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### The Importance of Baobab (*Adansonia digitata* L.) in Rural West African Subsistence—Suggestion of a Cautionary Approach to International Market Export of Baobab Fruits

Christine Buchmann <sup>a</sup>; Sarah Prehlsler <sup>a</sup>; Anna Hartl <sup>a</sup>; Christian R. Vogl <sup>a</sup>

<sup>a</sup> Department of Sustainable Agricultural Systems, Division of Organic Farming, Working Group: Knowledge Systems and Innovations, University of Natural Resources and Applied Life Sciences, Vienna, Austria

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# **The Importance of Baobab (*Adansonia digitata* L.) in Rural West African Subsistence— Suggestion of a Cautionary Approach to International Market Export of Baobab Fruits**

CHRISTINE BUCHMANN, SARAH PREHSLER, ANNA HARTL,  
and CHRISTIAN R. VOGL

*University of Natural Resources and Applied Life Sciences, Department of Sustainable  
Agricultural Systems, Division of Organic Farming, Working Group: Knowledge  
Systems and Innovations, Vienna, Austria*

*The European Commission recently authorized the import of baobab (*Adansonia digitata* L.) fruit pulp as a novel food. In rural West Africa the multipurpose baobab is used extensively for subsistence. Three hundred traditional uses of the baobab were documented in Benin, Mali, and Senegal across 11 ethnic groups and 4 agroecological zones. Baobab fruits and leaves are consumed throughout the year. The export of baobab fruits could negatively influence livelihoods, including reduced nutritional intake, change of power relations, and access rights. Capacity building and certification could encourage a sustainable and ethical trade of baobab fruits without neglecting baobab use in subsistence.*

**KEYWORDS** *Adansonia digitata, baobab, EU novel food, non-timber forest products, livelihood, resource commercialization*

## INTRODUCTION

The European Commission has authorized the placing on the market of baobab (*Adansonia digitata* L.) dried fruit pulp as a novel food ingredient

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Address correspondence to Christine Buchmann, University of Natural Resources and Applied Life Sciences, Department of Sustainable Agricultural Systems, Division of Organic Farming, Working Group: Knowledge Systems and Innovations, Gregor Mendel Strasse 33, 1180 Vienna, Austria. E-mail: christine.buchmann@boku.ac.at

on the 27th of June 2008 (Vassiliou 2008). Under the Novel Food Regulation (EC) No 258/97 a novel food is defined as a food or food ingredients that has "not been used for human consumption to a significant degree" (The European Parliament and the Council of the European Union 1997) within the EU prior to May 1997. Allowing baobab fruit import to the EU as a novel food has been lobbied for by the South African trade cooperation "PhytoTrade" with the aim to increase economic growth in the rural areas of Southern Africa based on the sustainable commercialization of baobab (PhytoTrade 2008; Welford and Breton 2008). Approving baobab fruit pulp as a novel food opens the door of the European market to the African export of fruit pulp from the baobab tree. Although this seems a good opportunity for economic growth in baobab exporting countries, a successful resource commercialization does not necessarily stimulate local development and reduce poverty (Lybbert, Barrett, and Narjisse 2002). On the contrary there is likely to be substantial inequality in the distribution of commercialization benefits, both across regions according to market access and among households based on tree access rights, as was the case with Moroccan argan (*Argania spinosa* (L) Skeels) oil commercialization (Lybbert et al. 2002). A similar situation may develop if baobab fruits are exported at a large scale from West Africa, without securing a framework that ensures sustainable production, ethically just supply chains, and continued access to baobab for rural West Africans who depend on baobab consumption as an essential part of their diets.

The baobab is a deciduous tropical fruit tree with a natural distribution in Sub-Saharan Africa. It has multiple uses and is appreciated throughout Africa as food and medicine, as well as for veterinary and spiritual uses. In addition, the baobab has a broad ecological tolerance (Sidibé and Williams 2002) which makes it a valuable tree species in otherwise harsh and dry growing conditions. Baobab trees thrive on a wide variety of soils, from sandy and stony soil to poorly drained soils and clay. Baobab tolerates very high temperatures and low rainfall, due to the early shedding of leaves and a thick, fire resistant, bark, as well as a trunk that absorbs water in the rainy season and contracts in the dry season (Sidibé and Williams 2002).

In several West African countries (e.g., Benin, Mali, Senegal, Burkina Faso, Nigeria) the baobab is inextricably linked with cultural identity and local belief systems and its use is guided through formal and informal regulations. Baobab based meals are consumed daily, and surplus products, including leaves and fruits, are either stored or sold on local markets, ensuring a baobab supply for most of the year. Different from South-Africa, in West Africa the possibility to export baobab fruits to the EU may have a rather negative impact on local livelihoods as baobab is used extensively in subsistence.

This research highlights the nutritional and medicinal importance of baobab in West African communities in Benin, Mali, and Senegal. This

article is based on ethnobotanical field research, a literature review of ethnobotanical literature documenting baobab use in Africa, and a review of recent Non-Timber Forest Products (NTFP) literature with an emphasis on the effect of NTFP commercialization. The possible impact new baobab fruit export markets could have on rural West Africans is discussed considering local tree management, cultural traditions, belief systems, and gender related tasks. Attention is called to the negative influence a commodification of baobab may have on local livelihoods and ecosystems.

The following section provides an overview on the nutritional and medicinal uses of baobab in Africa as documented in the literature. The traditional food and medicinal use of fruits, seeds, and leaves are discussed here exclusively, although all parts of the baobab are used by local people. The consumption of the leaves is included in the analysis, since their intense use and harvest leads to reduced fruit harvests and should therefore not be neglected in the discussion on the local impact that baobab fruit export may have. Before proceeding to the argument, research sites, ethnic groups, and methods are introduced. The concluding remarks examine research challenges and policy implications.

### Traditional African Uses of Selected Baobab Plant Parts for Consumption and Medicine Documented in the Literature

In many African countries rural people rely on a variety of nutritional and medicinal products provided by the baobab. The nutritional and medicinal use of baobab products in Africa has been documented in the literature and the most frequently documented food preparations based on baobab fruit pulp, seeds, and leaves are listed below. References for those most frequently named uses are listed in table 1, along with the countries of research covering the whole African continent (table 1).

Baobab fruit pulp tastes acidic and is of a dry and mealy consistence. It is low in protein and fat, but rich in mucilage, pectins, tartarate, free tartaric acids, calcium, vitamin B, and it contains 10 times higher concentration of vitamin C than oranges (De Caluwé, Halamová, and Van Damme, 2009; Gustad, Dhillion, and Sidibe 2004). Fresh or stored fruit pulp is eaten as a snack. It is dried, pounded, and added to water or milk to serve as a refreshing drink. The “juice” (solution of pulp powder in water) may also be added to milk to augment the quantity of milk for sale, and when there is little milk available. Pounded and sieved fruit pulp is added into warm millet or sorghum based gruel with water or milk. Such fruit powder is also added to sauces, soups, and couscous. Fruit powder is mixed with water, sweetened, and frozen to be consumed as an “ice lollipop.”

The leaves are an important component of the diet and are often eaten as staple food providing a significant protein and mineral source, especially of iron and calcium, for many African communities (De Caluwé et al. 2009).

**TABLE 1** Summary of the Most Frequently Documented Food Uses of Baobab Fruits, Seeds, and Leaves in Literature

References	Countries of research	Part of the tree consumed (F = fruit pulp, L = leaf, S = seed)
Ambé 2001	Ivory Coast	F
Assogbadjo 2006	Benin	F, L, S
Assogbadjo et al. 2008	Benin, Burkina Faso, Ghana, Senegal	F, L, S
Barminas, Charles, and Emmanuel 1998	Nigeria	L
Berhaut 1974	Senegal	L, S
Blench 2001	West-Central Africa	F
Booth and Wickens 1988	Africa	F, L, S
Bosch, Sié, and Asafa 2004	Sudan, Kenya, Tanzania, Congo, Malawi, Zambia, Sierra Leone, West Africa, Zimbabwe (literature review)	F, L, S
Burkill 1985	Mali, Burkina Faso, Nigeria, Senegal, Congo, Democratic Republic of Congo, Mozambique, Tanzania, South Africa (literature review)	F, L, S
Chadare et al. 2008	Benin	F, L, S
Codjia, Assogbadjo, and Ekué 2003	Benin	L
Dalziel 1937	Ghana, Nigeria, Senegal	S
Dansi et al. 2008	Benin	L
De Caluwé et al. 2009	Benin	F, L, S
De Caluwé, Halamová, and Van Damme 2009	Nigeria, Congo, Tanzania, Malawi, Ghana, Zambia (literature review)	F, L, S
Dhillion and Gustad 2004	Mali	L
Diop et al. 2006	Africa (literature review)	F, L, S
Dweck 1997	Central African Republic, Sierra Leone, Congo, Tanzania, Ghana, Zambia, Zimbabwe (literature review)	F, S
Etkin and Ross 1982	Nigeria	F, L, S
Gebauer, El-Siddig, and Ebert 2002	Sudan	F, L, S
Igboeli, Addy, and Salami 1997	Nigeria	S
Irvine 1961	Ghana, Senegal, Nigeria, Sierra Leone, Côte d'Ivoire, Democratic republic of Congo, Tanzania, Kenya, Sudan, South Africa, Zimbabwe (literature review)	S
N'Diaye, Kéita, and Martin 2003	Guinea	F
Lamien, Sidibe, and Bayala 1996	Burkina Faso	L
Lockett and Grivetti 2000	Nigeria	L
Obizoba and Amaechi 1993	Nigeria	S
Owen 1970	Africa (literature review)	S
Rashford 1987	Southern Africa	F, S
Salami and Okezie 1994		
Schütt and Wolf 2006	Africa (literature review)	L
Sidibé and Williams 2002	Africa (literature review)	F, L, S
Wickens and Lowe 2008	Africa (literature review)	F, L, S
Zimba, Wren, and Stucki 2005	Zambia	S

*Note.* Literature review covers Africa, with countries of research indicated. (Food uses may not apply to all countries of research in the case of literature reviews.)

Furthermore, the leaves are an excellent source of magnesium and potassium (Diop et al. 2006; Jama et al. 2008). Fresh leaves are cooked in water and consumed as green leafy vegetables or eaten raw as salad. Fresh ground leaves or leaf powder that is obtained through drying, pounding, and sieving, are added as a thickening and flavoring agent to sauces, soups, and cereals. Leaves are also used as fodder.

Baobab seeds are rich in protein and mono- and polyunsaturated fatty acids (De Caluwé et al. 2009). The seeds are roasted and kernel are eaten as snack food or pounded to produce flour. Seed flour can be obtained by first soaking, roasting, boiling or fermenting, and drying the seeds, then by pounding, crushing, or grinding them. The flour is used as a flavoring agent for cereal, porridge, gruels, and soups. It is also mixed with milk, then boiled and sweetened with honey to be consumed as a drink. Ground and roasted seeds are used as coffee substitute. Oil can be extracted by pounding or boiling the seeds.

Most societies recognize that food, medicine, and health are interrelated (Johns and Maundu 2006), therefore both nutritional and medicinal uses of baobab are considered in this study. Most frequently documented medicinal uses of baobab fruit pulp, leaves, and seeds are summarized in table 2. In addition to its many applications in nutrition and medicine, the baobab has numerous veterinary, spiritual, and other uses that are beyond the scope of this article.

## METHODS

This research has been conducted within the Domestication and Development of Baobab and Tamarind (DADOBAT<sup>1</sup>) project. Field research was designed and tested during an exploratory field trip in August–September 2007 to create a methodology that would allow for a regional comparison of the data gathered. The main data collection was undertaken from November 2007 to March 2008. In Benin, Mali, and Senegal, research sites were chosen in four agroecological zones (White 1983) (table 3). Within those agroecological zones, research sites (figure 1) were selected for their abundance of baobab tree populations, according to former tree surveys by our local partner institutes. Eleven ethnic groups were investigated in separate

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<sup>1</sup>DADOBAT is financed by the EU INCO-DEV, 6th framework program. Project Partners: (1) Laboratory of Tropical and Subtropical Agronomy and Ethnobotany, Department of Plant Production, Faculty of Bio-Engineering sciences, University of Ghent, Belgium. (2) Centre for Underutilized Crops (CUC), University of Southampton, UK. (3) Institute for Organic Farming, Department for Sustainable Agricultural Systems, University of Natural Resources and Applied Life Sciences, Vienna, Austria. (4) Laboratoire d'Ecologie Appliquée - Département d'Aménagement et Gestion de l'Environnement - Faculté des Sciences Agronomiques - Université d'Abomey-Calavi, Benin. (5) Insitute of Rural Economy, Mali. 6- Centre d'Etude Régional pour l'Amélioration de l'Adaptation (Ceraas), Senegal.

**TABLE 2** Medicinal Use of Baobab Fruits, Seeds, and Leaves Documented in Literature

Part of tree	Symptoms/illness treated	References
Fruit pulp	Constipation <sup>1</sup> Diarrhoea, dysentery Fever Intestinal inflammations Low iron content in blood Smallpox	(Assogbadjo 2006; Berhaut 1974; Burkill 1985; Codjia et al. 2001; Dalziel 1937; Dweck 1997; Gerber 1895; Hines and Eckman 1993; Kerharo 1974; Kerharo and Adam 1974; Maundu, Ngugi, and Kabuye 1999; Szolnoki 1985; Wickens and Lowe 2008)
Seeds	Diarrhoea, dysentery Diseased teeth and gum Fever Inflammations Intestinal inflammations Wounds	(Arbonnier 2004; Assogbadjo 2006; Berhaut 1974; Booth and Wickens 1988; Burkill 1985; Codjia et al. 2001; Dalziel 1937; Dweck 1997; El-Kamali and El-Khalifa 1999; Hines and Eckman 1993; Kerharo 1974; Kerharo and Adam 1974; Owen 1970; Sidibé and Williams 2002; Szolnoki 1985; Wickens and Lowe 2008)
Leaves	Coughs, asthma and respiratory problems Diarrhoea, dysentery Eye complaints Inflammations of the digestive tract Inflammations Lower blood pressure Malaria Tumors Wounds	(Arbonnier 2004; Assogbadjo 2006; Berhaut 1974; Booth and Wickens 1988; Burkill 1985; Dalziel 1937; Diallo et al. 1999; Dweck 1997; Gerber 1895; Gustad, Dhillion, and Sidibe 2004; Hines and Eckman 1993; Joshi et al. 2004; Kerharo 1974; Kerharo and Adam 1974; Kerharo and Bouquet 1950; Owen 1970; Sidibé and Williams 2002; Wickens and Lowe 2008)

Note. <sup>1</sup>Although baobab fruit pulp is widely used to treat diarrhea and dysentery, in several countries the pulp is also used to treat constipation (Gustad, Dhillion, and Sidibe 2004; Wickens and Lowe 2008).

villages, each with a majority of the particular ethnic group to be investigated and only those informants belonging to that ethnic group took part in the research (table 3). The Peulh, also called Fulani or Fulbe, took part in the research in all three countries. Since migration and subsequent adaptation to different local ecosystems is expected to result in different knowledge systems, these three Peulh groups are therefore regarded as three different ethnic groups in this ethnobotanical research and are thus counted three times.

A stratified purposeful sample (Bernard 2006) was used with the strata “ethnic group” and “sex.” Local informants participated and provided information on a voluntary basis after educated prior informed consent. The International Society of Ethnobiology (ISE) Code of Ethics (ISE 2009) was respected during all stages of research. The informants were aged between 10 and 108 years (mean: 41). Informants ( $N = 220$ ) perform work as farmers (43%), in the household (25%), as pupils/students (11%), in commerce (7%), in handcraft (4%), as traditional healers (3%), as herders (1%), and in other occupations (6%). Fifty-three percent of informants (32% male and 20%





**FIGURE 1** Research sites in West Africa (countries of research in dark gray, each research site marked by dot and village name).

female) have been formally educated: 26% of informants attended primary school level, 17% of informants attended secondary school level, and only 1% continued with higher education. The prevalent religion in the research region is Islam. Among the informants 79% are Muslims, 15% are Christians, and 6% stated they were animists, although most informants continue to practice animism even if they officially report to be Muslim or Christian.

In total 220 individual interviews were conducted. The structured questionnaire (Bernard 2006) used in the individual interviews yielded the main body of ethnobotanical data on:

- characteristics, use, processing, storage, harvest, management, and propagation of baobab
- dynamics, origins, and distribution of knowledge
- access rights and tree tenure
- belief systems and ceremonies related to baobab

Semi-structured interviews based on agricultural calendars and participatory resource mapping were used in group discussions on resource access and

**TABLE 3** Research Sites, Ethnic Groups, and Vernacular Names of Baobab Used

Country	Agroecological zone	Village	Ethnic group	Vernacular name of baobab
Benin	Soudanean	Mamassy Peulh	Peulh (Fulbe)	Boki
		Birni Lafia	Dendi	Kôô
		Mamassy Gourma	Gourmantché	Boutouobou
Mali	Soudano-Guinean	Manigri	Nagot (Yoruba)	Ossé
	Soudano-Guinean	Kpakpa Igbo	Idatcha	Oche
	Sahelian	Bendjely	Dogon	Oro
	Soudanean (North)	Njaanaanjali	Peulh (Fulbe)	Oki
	Soudanean (South)	Bakaribougou	Sénoufo	Sira (Bambara name)
Senegal	Sahelian	Tabarako		Jaigue
		Niakhoul	Wolof	Guiy
		N'Dande		Gouye
		Sackal		Gouye
	Soudano-Sahelian	Coki		Gui
		M'bassis	Serer	Mbak
		Mt Rolland		Mbak
	Soudanean	Foua 1		Mbah
Ibel		Peulh (Fulbe)	Bohehi (Sing.), Bohe (Plural)	
Velingara			Bohi	

local tree tenure systems. Notes on participant and non-participant observation were collected in a field diary, and subsequently coded and analyzed. This information served to triangulate data and provide additional qualitative data about the informants' life and plant related actions. No plant voucher specimen were collected as the main emphasis of this study lies on one plant species, *Adansonia digitata* L., easily identifiable by all researchers. In the study region there are no other *Adansonia* species to be found that could be misleading identification by both researchers and informants. Data was stored in an Access database. For the data analysis Microsoft Access (Microsoft 2003), Excel (Microsoft 2003) and SPSS 16 (Novell 2007) were used.

## RESULTS

In total, 300 different uses were recorded during the field research and sorted into use groups: medicinal, nutritional, spiritual, ethnoveterinary, and other uses. The differentiation between the uses is based on variations in preparation (e.g., cold extraction, boiling, fermentation), application (e.g., external, internal) and product form (liquid, paste, powder). When related to medicinal uses the differentiation is also based on the illness or symptoms that need to be treated (e.g., malaria, fever, fractures). The resulting overview shows that the medicine-use group contains the greatest variety

with 179 different uses. In comparison with the great variety of medicinal uses, the 34 documented nutritional uses seem few. Although only 24 spiritual uses were documented, the number of applications for spiritual uses can be assumed to be much higher in reality, as it proves difficult for those outside the community to collect such privileged information. There were 47 “other uses” documented, including uses such as construction (baobab wood used as formwork for cement), fire wood, rope-making (used to attach livestock, or water buckets at wells), fertilizer, soap making, and many others which were not mentioned frequently. Sixteen ethnoveterinary uses were reported. This is the only use category that shows statistical significance ( $p = .001$ , using a chi-square test) between the sexes, explained by the fact that it is usually men that are herders. One-third of informants stated that the baobab is their “most important” tree in comparison with other useful trees found in the local ecosystems. In order to understand the prominent position of the baobab, direct questions were asked on the reasons for that choice (table 4). The reason “multiple uses” applies when informants stated that they value the range of uses that can be applied from just one tree species. The Kruskal-Wallis test indicates significant differences between the uses ( $p = .000$ ). The Mann-Whitney test shows that the use as nutrition is cited significantly more often than the other uses ( $p = .000$  for each) and that the use as medicine is listed more often than multiple uses, commerce and tradition ( $p = .000$  for each). There is no difference between these last three uses.

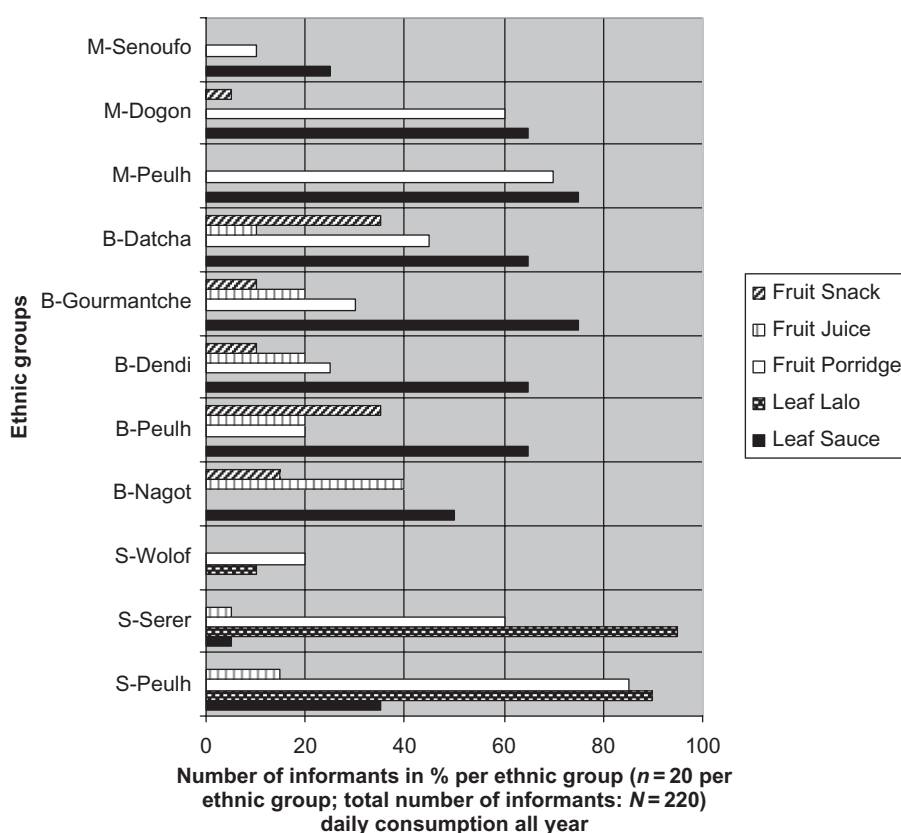
Every part of the baobab is used. The uses of capsule (36 uses), roots (26), *Tapinanthus spp.* (French: *gui*) (30), seeds (19), wood (11), and gum (10) are more numerous than expected and provide proof for the “holistic” use of the baobab in rural West Africa. The inclusion of *Tapinanthus* species in this calculation is grounded in the fact that the informants consider this (semi-) parasitic plant as part of the tree thus carrying the same properties as their host. The fruit pulp carries the greatest variety of uses (49) and is named most frequently by all ethnic groups as being used in nutrition (368 answers,  $N = 220$ , multiple answers possible) and medicine (66). Baobab leaves are used frequently for nutrition (239) and medicine (65) and their use is based on 35 different applications.

**TABLE 4** Reasons for Local Importance of Baobab (Multiple Answers Possible)

Reason	Number of informants ( $N = 220$ )
Nutrition	164
Medicine	58
Multiple uses	23
Commerce	19
Tradition	13

## Frequency of Consumption

Baobab leaves and fruits are consumed daily by over 90% of all informants (leaves: 97%, fruits: 93%) including all ethnic groups (figure 2). Differences of food use between ethnic groups relate to preferred food preparation methods. “Lalo,” dried leaf powder that is added to couscous, is preferred in Senegal. In Benin and Mali the leaf sauce, prepared from dried or fresh leaves to serve as a separate condiment to a staple food, such as boiled millet, is most widely appreciated. Fruit porridge and/or fruit juice is consumed daily by each ethnic group (figure 2). Additional consumption during harvest periods, when there are plenty of baobab products available, and frequency of consumption per day are not included in figure 2. However, data reveals that in Mali the leaf sauce is consumed twice daily by the Peulh,



**FIGURE 2** Frequencies of year-round baobab leaf and fruit consumption (at least 1 portion/day) per ethnic group (countries coded: Mali: M, Benin: B, Senegal: S). Percentages reflect the number of informants stating leaf and fruit consumption per ethnic group (100% = 20 informants). The figure primarily indicates the continuous and daily use of leaves and fruits and not the amount of leaves and fruits consumed.

Dogon, and Sénoufo ethnic groups and in Benin, the Peulh, Dendi, and Gourmantché ethnic groups all consume the fruit porridge twice daily.

### Distribution of Knowledge on Baobab Use

No significant correlation was confirmed between baobab fruit and leaf use with gender, occupation, education, ethnic group or religion (using chi-square tests), and age (using Pearson correlation). Thus, social background of the informants does not seem to influence the use of baobab fruits and leaves. However, the exact knowledge on the preparation is partly linked to gender, the most prominent example being the production of rope using baobab bark fibers, as this is an activity undertaken by men only. Women may be more trained in the practical preparation of the daily food, but men knew very well how to explain the food preparation. Young boys are often called to assist their mothers and learn the traditional food preparation according to the family's traditions. The preparation of a tasty baobab sauce is regarded as an important heritage that is passed on to the younger generations within the families, but not necessarily shared with the neighbors. In a Senoufo village in Mali, some women are well-known for their delicious baobab sauce, thus raising their stakes in the search for a husband. This is just one example of how ethnic identities are interwoven with the use of the baobab. Specialist knowledge that may not be shared evenly throughout the population includes spiritual and medicinal knowledge. Such knowledge most probably was not shared with the researchers and therefore will not appear in the statistics, but is assumed to be significant.

### Local Fruit Preferences

More than half of the informants (57%,  $N = 220$ ) prefer sweet fruits. Baobab trees bearing the “most delicious” fruits, according to local preferences, are quickly harvested with no mature fruit left hanging on the tree. Baobab varieties that have no acquired fruit taste are left untouched, and fruits from the past year can be seen among the present years fruit crop on the same tree. Less preferred fruits are mixed with more tastier fruits or sold to larger city markets, where customers may not be so “picky” about the taste of the fruit pulp.

### Harvesting Techniques

Harvesting requires virtually no cash investment, as equipment is generally confined to inexpensive hand tools such as knives or bamboo canes. Harvesting baobab leaves can be difficult, due to the trees' height and soft, spongy wood, both increasing the risk of accidents for the harvesters climbing

the tree. Baobab leaves are not picked from the shoots, but complete shoots are often broken off the tree. Such harvest technique reduces the number of flower buds, as these are either damaged or removed entirely together with the shoots. This sometimes results in a rather strange picture of a baobab fruiting only in parts of the crown that people cannot reach. Trees that are known to produce delicious leaves, according to local taste, are harvested as soon as 1–2 weeks after the young leaves emerge at the beginning of the rainy season. Some baobab trees are protected through sacred forests and may not be harvested. The fruits from non-sacred baobab trees are harvested through handpicking by children climbing the trees, or by women pulling off the fruits with a knife or hook mounted on a long bamboo cane.

### Access Rights

Access rights to baobab trees may be officially regulated by forestry laws. But in reality it is often at the village community level where access to baobab trees is regulated through informal institutions and local rules, usually set by the village chief and a group of village elders. Access regulations can, for example, depend on the state and ownership of the field in which a baobab is growing, e.g., access may be guaranteed to the family owning the field in time of cultivation, but access to trees on the same field may be open to any village member or even passers-by in times of fallow. Signs, such as stones and branches, are placed under the trees to indicate special harvest restrictions, e.g., for spiritual reasons or to ward off “thieves.”

The following example shows how difficult it is to conserve the wild baobab trees through formal law. In Northern Benin, a forestry law was put in place with the aim to support baobab regeneration as well as to control and reduce unsustainable harvest techniques. The law requires that farmers buy harvest-permits from the local forestry service. Ironically, the law may protect some wild trees, but does undermine local farmers' incentives to domesticate and integrate the baobab in their agroforestry systems. The farmers in Northern Benin reported that they now chose to remove baobab seedlings from their fields, because they would need to buy permits for their use in the future. From their perspective, and with the current baobab-forestry law in place, it makes more sense to plant exotic trees that can be freely harvested, sell those products and buy baobab leaves and fruits on the market.

## GENDER RELATED TASKS

Women help young boys and girls in harvesting and then process, store, and prepare baobab leaves and fruits for consumption. Surplus is sold by

women at the local market to earn some cash income, which is often spent on children's clothing, food, or school fees. Local women know the types, quality, and prices of baobab fruit pulp, seeds, and leaves on the local markets and can therefore make a conscious decision when, or if, to sell or to store the baobab surplus.

As space in agricultural fields is highly valued, large baobab trees present a competition to the main staple crop. Traditionally, men decide which trees to cultivate in the fields and they often prefer exotic cash crops, such as mango (*Mangifera indica* L.) or cashew (*Anacardium occidentale* L.). Women sometimes try to influence the decision making process, but rarely succeed in convincing the men to plant baobab trees to facilitate women's access to baobab trees. As a result, women and children may have to walk up to two hours in one direction to collect baobab fruits, leaves, and other useful parts from wild growing trees, an issue that was raised during the participatory resource mapping exercises. Women may be allowed access to baobab trees which line the fields owned by other families saving them the long walk to the baobab trees growing in the bush land. Social networking, especially among women, is vital to ensure a continuous access to privately owned baobab trees.

## DISCUSSION

One argument supporting the commercialization of natural products is to improve livelihoods through an increased value in natural products and a subsequent increase in income and employment opportunities, especially for poor and otherwise disadvantaged people (Nemarundwe, Ngorima, and Welford 2008; Shackleton, Shanley, and Ndoye 2007). On the contrary, Belcher and Schreckenbergh argued, that the commercialization of NTFP, in this case baobab, cannot achieve both livelihood improvement as well as ecosystem and species conservation (in Nemarundwe et al. 2008). Possible effects of the export oriented commercialization of baobab are estimated on the rural livelihoods in Mali, Benin, and Senegal. The effects of any potentially profitable changes on well-being (quality of life, health, education), economic factors (assets, capital, labor availability, credit, and cash), equity (fairness, benefit sharing) and risk should be thoroughly examined (Lowore 2001) and feed into business plans aiming to develop a sustainable export market of baobab. Some of these topics are discussed in detail highlighting regional differences and local peculiarities that may otherwise be overlooked.

### Regional Differences in Subsistence Use and Preferences

In the ethnobotanical literature a great variety of baobab uses are documented (tables 1 and 2). Many of these papers refer to traditional uses of

baobab in West African countries. This study confirms the importance of the baobab in three West African countries, Mali, Benin, and Senegal, where it is used extensively in daily subsistence of rural people. But as consumption increases in times of cereal crop failures it also serves as a crucial source of nutrition during times of scarcity, for example in Mali (Dhillion and Gustad 2004). In Benin, the time of baobab fruiting and harvest corresponds to the season of food shortage (Assogbadjo et al. 2006).

Knowledge on baobab uses is spread evenly across rural communities, mostly unrelated to social data, such as ethnic group, gender, age, occupation, education, or religion. The baobab is inextricably linked with the cultural identity and social well-being. This is particularly the case with regions, such as the Sahel, where people have been living off the same resources for centuries (Kahlheber 2005). These natural resources, such as the baobab, represent their origin, ancestors, culture, and thus their identity.

This field research confirms that in West Africa the fruits and leaves of the baobab are consumed daily and all year around (Assogbadjo et al. 2008). This adds valuable minerals and vitamins to the otherwise micronutrient-“poor” staple crops. It has been estimated that 6–55 g of baobab dried leaf powder is consumed in West Africa per day per person (Gustad, Dhillion, and Sidibe 2004), and on a larger scale, that several thousand tons of baobab leaves are consumed in the Sahel per year (Von Maydell in Gebauer 2003). It has also been described as the most consumed tree in the Ivory Coast (Ambé 2001). In comparison, a thorough literature review on ethnobotanical use of baobab leads to the impression that baobab products are not as integrated in the South African daily local diet and rural subsistence as in other parts of Africa. If based on an abundance of otherwise unused baobab fruits, their export from South Africa is expected to support local livelihoods, especially when export is facilitated through a well established cooperation of several companies and NGOs that base their activities on socially just and environmentally sustainable principles. It should, however, not be overlooked that baobab trees act as “safety-nets” providing multiple goods and services needed by local people in times of scarcity. Developing a market for baobab products needs to be thoroughly kept in balance with consideration of the continuing local use in subsistence (Lowore 2001).

Although there may be ethnic differences in baobab use value and use patterns (Assogbadjo et al. 2008; Chadare et al. 2008; De Caluwé et al. 2009), baobab is used by many different ethnic groups in West Africa as a significant part of their diet and pharmacopoeia (Gustad et al. 2004). Our sample shows that across 11 ethnic groups baobab leaves and fruits are consumed by over 90% of all informants (leaves: 97%, fruits: 93%). Although all parts of the baobab are used (see also Gustad et al. 2004; Wickens and Lowe 2008), this study has shown that baobab fruit pulp carries the greatest variety of uses. West Africans recognize several types of baobab (Assogbadjo



et al. 2008) and prefer sweet fruit varieties. One solution to share fruit supply with the EU market, based on a limited amount of fruits harvested from the wild, could include exporting the locally “rejected” fruits and keeping the preferred varieties in West Africa. Export markets usually keep the low quality goods in the producing country while supporting the export of high quality goods (“export quality”). However, since the fruit pulp will most likely be added as an additional ingredient into smoothies, yoghurt, muesli bars, and other snacks, the difference in taste will most likely not be detected by the European consumers. But to export locally preferred varieties to the EU would create a nutritional gap in the local diets of rural West Africans.

### Sustainable Tree Management

The local and regional high demand for baobab leaves reduces the number of fruiting baobab trees due to unsustainable leaf harvest techniques that include removing the flower buds. In addition, large branches of baobab varieties with preferred leaves are deliberately pruned to stimulate leaf growth instead of fruit production (Assogbadjo 2006). Undoubtedly, the growing local demand as a result of an increasing human population needs to be accompanied by more sustainable harvest techniques to secure the harvest for future generations. High land pressure, high dispersion of agriculture and pasture pressure limit natural regeneration of the baobab (Johansson 1999). Other risk factors for young trees are drought, fire, and damages caused by animals and agriculture (Schütt and Wolf 2006). Recent studies in Benin emphasized a natural regeneration problem of baobab, due to wild bush fires and other anthropogenic activities, such as land clearing and browsing leading to declining baobab populations (Assogbadjo 2006; Assogbadjo et al. 2008). Shortened fallow periods of Sahelian parklands could exacerbate this trend (Schreckenber 2004).

The baobab has not been commercially domesticated and there are currently no baobab plantations, nor conservation areas that have been specifically set aside for the protection of the baobab. Throughout most of Africa, indigenous trees belong to the “bush,” are considered “wild” and are therefore not planted (Jama et al. 2008; Kristensen and Lykke 2003; Lemay 2005; Mukadasi and Nabalegwa 2007; Muok et al. 2000; Nordeide et al. 1996; Robinson 2006; Shepherd 1992; Tabuti, Dhillion, and Lye 2003). The domestication of baobab and the development of plantations may be needed to create a “sustainable” production of baobab for export. When grafted, baobab trees will produce fruits after 3–4 years (SCUC 2006), however none of the 220 informants reported grafting nor any other vegetative propagation technique. Workshops on propagation techniques will be held across all research countries by the DADOBAT project in spring 2010 to encourage local domestication efforts. However, plantations require a high

investment (Lowore 2001) and arable soil and access to water is limited. One plantation solution may be young baobab, or bonsai baobab, gardening systems for the production of leaves, as has been tested in Mali (ICRAF 2003; Lemay 2005; Sidibé and Williams 2002). These systems could increase fruit production of wild baobab trees as flower buds, otherwise damaged through leaf harvest, will be left undisturbed. Even if leaf production for local use could be met through young baobab plantations, fruit production will, at least in the next decade, depend on wild and mature baobab trees. Therefore the trees and their natural habitat need to be sustainably managed.

### Locally Acceptable Regulations

As a prerequisite, trade promotion initiatives should be supported by a favorable policy environment to avoid detrimental impacts on vulnerable ecosystems. Welford and le Breton (2008, 70), partners at PhytoTrade Africa, the trade cooperation that lobbied for the EU novel food law, have acknowledged the risk that “growing demand will promote unsustainable harvesting practices that, eventually, will threaten the resources from which the trade is derived.” If the new export plans are implemented without any enforceable regulations regarding sustainable harvest mechanisms, there is a high risk of the overexploitation of existing baobab populations. However, implementing regulations could prove difficult. As the example of local forestry law in Benin has shown, formal regulations to conserve wild baobab populations with a harvest-permit scheme, could prove counterproductive and even diminish domestication efforts by local farmers. Regulations aiding the commercialization of baobab fruits, while ensuring sustainable harvest, need to be well adapted to the local conditions. Tree management for commercial enterprise and for subsistence services needs to be based on data specifying off-take and regeneration rates. Such rates need to be known and monitored to assess ecological and socio-economic sustainability. Local harvesters could be trained to ensure sustainable harvest and yields and receive a one-year certificate (Nemarundwe et al. 2008). Monitoring of natural tree regeneration and impact of harvesting techniques can be regularly assessed and directly feed into new training courses. In Namibia such training courses, led by the Ecoso Dynamics Company, have been successfully guiding local harvesters towards environmentally friendly harvest methods of the Devil’s Claw (Nemarundwe et al. 2008).

### Secured Access and Food Safety

Access rights are influenced by formal, informal, and bylaws, including local conventions and social customs within villages and between neighboring villages (Alinon and Kalinganire 2008; Shepherd 1992; Vermeulen et al.

2008). Traditionally women and children are responsible for the baobab leaf and fruit harvest. If the harvest is plentiful, women sell the surplus at local markets and often invest in clothes for children or condiments for family meals (Assogbadjo 2006). The commodification of NTFPs, such as baobab, may have profound effects locally, including the change from a women's to a men's crop as it gains commercial value (Lowore 2001; Schroeder 1995). In addition to losing the cash income from selling baobab produce locally, women may lose access rights and social networks related to baobab management and exchange. When rural populations lose access to important natural resources their reduced diet could result in food insecurity, malnutrition, and disease (Johns and Maundu 2006). Especially children and pastoralists, heavily involved in harvesting baobab fruits, may lose their access to snacking on the fruits, and therefore miss out on a valuable source of minerals and nutrients in their diet.

The commodification of natural resources can also lead to the imposition of new forms of property claims and the introduction of inequitable labor relations that will further marginalize the poor, who could be out-competed by more powerful elites that have more capital to invest and better connections (Belcher 2003; Emery 2002; Nemarundwe et al. 2008; Schroeder 1995; Welford and Breton 2008). What is now commonly shared bush land may be taken over by agribusiness men and turned into plantations. The risk of the introduction of novel market mechanisms is that they will “not alter existing unequal power relations, but provide yet another field in which those inequalities are played out” (Schroeder 1995, 142). As a consequence, harvest restrictions, imposed by powerful elites, could overrule traditionally regulated access rights and “raise the specter of previously traditional practices being converted into criminal offences” (Emery 2002, 311).

If restricted access is introduced, it is likely to apply to the whole tree and today's 300 different uses of baobab may no longer be employed. Restricted access could be especially detrimental in the medicinal domain, possibly resulting in a loss of knowledge of the great variety of 179 baobab-based medicinal treatments. This could force patients to use substitute species that may not be as effective, or to spend money on pharmaceuticals. Restriction of access to the baobab will also impact people's spiritual relationships to the trees, which is important to many West African cultures.

### Certification of Baobab Products for the Export Market

European consumers are increasingly aware of the social and environmental issues related to the products they buy. Attention to such issues is increasingly being seen as a marketing plus, while ignoring them is seen as a business risk (Vermeulen et al. 2008). Article 11 of the Convention on Biological Diversity (CBD) recognizes the development or promotion of markets for biodiversity-based goods as an important measure for conservation

and sustainable use of biodiversity, and the program of work, adopted by the Conference of Parties in 2000, suggests the development of methods to promote biodiversity awareness in consumer decisions, for instance through eco-labeling (Lehmann 2007). Certification of baobab products could “address the socio-political, ecological, and economic failings that have been empirically observed in ongoing NTFP commercialization efforts” (Wilsey and Radachowsky 2007, 46).

The certification scheme for NTFPs, such as baobab pulp, needs to fit into the socio-ecological conditions of the region of production and be supported by relevant policies and regulations (Mayrand and Paquin 2007). New certification schemes are specifically developed for NTFP commercialization, for example the Natural Futures program supported by the IUCN (IUCN 2008). The advantage of committing to certification is that stakeholders are forced to be specific in choosing trading partners and identifying customers, thereby creating a relationship and direct feedback, and possibly cutting out the middlemen (Lowore 2001). Possible certification schemes for baobab fruit pulp commercialization are as follows.

#### ORGANIC CERTIFICATION

Baobab pulp is an organic product, and will continue to be so, if fruits are harvested from the wild and from agroforestry systems that are traditionally managed without agrochemicals. The International Federation of Organic Agriculture Movements (IFOAM), the Codex Alimentarius Commission of the Food and Agriculture Organisation (FAO) and the World Health Organisation (WHO) are working to develop international standards for organic products with special criteria for wild-harvested products. Their principles include not only the conservation of biodiversity and natural ecosystems, but also social principles, such as promoting farmers' quality of life through adequate returns and work satisfaction (Wiersum 2006). However, organic certification is costly and logistically challenging (Welford and Breton 2008; Wiersum 2006). Community-based internal inspectors can be trained to monitor organic production and ensure that set standards are met (Nemarundwe et al. 2008), since the simple costs of inspecting a widely dispersed, geographically remote, and comparatively unorganized set of rural producers could otherwise act as a disincentive to certification (Welford and Breton 2008).

#### FAIR TRADE CERTIFICATION

Through the development of efficient and reliable value chains, Fair trade systems could improve the livelihoods of poor rural communities (Nemarundwe et al. 2008). Fair trade certification specifically supports small-scale, family based producers, who have been disadvantaged by trade conditions. The overall principles underlying the Fair trade certification system relate primarily

to the need for a just social and economic development as well as labor relations, in addition attention is given to the need for sustainable environmental development (Wiersum 2006). But, “Environmental issues are included only as they relate to the worker environment, to the quality of the natural resource base as a component of the quality of life, and to economic sustainability” (Wilsey and Radachowsky 2007, 53). Emery warns that Fair trade certification “is unlikely to protect subsistence gatherers’ interests” (Emery 2002, 312), which is a major concern for baobab in West Africa, as argued here.

#### NTFP CERTIFICATION

Wilsey and Radachowsky (2007) state that the Forest Stewardship Council’s (FSC) Principles and Generic Guidelines have emerged as the most advanced and legitimate attempts at NTFP management standards (See also Shanley, Pierce, and Laird 2005). As the name suggests, this certification applies to forests rather than to agroforestry systems and it may be especially difficult to apply this scheme to baobab production in the Sahelian bush land with sparse cover of indigenous trees. Another hurdle may be the FSC principle that demands a clear definition and document on long-term tenure and land use rights. Creating land-right documents where tenure and access rights may have been traditionally passed on orally and were subject to discussion in informal institutes could further marginalize the poor and landless. In addition, “The drive to specify who has access to products in a given location is likely to privilege those who are identified as gatherers at the time such terms are set and exclude those who are not, thus reducing the temporal flexibility of NTFP subsistence uses” (Emery 2002, 311).

In choosing the most fitting certification scheme in accordance with local social-ecological conditions and in considering the above arguments to carefully develop certified, sustainable baobab production for international markets, the baobab trade may be spared the price volatility that accompanied the concentration of drylands exports of commodities such as cotton and groundnuts (Chamay, Bellmann, and Gueye 2007; Robbins 2003) or the inequality of benefit distribution as was the case with argan oil commercialization in Morocco (Lybbert et al. 2002). In addition to developing and adhering to a holistic certification scheme, as discussed above, the development of sustainable production and trade chains of baobab products should not only focus on export, but also ensure supply for local markets.

#### Keeping Baobab on Local Markets while “Trading Up” to International Markets

The emphasis on global markets often overshadows attention to the local markets in traditionally important products. Local markets provide low-income

consumers with culturally valued, low-cost, and often highly nutritious products (Shackleton et al. 2007). Local markets also play a crucial role in strengthening livelihoods and improving income opportunities. They may in fact provide more development than export to international markets, as many more people are involved in those markets, and they are more easily understood and accessible to small producers (Lowore 2001; Shackleton et al. 2007). Farmers can participate in local markets on the base of their harvesting and processing skills, not necessarily needing marketing skills and education. An inattention to local markets can result in diminished appreciation of their role in supporting livelihoods, which could potentially lead to further marginalization of the low-income groups, and especially women, involved (Shackleton et al. 2007).

In West Africa, baobab products play an important role in the local markets (Assogbadjo et al. 2008; Gustad et al. 2004; Shackleton et al. 2007). On the weekly market in Cinzana, Mali, baobab fruit powder was among the highest priced NTFPs costing 6 to 10 times more than small millet, which is the main staple crop in the region (Gustad et al. 2004). A five month survey on the weekly regional market in Malanville, Benin, has shown that 200 tons of baobab seeds coated with pulp, 10 tons of baobab pulp and 1 ton of baobab leave powder were commercialized and generated up to 15 million FCFA (US\$30,000), 400,000 FCFA (US\$800) and 200,000 FCFA (US\$400), respectively, for 139 rural populations involved in that business (Assogbadjo 2006). The marketing of baobab peaks in the dry season, when other agricultural goods are becoming rare (Assogbadjo 2006) and often provides a secondary means of income generation and a much needed buffer in times of drought and famine (Sidibé and Williams 2002). It has also been noted that the present demographic growth and urbanization suggest that the regional demand for these products is not declining (Gustad et al. 2004).

Value is added through processing and packaging, although unprocessed fruits and fresh leaves are marketable as well. Processed baobab products, such as dried leaf powder, cleaned seeds, and fruit pulp flour are sold on local and regional markets in West Africa (Chadare et al. 2008; Sidibé and Williams 2002). On the contrary, in South Africa whole fruits are sold, generating little income as no value is added (Nemarundwe et al. 2008). This regional difference between South and West Africa show that there will be great disparities in impact and outcomes of the commercialization of the baobab.

For local communities now selling baobab on local markets, the EU market is an unpredictable one. Export markets tend to be guided by policies that favor large-scale corporate interests that frequently conflict with local priorities and values, whereas local markets can potentially offer a more appropriate socio-cultural fit (Shackleton et al. 2007). Growing concerns regarding carbon emissions, the cost of aviation fuel, and airfreight

could negatively impact export. In addition, the access to international markets usually requires pre-arranged, often already contracted, quantities of goods. The engagement of specialists to organize the production and marketing of large quantities of products becomes essential (Lowore 2001). Such dependence on new intermediaries will leave the local people more vulnerable to corruption. This underlines the critical need to train local people to be better able to negotiate fair prices, as well as to gain other skills and assets required in trade and business. Training should be provided by local and international NGOs as it is unlikely that trade companies will deliver business training, risking tougher negotiations with local producers as a consequence. Real improvements in trading require a simultaneous attention for improved chain relations, i.e., the strengthening of relationships between farmers and traders, and the introduction of stronger market institutions (KIT and IIRR 2008). At the same time, governments of countries that represent potential markets, in this case the EU member countries, need to create an enabling economic environment that is conducive to the promotion of sustainable management, as stipulated in article 4(b) of the United Nations Convention to Combat Desertification (Kutsch-Lojenga 2007). The combination of strong domestic, regional, and export markets seems the best option allowing for diversification, and thus increased livelihood resilience against fluctuations in any one of these markets.

## CONCLUSION

This article draws upon research in three West African countries and across 11 ethnic groups to demonstrate the importance of baobab leaves and fruits in subsistence for rural communities, and compares this research with the wider literature on baobab throughout Africa. Although preferences and preparation of baobab-based meals differ between ethnic groups, these meals are consumed daily and throughout the year by all ethnic groups within our sample. Baobab fruits and leaves provide essential nutrients, vitamins, and minerals to rural communities complementing an otherwise nutrient-poor staple-crop based diet. In addition the use of baobab is appreciated in traditional medicine.

The approval of baobab fruit pulp as a novel food on the European market provides a great opportunity. However, this new export market opportunity needs a cautionary approach that is adapted to regional conditions and differences. It is of utmost importance that current baobab use in subsistence is not undermined by commercialization and that access to wild baobab populations remains guaranteed for local communities.

In the interest of local resource needs, nutrition, and conservation and to prevent conflict between local consumers and international traders this article aims to emphasize current problems that need to be faced before

considering export of baobab fruits for international markets. This study aims to trigger a discussion between all the stakeholders which is best held now rather than later.

Domestication and market development efforts need to consider local use of all baobab plant parts. The commercialization of baobab needs to be based on sound scientific information, include capacity building on sustainable land management, and be developed in accordance with good economic, environmental, and social governance. If West African countries strive to further commercialize the baobab beyond regional markets, stakeholders need to tread carefully to ensure the creation of a reliable, socially and ethically just supply chain. It is important that primary producers are engaged in sustainable harvesting and receive an equitable share of the profits in compliance with access and benefit sharing standards. Trade policies should take gender disparities into account and create an environment that empowers communities to participate in advocacy. Stakeholders that will be part of the baobab fruit export should grasp the opportunity to cater certified products for consumers that are increasingly aware of the social and environmental impact of their consumption patterns.

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#### REFERENCES

- Alinon, K., and A. Kalinganire. 2008. Effectiveness of bylaws in the management of natural resources: The West African experience. CAPRI (Collective Action and Property Rights), Working Paper No. 93. Washington, DC.
- Ambé, G. A. 2001. Les fruits sauvage comestibles des savanes guinéennes de Côte d'Ivoire: État de la connaissance par une population locale, les Malinké [Edible wild fruits in Guinean savannas of the Ivory Coast: State of knowledge by local population, the Malinké]. *Biotechnology, Agronomy, Society and Environment* 5 (1): 43–58.
- Arbonnier, M. 2004. *Trees, shrubs and lianas of West African dryzones*, CIRAD. Weikersheim, Germany: Margraf Publishers GmbH, MNHN.



- Assogbadjo, A. E. 2006. Importance socio-economique et etude de la variabilité écologique, morphologique, Génétique et Biochimique du Baobab (*Adansonia digitata* L.) au Benin. Diss., Faculty of Bioscience Engineering, University of Ghent, Belgium.
- Assogbadjo, A. E., E. de Caluwé, B. Sinsin, J. T. C. Codjia, and P. van Damme. 2006. Indigenous knowledge of rural people and importance of Baobab tree (*Adansonia digitata*) in Benin. Paper read at IVth International Congress of Ethnobotany (ICEB), 2005, Istanbul, Turkey.
- Assogbadjo, A. E., R. Glèlè Kakai, F. J. Chadare, L. Thomson, T. Kyndt, B. Sinsin, and P. Van Damme. 2008. Folk classification, perception and preferences of baobab products in West Africa: Consequences for species conservation and improvement. *Economic Botany* 62 (1): 74–84.
- Barminas, J. T., M. Charles, and D. Emmanuel. 1998. Mineral composition of non-conventional leafy vegetables. *Plant Foods for Human Nutrition* 53 (1): 29–36.
- Belcher, B. M. 2003. What isn't an NTFP? *International Forestry Review* 5 (2): 161–168.
- Berhaut, J. 1974. *Flore illustrée du Sénégal* [Illustrated flora of Senegal]. Senegal: Librairie Clairafrique.
- Bernard, H. R. 2006. *Research methods in anthropology. Qualitative and quantitative approaches*. 4th ed. Walnut Creek, CA: AltaMira Press.
- Blench, R. 2001. Trees on the march: The dispersal of economic trees in the prehistory of West-Central Africa. ODI, SAFA Conference, Cambridge, UK, May 26, 2000.
- Booth, F. E. M., and G. E. Wickens. 1988. *Non-timber uses of selected arid zone trees and shrubs in Africa, FAO Conservation Guide*. Rome: Food and Agriculture Organization of the United Nations.
- Bosch, C. H., K. Sié, and B. A. Asafa. 2004. *Adansonia digitata* L. Record from Protabase, ed. G. J. H. Grubben and O. A. Denton. Wageningen, the Netherlands: PROTA (Plant Resources of Tropical Africa). <http://database.prota.org/search.htm> (accessed April 26, 2010).
- Burkill, H. M. 1985. *The useful plants of west tropical Africa*. vol. 1. Kew, UK: Royal Botanical Gardens, Kew.
- Chadare, F. J., J. D. Hounhouigan, A. R. Linnemann, M. J. R. Nout, and M. A. J. S. van Boekel. 2008. Indigenous knowledge and processing of *Adansonia digitata* L. food products in Benin. *Ecology of Food and Nutrition* 47:338–362.
- Chamay, M., C. Bellmann, and M. Kamal Gueye. 2007. Trade, rural development, livelihood and food security in dryland countries. In *Trade and sustainable land management in the context of drylands. ICTSD Project on Trade and Sustainable Land Management. Selected issue briefs.*, 5–14. Geneva: International Centre for Trade and Sustainable Development.
- Codjia, J. T. C., A. E. Assogbadjo, and M. R. M. Ekué. 2003. Diversité et valorisation au niveau local des ressources végétales forestières alimentaires du Bénin. *Cahiers d'études et de recherches francophones / Agricultures* 12 (5): 321–331.
- Codjia, J. T. C., B. K. Fonton, A. E. Assogbadjo, and M. R. M. Ekué. 2001. Le baobab (*Adansonia digitata*), une espèce à usage multiple au Bénin. Cotonou, Benin: CECODI/CBDD/VeCo/SNV/FSA.
- Dalziel, J. M. 1937. *The useful plants of west tropical Africa*. London: Crown Agents for the Colonies.

- Dansi, A., A. Adjatin, H. Adoukonou-Sagbadja, V. Faladé, H. Yedomonhan, D. Odou, and B. Dossou. 2008. Traditional leafy vegetables and their use in the Benin Republic. *Genetic Resources and Crop Evolution* 55 (8): 1239–1256.
- De Caluwé, E., S. De Smedt, A. E. Assogbadjo, R. Samson, B. Sinsin, and P. Van Damme. 2009. Ethnic differences in use value and use patterns of baobab (*Adansonia digitata* L.) in northern Benin. *African Journal of Ecology* 47 (3): 433–440.
- De Caluwé, E., K. Halamová, and P. Van Damme. 2009. Baobab (*Adansonia digitata* L.): A review of traditional uses, phytochemistry and pharmacology. In *African natural plant products: New discoveries and challenges in chemistry and quality*, ed. J. H. Rodolfo, J. E. Simon, and C.-T. Ho, chap. 4, 51–84. Washington, DC: American Chemical Society.
- Dhillion, S. S., and G. Gustad. 2004. Local management practices influence the viability of the baobab (*Adansonia digitata* Linn.) in different land use types, Cinzana, Mali. *Agriculture, Ecosystems & Environment* 101 (1): 85–103.
- Diallo, D., B. Hveem, M. A. Mahmoud, G. Berge, B. S. Paulsen, and A. Maïga. 1999. An ethnobotanical survey of herbal drugs of Gourma District, Mali. *Pharmaceutical Biology* 37:80–91.
- Diop, A. G., M. Sakho, M. Dornier, M. F. Cisse, and M. Reynes. 2006. Le baobab africain (*Adansonia digitata* L.): Principales caractéristiques et utilisations; The African baobab tree (*Adansonia digitata* L.): principal characteristics and uses. *Fruits* 61 (1): 55–69.
- Dweck, A. C. 1997. Ethnobotanical plants from Africa—Part two: African plants. *Cosmetics & Toiletries Magazine* 112: 47–54.
- El-Kamali, H. H., and K. F. El-Khalifa. 1999. Folk medicinal plants of riverside forests of the Southern Blue Nile district, Sudan. *Fitoterapia* 70 (5): 493–497.
- Emery, M. R. 2002. Space outside the market: Implications of NTFP certification for subsistence use (US). In *Tapping the Green Market: Certification and management of non-timber forest products*, ed. P. Shanley, S. A. Laird, A. R. Pierce, and A. Guillén, 302–312. London: Earthscan.
- Etkin, N. L., and P. J. Ross. 1982. Food as medicine and medicine as food—An adaptive framework for the interpretation of plant utilization among the Hausa of northern Nigeria. *Social Science & Medicine* 16 (17): 1559–1573.
- The European Parliament and the Council of the European Union. 1997. Regulation (EC) No 258/97 of the European Parliament and of the Council of 27 January 1997 concerning novel foods and novel food ingredients.
- Gebauer, J. 2003. Ökophysiologie und Verwendungsmöglichkeiten der Wildobstarten *Adansonia digitata* und *Tamarindus indica* im Sudan, [Ecophysiology and potential uses of wild fruit species *Adansonia digitata* and *Tamarindus indica* in Sudan]. PhD diss., Agriculture and Horticulture Faculty, Humboldt-Universität, Berlin.
- Gebauer, J., K. El-Siddig, and G. Ebert. 2002. Baobab (*Adansonia digitata* L.): A review on a multipurpose tree with promising future in the Sudan. *Gartenbauwissenschaft* 67 (4): 155–160.
- Gerber, C., ed. 1895. *Contribution à l'histoire botanique, thérapeutique et chimique du genre Adansonia (Baobab)*. Vol. 2, *Annales de l'Institut colonial de Marseille*. Lille, France: Le Bigot Frères.

- Gustad, G., S. S. Dhillion, and D. Sidibe. 2004. Local use and cultural and economic value of products from trees in the parklands of the municipality of Cinzana, Mali. *Economic Botany* 58 (4): 578–587.
- Hines, D. A., and K. Eckman. 1993. *Indigenous multipurpose trees of Tanzania: Uses and economic benefits for people*. Ottawa, Ontario, Canada: Cultural Survival Canada, and Development Services Foundation of Tanzania.
- ICRAF. 2003. When a tree becomes a garden vegetable—Baobab gardens in Mali. *Agroforestry in action* (2), [www.worldagroforestrycentre.org/ar2003/agroforestry\\_action.htm](http://www.worldagroforestrycentre.org/ar2003/agroforestry_action.htm) (accessed March 31, 2007).
- Igboeli, L. C., E. O. H. Addy, and L. I. Salami. 1997. Effects of some processing techniques on the antinutrient contents of baobab seeds (*Adansonia digitata*). *Bioresource Technology* 59:29–31.
- International Society of Ethnobiology (ISE). 2009. *International Society of Ethnobiology Code of Ethics (with 2008 additions)*. [http://ise.arts.ubc.ca/global\\_coalition/ethics.php](http://ise.arts.ubc.ca/global_coalition/ethics.php) (accessed July 8, 2009).
- Irvine, F. R. 1961. *Woody plants of Ghana with special reference to their uses*. London: Oxford University Press.
- IUCN. 2008. Final Report to Regional Trade Facilitation Programme. In *Natural Futures Programme, Trade Component*. South Africa: World Conservation Union (IUCN).
- Jama, B. A., A. M. Mohamed, J. Mulatya, and A. N. Njui. 2008. Comparing the “big five”: A framework for the sustainable management of indigenous fruit trees in the drylands of East and Central Africa. *Ecological Indicators* 8 (2): 170–179.
- Johansson, M. 1999. The baobab tree in Kondoa Irangi Hills, Tanzania. MSc thesis, Swedish University of Agricultural Sciences, Uppsala.
- Johns, T., and P. Maundu. 2006. Forest biodiversity, nutrition and population health in market-oriented food systems. *Unasylva* 224 (57): 34–40.
- Joshi, P. N., D. C. Bhati, R. P. Parmar, S. K. Dodia, and P. L. Lashkari. 2004. Medicinal value of *Adansonia digitata* L. in Kutch, Gujarat. In *Ethnomedicinal Plants*, ed. P. C. Trivendi and N. K. Sharma, 160–163. Jaipur, India: Pointer Publishers.
- Kahlheber, S. 2005. Perlhirse und baobab: Archäobotanische Untersuchungen im Norden Burkina Faso [Pearl millet and baobab: Archaeobotanical studies in northern Burkina Faso]. PhD diss., Department of Biological Sciences, Johann Wolfgang Goethe Universität Frankfurt am Main.
- Kerharo, J. 1974. Aperçu historique et ethnopharmacologique sur les croyances et les pratiques traditionnelles de traitements relatives à la maladie du sommeil en Afrique de l'Ouest [Historic and ethnopharmacologic review on the belief and traditional practices in the treatment of sleeping sickness in West Africa]. *Bulletin de la Société Médicale d'Afrique Noire de Langue Française* 19 (4): 400–410.
- Kerharo, J., and J. G. Adam. 1974. *La pharmacopée sénégalaise traditionnelle. Plantes médicinales et toxiques*. Paris: Editions Vigot Frères.
- Kerharo, J., and A. Bouquet. 1950. *Plantes médicinales et toxiques de la Côte d'Ivoire et Haute-Volta*. Paris: Vigot Freres.
- KIT and IIRR. 2008. Trading up: Building cooperation between farmers and traders in Africa. Amsterdam, The Netherlands and Nairobi, Kenya: Royal Tropical Institute, Amsterdam and International Institute of Rural Reconstruction, Nairobi.

- Kristensen, M., and A. M. Lykke. 2003. Informant-based valuation of use and conservation preferences of savanna trees in Burkina Faso. *Economic Botany* 57 (2): 203–217.
- Kutsch-Lojenga, R. 2007. BioTrade and its implications for sustainable land management. In *Trade and sustainable land management in the context of drylands. ICTSD project on trade and sustainable land management, selected issues briefs*, 58–63. Geneva.: International Centre for Trade and Sustainable Development (ICTSD).
- Lamien, N., A. Sidibe, and J. Bayala. 1996. Use and commercialization of non-timber forest products in western Burkina Faso. In *Domestication and commercialization of non-timber forest products in agroforestry systems. Proceedings of an international conference held in Nairobi, Kenya, 19 - 23 February 1996*, ed. R. R. B. Leaky, A. B. Temu, M. Meinyk, and P. Vantomme. Nairobi, Kenya: FAO.
- Lehmann, M. 2007. Trade in dryland products as an incentive for the sustainable use of biodiversity: The work under the Convention on Biological Diversity. In *In trade and sustainable land management in the context of drylands. ICTSD project on trade and sustainable land management, selected issues briefs*, 53–57. Geneva: International Centre for Trade and Sustainable Development (ICTSD).
- Lemay, A. M. 2005. *Le changement agricole et la dynamique familiale en milieu rural Malien: exemple de technologies agroforestières*. Ottawa: Library and Archives Canada, Bibliothèque et Archives Canada.
- Lockett, C. T., and L. E. Grivetti. 2000. Food-related behaviors during drought: A study of rural Fulani, northeastern Nigeria. *International Journal of Food Sciences and Nutrition* 51 (2): 91–107.
- Lowore, J. 2001. Report on natural resource enterprises in Malawi: Study on the contribution of NRBEs to economic development and community-based natural resource management in Machinga District. Blantyre, Malawi: Community Partnerships for Sustainable Resource Management in Malawi (COMPASS).
- Lybbert, T. J., C. B. Barrett, and H. Narjisse. 2002. Market-based conservation and local benefits: The case of argan oil in Morocco. *Ecological Economics* 41 (1): 125–144.
- Maundu, P. M., G. W. Ngugi, and C. H. S. Kabuye. 1999. *Traditional food plants of Kenya*. Nairobi: National Museum of Kenya.
- Mayrand, K., and M. Paquin. 2007. Agricultural trade liberalisation, poverty and land degradation in rural drylands. In *Trade and sustainable land management in the context of drylands. ICTSD project on trade and sustainable land management, selected issues brief*, 27–31. Geneva: International Centre for Trade and Sustainable Development (ICTSD).
- Mukadasi, B., and M. Nabalegwa. 2007. Gender mainstreaming and community participation in plant resource conservation in Buzaya county, Kamuli district, Uganda. *African Journal of Ecology* 45 (suppl. 1): 7–12.
- Muok, B. O., B. Owuor, I. Dawson, and J. Were. 2000. The potential of indigenous fruit trees: Results of a survey in Kitui District, Kenya. *Agroforestry Today* 12 (1): 13–16.
- N'Diaye, M., F. B. Kéita, and P. Martin. 2003. Principaux fruits de cueillette consommés et commercialisés en Guinée [Principal fruits of gathering consumed and marketed in Guinea]. *Fruits* 58 (2): 99–116.
- Nemarundwe, N., G. Ngorima, and L. Welford. 2008. Cash from the commons: Improving natural products value chains for poverty alleviation. In *12th*

- biennial conference of the international association for the study of commons (iasc). Governing shared resources: Connecting local experience to global challenges.* Cheltenham, England.
- Nordeide, M. B., A. Hatloy, A. Oshaug, M. Folling, and E. Lied. 1996. Nutrient composition and nutritional importance of green leaves and wild food resources in an agricultural district, Koutiala, in Southern Mali. *International Journal of Food Sciences and Nutrition* 47 (6): 455–468.
- Obizoba, I. C., and N. A. Amaechi. 1993. The effect of processing methods on the chemical composition of baobab (*Adansonia digitata* L.) pulp and seed. *Ecology of Food and Nutrition* 29 (3): 199–205.
- Owen, J. 1970. The medico-social and cultural significance of *Adansonia digitata* (Baobab) in African communities. *African Notes: Bulletin of the Institute of African Studies* 6:24–36.
- PhytoTrade. 2008. Press release: Move over goji berries, here comes Baobab! July 3.
- Rashford, J. 1987. The baobab tree and seasonal hunger in Africa: The case of the San. *Botswana Notes and Records* 19:57–68.
- Robbins, P. 2003. *Stolen fruit—The tropical commodities disaster*. London: Zed Books.
- Robinson, J. 2006. Useful wild tree resources of southern Sudan: A review. *Plant Genetic Resources Characterization and Utilization* 4 (3): 188–197.
- Salami, L. I., and U. N. Okezie. 1994. The nutritional composition and storage stability of millet (*Pennisetum americanum*) supplemented with varying levels of baobab (*Adansonia digitata*) flours. *Ecology of Food and Nutrition* 31 (3/4): 211–8.
- Schreckenber, K. 2004. The contribution of shea butter (*Vitellaria paradoxa* C.F. Gaertner) to local livelihoods in Benin. In *Forest products, livelihoods and conservation-case studies of non-timber forest products systems: Volume 2 Africa*, ed. T. Sunderland and O. Ndoye, 91–113. Indonesia: CIFOR.
- Schroeder, R. A. 1995. Contradictions along the commodity road to environmental stabilization: Foresting Gambian gardens. *Antipode* 27 (4): 325–342.
- Schütt, P., and H. Wolf. 2006. *Adansonia digitata*. In *Enzyklopädie der Holzgewächse*, ed. P. Schütt, H. Weisgerber, U. M. Lang, A. Roloff, and B. Stimm, 1–12. Landsberg am Lech, Germany: Ecomed Biowissenschaften, Verlagsgruppe Hüthig Jehle Rehm GmbH.
- SCUC, Southampton Centre for Underutilised Crops. 2006. *Baobab manual, field manual for extension workers and farmers*. Southampton, UK: University of Southampton.
- Shackleton, S., P. Shanley, and O. Ndoye. 2007. Invisible but viable: Recognising local markets for nontimber forest products. *International Forestry Review* 9 (3): 697–712.
- Shanley, P., A. R. Pierce, and S. A. Laird. 2005. Beyond timber: *Certification of non-timber forest products*. Washington, DC: Forest Trends.
- Shepherd, G. 1992. *Managing Africa's tropical dry forests: A review of indigenous methods*. Vol. 14, *Agricultural Occasional Papers*. London: Overseas Development Institute (ODI).
- Sidibé, M., and J. T. Williams. 2002. *Baobab. Adansonia digitata L.* Vol. 4, *Fruits for the future*. Southampton, UK: International Centre for Underutilised Crops, University of Southampton.

- Szolnoki, T. W. 1985. *Food and fruit trees of The Gambia*. Hamburg, German Federal Republic: Stiftung Walderhaltung in Afrika.
- Tabuti, J. R. S., S. S. Dhillion, and K. A. Lye. 2003. Firewood use in Bulamogi County, Uganda: Species selection, harvesting and consumption patterns. *Biomass and Bioenergy* 25 (6): 581–596.
- Vassiliou, A. 2008. Commission decision—Baobab dried fruit pulp as a novel food ingredient. Document C (2008) 3046. Brussels, Belgium: Official Journal of the European Union.
- Vermeulen, S., J. Woodhill, F. J. Proctor, and R. Delnoye. 2008. Chain-wide learning for inclusive agrifood market development: A guide to multi stakeholder processes for linking small-scale producers with modern markets. London, UK and Wageningen, The Netherlands: International Institute for Environment and Development (IIED) and Wageningen University and Research Centre.
- Welford, L., and G. L. Breton. 2008. Bridging the gap: Phytotrader Africa's experience of the certification of natural products. *Forests, Trees and Livelihoods* 18 (1): 69–79.
- White, F. 1983. *The vegetation of Africa*. Paris: UNESCO Natural Resources.
- Wickens, G. E., and P. Lowe. 2008. *The Baobabs: Pachycauls of Africa, Madagascar and Australia*. Springer.
- Wiersum, K. F. 2006. Certification of non-timber forest products—Lecture notes. Wageningen Forest and Nature Conservation Policy Group, Wageningen University.
- Wilsey, D. S., and J. Radachowsky. 2007. Keeping NTFPs in the forest: Can certification provide an alternative to intensive cultivation? *Ethnobotany Research and Applications* 5:45–58.
- Zimba, N., S. Wren, and A. Stucki. 2005. Three major tree nut oils of southern central Africa: Their uses and future as commercial base oils. *International Journal of Aromatherapy* 15 (4): 177–182.