE et al. 1994). During the rainy season when the baobab leaves are tender, people harvest the leaves fresh. During the last month of the rainy season, leaves are harvested in great abundance and are dried for domestic use and for marketing during the dry season. The leaves are typically sun-dried and either stored as whole leaves or pounded and sieved into a fine powder. In markets, the powder is the most common form (SIDIBE et al. 1998b). The leaves of *A. digitata* are important protein sources in

complementing the amino acid profile and thereby improving the protein quality of the diet (NORDEIDE et al. 1996). Young leaves are commonly used as a vegetable in soups or cooked and eaten as spinach (VENTER and VENTER 1996). Dried green leaves are used throughout the year, mostly in soups served with the staple dish of millet (DELISLE et al. 1997). Flowers can be eaten raw or used to flavour drinks.

The seeds are characterized as a potential protein source. In Sudan they are pounded whole into a coarse meal and added to soups and other dishes like 'Burma' (DIRAR 1993). In some areas roasted seeds are used as a coffee substitute.

The bark, which produces strong fibre, is used in making ropes, mats, bags, and hats (Fig. 5). The smooth fibres of the inner side of the bark are more important than the outer bark for weaving (IGBOELI et al. 1997). The wood is whitish, spongy and light (air-dried  $320 \text{ kg m}^{-3}$ ) and is used mainly for fuel (VENTER and VENTER 1996). Hollow trees provide reservoirs of fresh water which are used by nomads, particularly in the western part of the Sudan (TOTHILL 1954). Water storage capacities range from 1000 to 9000 litres per tree (CRAIG, 1991).

The use of trees as cattle feed is extremely important in the savanna areas especially in the arid zones, where animals obtain much of their feed in the form of pods and leaves. The pulp and seeds have a high nutritional value and are recommended for feeding the herd late in the dry season when grazing is poor (VENTER and VENTER 1996).

In the folk medicine, baobab pulp is used in the treatment of fevers and dysentery. Pulp extract is applied as eye-drops in cases of measles. The leaves form a component of many herbal remedies and a mash prepared from the dried powdered roots is given to malarial patients as a tonic. A semi-fluid gum, obtained from baobab bark, is used to treat sores (FAO 1988).

### Genetic Improvement

*A. digitata* occurs widely throughout tropical Africa. Within the species, however, there is evidence indicating the existence of a number of local types differing in habit, vigour, size, quality of the fruits and vitamin content of the leaves. The considerable size differences which exist between single trees of identical age suggest that the differences are mainly of genetic origin (VON BREITENBACH 1985). SIDIBE et al. (1996) reported a 3-fold variation in vitamin C content in the leaves, indicating significant potential for selecting trees and clones with high vitamin C content. They distinguished 4 major types of baobab: black-bark, red-bark, grey-bark and dark-leaf vegetable baobabs.

In Sudan, no records on named varieties are available; but it is widely known that ecotypes from different areas of the Sudan have different fruits in terms of size, shape and sweetness. Therefore, the potential for selecting or breeding better quality, higher yielding cultivars seems to be promising. Farmers are able to guide researchers in collecting germplasm from superior species. They are also open to the planting of wild fruit trees especially if they would produce larger and sweeter fruits in a shorter period of time.



Fig. 5. Stripped bark from the base of a baobab trunk, for making ropes.

*Abgezogene Rinde an der Basis eines Baobabstammes, zur Seilherstellung.*

### Future Economic Potential

Edible wild plants, in contrast to cultivated crops are often the highest in vitamins and minerals concentrations in semi-arid and arid regions (SMITH et al. 1996). *A. digitata* is one of those superior wild fruit trees. However, plantations of baobab have never been seen in Sudan and varieties are unknown. But there is significant potential for selecting trees and clones with different features. While there is plenty of room for improvement through tree selection, the average vitamin C content of more than 2500 mg kg<sup>-1</sup> is considered to be high compared to other fruits. Education on the nutritional value and use of baobab fruit could raise nutritional standards and also stimulate the market availability and trade of baobab powder (SIDIBE et al. 1996). Current collection and use of the fruit constitutes are already an important source of both income and food for certain tribes living in Central and South Sudan. It is for this reason that greater attention should be given to their improvement through selection, breeding, germplasm conservation and increased overall production.

The baobab have not been subjected to well known horticultural propagation techniques such as budding and grafting or even modern breeding techniques requiring controlled pollination (OKAFOR 1980). Grafted baobabs offer not only faster development and lower bottom branches that make fruit harvest easier but also provide an opportunity for propagating individual trees selected for high vitamin C levels in the fruit pulp (SIDIBE et al. 1996). Traditional food technologies for baobab powder need to be encouraged, and these principles can be maintained in any innovative technologies (EZEAGU et al. 1998).

There is great potential for this indigenous wild fruit tree of Sudan in regional and even world markets (BUWALDA et al. 1997), and it is hoped that this article will be a strong stimulus for research and development efforts towards better understanding and utilization of this species.

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