Folk Classification, Perception, and Preferences of Baobab Products in West Africa: Consequences for Species Conservation and Improvement[1]

A. E. Assogbadjo[*,2], R. Glèlè Kakaï[2], F. J. Chadare[2], L. Thomson[3], T. Kyndt[4], B. Sinsin[2], and P. Van Damme[4]

[2]Faculty of Agronomic Sciences, University of Abomey-Calavi, 05 BP 1752 Cotonou, Benin
[3]Bioversity International, Via dei Tre Denari 472/a, 00057 Maccarese, Rome, Italy
[4]Faculty of Bioscience Engineering, Coupure Links 653, 9000 Ghent, Belgium
*Corresponding author; e-mail: assogbadjo@yahoo.fr

Folk Classification, Perception, and Preferences of Baobab Products in West Africa: Consequences for Species Conservation and Improvement.
The present study is a component of a baobab (*Adansonia digitata* L.) domestication research program being undertaken in Benin, Burkina Faso, Ghana, and Senegal. Surveys conducted on a total of 129 women and 281 men of different ages included questions on perceptions and human/cultural meaning of morphological variation, use forms, preferences (desirable/undesirable traits), and links between traits. Local people in the four countries use 21 criteria to differentiate baobab individuals *in situ*. According to them, the easier the bark harvesting, the tastier the pulp and leaves; the slimier the pulp, the less tasty it is; the more closely longitudinally marked the fruit capsules, the tastier the pulp. This study shows that farmers are able to use preferred combinations of traits as a guide in collecting germplasm from trees. This can allow the selection of trees that would be candidates for propagation, and planning for a domestication program based on the indigenous knowledge.

Key Words: Baobab, indigenous knowledge, preferences, domestication, ethnobotanical survey, agroforestry, West Africa.

Introduction

Millions of the world's poor rely on a wide variety of forest products to sustain their livelihoods. At the same time, most agricultural crops have been domesticated over a long period of time, while few of the tens of thousands of forest tree species can be considered to be domesticated. Among the nondomesticated agroforestry species, the baobab tree (*Adansonia digitata* L.) is a key economic species used daily in the diet of rural communities in West Africa (Assogbadjo et al. 2006a; Codjia et al. 2001; Sidibé and Williams 2002). The species contributes to rural incomes (Diop et al. 2005) and has various important medicinal and food uses (Assogbadjo et al. 2006a; Delisle et al. 1997; Diop et al. 2005; Sena et al. 1998; Sidibé et al. 1996; Sidibé and Williams 2002; Yazzie et al. 1994). Within the species, there is evidence indicating the existence of a number of local forms differing in habit, vigor, size, quality of the fruits, and foliar vitamin content (Assogbadjo et al. 2005a; Gebauer et al. 2002; Sidibé and Williams 2002).

Regional consultations organized by the International Centre for Underutilised Crops have accorded high priority to the enhancement of research and development of *Adansonia digitata* (Sidibé and Williams 2002). Baobab has been identified as among the top ten agroforestry tree species to be conserved and domesticated in West Africa (Eyog Matig et al. 2002). National research efforts, especially in Benin, Burkina Faso, Mali, Nigeria, and Senegal, have provided data on food

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values, agronomy, ethnobotanical knowledge, ecology, and genetic diversity of baobab (Assogbadjo et al. 2005a, b; Assogbadjo et al. 2006a, b; Codjia et al. 2001, 2003; Diop et al. 2005; Sidibé and Williams 2002). Baobab might be classified as a species in the early stages of domestication, without established, well-known varieties. Very little information is available on baobab tree variation using either quantitative descriptors or local perceptions on the variation.

The main objective of this study is to provide the basis for an efficient strategy for the domestication and improvement of baobab in West Africa. Specifically, the study involves an ethnobotanical survey among local people in four West African countries in order to (1) understand local perceptions of baobab tree variation, (2) identify local people's preferences (both desirable and undesirable) regarding baobab traits, and (3) assess correlations between various traits according to local people in order to identify easy-to-monitor parameters for desired traits.

Materials and Methods

Sampling

In this study, four countries have been sampled in the Sudanian and Sudano-Sahelian regions of West Africa: Benin, Burkina Faso, Ghana, and Senegal (Fig. 1). These countries encompass the most important climatic regions suitable for baobabs in West Africa (Wickens 1982). Within each country, sampling of localities has been done in the areas where local ethnic groups use baobabs on a daily basis and have been shown to have outstanding and important knowledge of baobabs. This has been assessed through both literature review and surveys among local populations, with the help of the forestry and agricultural departments in each selected country. Local informants participated and provided information on a voluntary basis. Surveys have been conducted among 129 women and 281 men randomly drawn from nine ethnic groups: the Ditamari (Benin); the Mossi and Gourmantché

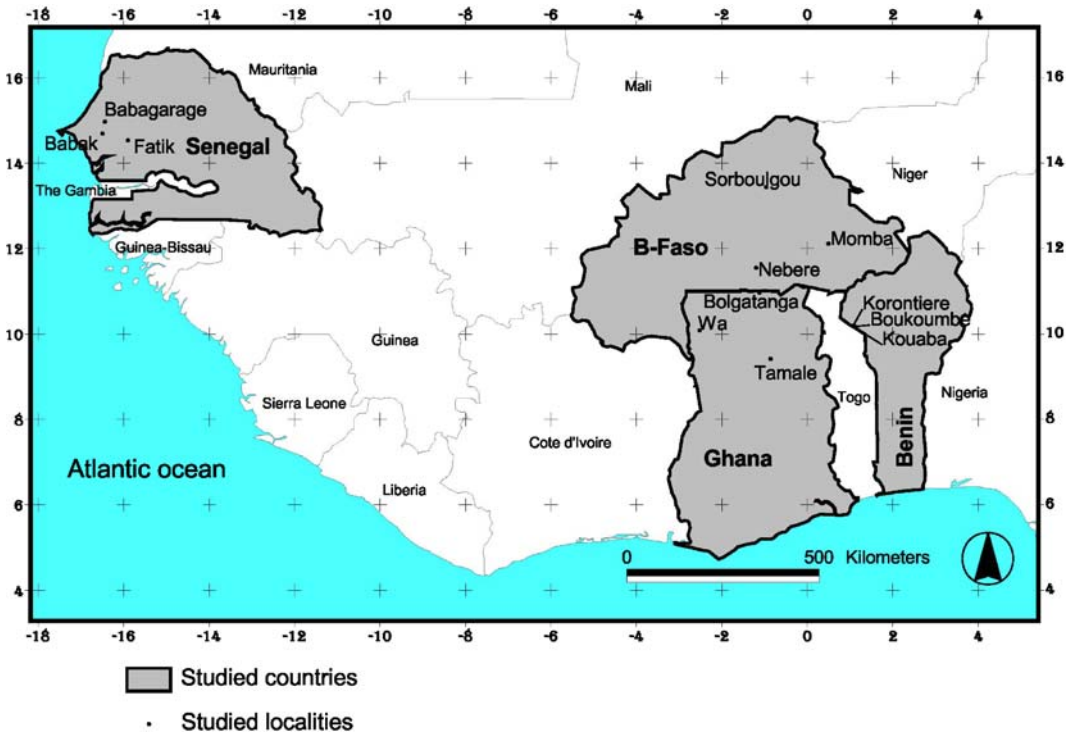

Fig. 1. Studied countries and localities. The localities were selected because local ethnic groups are considered to have outstanding and important knowledge of baobab.

(Burkina Faso); the Grune, Dagbale, Kaseem, and Wale (Ghana); and the Wolof and Sérére (Senegal). In each ethnic group, interviews have been conducted with men (Mi) and women (Fi) of different ages (1): youth ($i \leq 30$ years old), adults ($30 < i \leq 60$ years old), and old persons ($i \geq 60$ years old).

Ethnobotanical Survey

An ethnobotanical survey was carried out between October 2006 and January 2007. Structured interview surveys were conducted among various randomly selected people from different ethnic groups. Interviews included questions on perception and human/cultural meaning of morphological baobab variation, use forms, preferences (desirable/undesirable traits), and links between traits and different uses of baobab products according to these people of different ages, sexes, countries, and climatic zones.

Data Analysis

The interviewees were grouped according to ethnic group, sex, and age so that in each ethnic group, six subgroups were defined: young men (M1), adult men (M2), old men (M3), young women (F1), adult women (F2), and old women (F3). Within the nine ethnic groups, a total of 48 subgroups were constituted instead of 54 (9×6), because of the absence of some subgroups in the overall surveyed sample.

Because the size of subgroups differed and an interviewee could choose more than one baobab trait, relative frequency of each trait was determined for each of the 48 subgroups. This parameter is defined as the proportion of interviewees belonging to the subgroup who identified the particular baobab trait. A data matrix comprising the relative frequencies of baobab traits according to the 48 subgroups was then submitted to Principal Component Analyses (PCA) using SASv9 software. This statistical method was used at each step of this study to describe linkages between choices of baobab traits by different local populations. It was also used to identify traits that best explained the patterns of variation according to the different subgroups.

For graphic purposes, the subgroups are labeled by preceding the ethnic group prefix with the label of one of the six subgroups defined above. For example, a young man from Ditamari ethnic group is labeled DitamM1, whereas an old woman from the same ethnic group is labeled DitamF3.

Results

Local Perception of Baobab Tree Variation in West Africa: Folk Classification

In West Africa, local perceptions of baobab differentiation vary from one country to another. Local people in the four investigated countries used 21 criteria to differentiate individual baobab trees growing in traditional agroforestry systems. These criteria are related to the characteristics of the leaves (taste, color, smoothness, phenology, resistance to insect attack), fruits (color of pulp, smoothness of capsule, sliminess of pulp, size and shape of capsule, hardness of capsule, fiber and pulp yield in the capsule, seed color, kernel taste), bark (color, structure, harvesting), and the whole tree (crown shape, fertility). Table 1 shows the percentage of persons using different criteria and variants to identify and distinguish baobab individuals in each of the four countries. The most commonly used criteria were: leaf taste, pulp taste, sliminess of fruit pulp, pulp color, size and shape of capsule, and the fertility of baobab trees (Table 1). There were some criteria which were seldom used, and were only recorded in one or two countries. These were leaf phenology (1% in Ghana), leaf resistance to insect attacks (3.1% in Benin and 1.2% in Senegal), fiber quantity in the capsule (0.2% in Senegal), and speed of capsule maturity (5.1% in Benin).

Based on locally recognized variants, several different types of baobab were distinguished in the traditional agroforestry systems of West Africa. Using color and structure of bark as criteria, four types of baobab were distinguished by Burkinabe in Burkina Faso: smooth pink bark, rough gray bark, smooth gray bark, and black bark. Considering the size and shape of the fruits, four types of baobab can be distinguished: small-sized capsules, long and middle-sized, round and middle-sized, and large capsules. In terms of the taste of the leaves, two types of baobab can be distinguished: baobab with bitter leaves and baobab with delicious leaves. Regarding the taste of the pulp, local populations distinguish the baobab with sweet pulp from the baobab with acidic and slightly acidic taste. Using fruit production as a criterion, local people distinguished two types of baobab tree: the so-called

Table 1. Variation in the baobab tree according to local people (number in parentheses is the sample size).

Organs/tree	Criteria	Variant	Percent of interviewees using the criteria per country			
			Benin (98)	Burkina Faso (92)	Ghana (92)	Senegal (128)
Leaves	Leaf taste	Delicious	100	100	100	100
		Bitter				
	Smoothness of leaves	Hairy	72.4	0	0	3.1
		Smooth				
	Leaf phenology	Precocious	0	0	0	1
		Tardy				
	Precociousness of leaf defoliation	Precocious	53.1	0	0	6.4
		Tardy				
	Leaf resistance to insect attack	High	3.1	0	0	1.2
		Low				
	Leaf color	Green	0	1.79	0	0
		Green shiny				
Fruit	Pulp taste	Sweet	100	50	33.33	25
		Acidic				
		Slightly acidic				
	Smoothness of capsules	Hairy	3.1	0	0	1
		Smooth				
	Sliminess of fruit pulp	Slimy	67.3	47.8	23.6	18.8
		Not slimy				
	Pulp color	Floral white	25.5	17.9	2	6.1
		Yellowish				
	Capsule size and shape	Small	69.4	47.8	18.8	3.5
		Medium and long				
		Medium and round				
		Big				
	Capsule hardness	Hard	0	0	0	2.3
		Less hard				
	Yield of fruit pulp	A lot	0	47.8	0	0
		Little				
	Speed of capsule maturity	Precocious	5.1	0	0	0
		Tardy				
	Fiber quantity in capsule	Many	0	0	0	0.2
		Few				
	Seed color	Violet	0	17.9	0	0
		Back				
	Kernel taste	Fatty and delicious	0	17.9	0	0
		Tasteless				
Bark	Ease of bark harvest	Easy	3.1	0	1.8	23.8
		Difficult				
	Bark color and texture	Pink and smooth	0	41.3	0	0
		Black				
		Rough and gray				
		Smooth and gray				
Tree	Fertility of tree	"Male" (never produce mature fruits)	59.2	19	26.8	16.2
		"Female" trees (produce fruits)				
	Crown color-aerial view	Reddish	19.4	0.5	0	1.6
		Light green				

"female," fruit-producing trees, and the "male" trees, which never produce fruits. It has to be noted that the "male" trees are not biologically male, since baobabs are hermaphrodites (Wickens 1982), but they are specified as such by the local people because of the fact that they never produce (mature) fruits. This may be due to some kind of incompatibility within the reproduction system or genetic inbreeding at the tree level.

Preference of Baobab Products in West Africa: Desirable and Undesirable Traits

Several traits of baobab are considered desirable and others undesirable by local people (Table 2). A PCA analysis, performed on the available interview data (results not shown), revealed several interesting differences and correspondences between the studied ethnic groups at the level of baobab preferences. The Ditamari ethnic group (Benin) identify desirable traits as hard kernels, delicious leaves, hairy capsules, high pulp yield in the fruit, tardy maturity of capsules, easy-to-harvest bark, and small capsule size. Desirable traits for the Gourmantché and Mossi ethnic groups (Burkina Faso) include high yields of sweet, acidic, nonslimy pulp, good-tasting leaves, and big capsules with fatty, delicious kernels. The Kaseem, Wale, and Grune ethnic groups (Ghana) often consider sweet, nonslimy pulp, delicious leaves, and big capsules as desirable baobab traits.

In contrast, the undesirable baobabs are the so-called "male" trees, or the ones producing acidic pulp, slimy pulp, tasteless kernels, bitter leaves, hard seed coat, low yield of pulp, and/or difficult-to-harvest bark. Specifically, people from the Gourmantché ethnic group consider baobabs with following features as undesirable: "male" baobabs, acidic pulp, tasteless kernels, big capsules, floral white slimy pulp, and low pulp yield in capsule. Desirable traits for the Ditamari ethnic group in Benin often include fragility of the seed coat and precociousness or tardy capsule maturity. But adult and old Ditamari, especially the men, often add the following to the above-listed traits: tastelessness of the kernel, low pulp yield in the capsule, and floral white pulp. The Mossi ethnic group (Burkina Faso) mention small capsules and low pulp yield in the capsule as undesirable traits.

Table 2. Desirable and undesirable traits for baobab according to local people.

			Traits	
Organs	Criteria	Variant	Desirable	Undesirable
Leaves	Leaf taste	Delicious	+	
		Bitter		+
Fruits	Pulp taste	Sweet	+	
		Acidic		+
		Slightly acidic	+	
	Sliminess of fruit pulp	Slimy		+
		Not slimy	+	
	Pulp color	Floral white	+	+
		Yellowish	+	
	Capsule size and shape	Small	+	+
		Large	+	+
	Yield of fruit pulp	High	+	
		Low		+
	Speed of capsule maturity	Precocious	+	+
		Tardy	+	+
	Kernel taste	Fatty and delicious	+	
		Tasteless		+
Bark	Ease of bark harvest	Easy	+	
		Difficult		+
Tree	Fertility of tree	"Male"		+
		"Female"	+	

+, positive response.

Most of the Sérére and Wolof (Senegal) and the ethnic groups from Ghana consider baobabs having bark that is difficult to harvest to be undesirable.

Finally, there are some criteria (size and shape of capsules, speed of capsule maturity, and floral white pulp color) considered both as desirable and undesirable traits by different local people.

Links between Baobab Tree Characteristics as Perceived by Local People

In rural areas, local people are aware of the links between different traits of baobab. Whereas some criteria are related to the whole tree, others are related to the characteristics of baobab products. According to local people, hairy baobab leaves are also tasteless; trees for which bark can be easily harvested or which have hard or middle-sized, long-shaped capsules are the ones that produce sweet pulp and delicious leaves; those with precocious or tardy maturity of their capsules produce a sweet pulp. Baobabs that produce soft seeds are the ones yielding "male" offspring. Moreover, local people are able to link (1) the sliminess of the pulp with its taste: the slimier the pulp, the worse its taste; (2) the capsule size and shape with its pulp yield: the bigger and rounder the capsules, the higher the yield in pulp; and (3) the presence of scratches on capsule and its pulp taste: the more scratches on capsules, the sweeter the pulp. Also, according to local people, "male" baobabs always produce tasteless and sometimes bitter leaves.

The result of the principal component analysis (PCA) performed on the desirable traits showed that the first three axes explained 61.5% of the observed variation. Therefore, only the first three axes were used to describe the relationship between capacity to link traits and the factors of country, age, sex, and climatic zones. Table 3 shows the sign of correlations between the different criteria and the three PCA axes. Figure 2A and B show the projection of the different socioethnic subgroups onto the 1st and 2nd, 1st and 3rd axes, respectively.

Taking into account Fig. 2A and B and data from Table 3, it can be deduced that the Ditamari ethnic group (Benin), especially young and adult men, link "male" progeny to easily breakable seeds; sweet pulp and delicious leaves to middle-sized and long-shaped capsules; "male" tree to tasteless leaves; "female" tree to tasty leaves; and precocious or tardy maturity of the

Table 3. Correlation (Corr) between linked traits and PCA axes.

Axis1	Corr	Axis2	Corr	Axis3	Corr
Bark easy to harvest and taste of pulp and leaves	0.97	Easily breakable seed and "Male" progeny	0.96	Pulp yield and capsule size	0.94
Thin capsule end and good taste	0.89	Middle-sized and long-shaped capsules and sweet pulp, delicious leaves	0.96	"Male" tree has tasteless leaves and "female" tree has tasty leaves	0.83
Existence of filament in leaves and pulp and leaf taste	0.87	Hairy and tasteless leaves	0.93	Sliminess of pulp and tasteless of pulp	0.71
Pulp color and pulp taste	0.87	"Male" tree has tasteless leaves and "Female" tree has tasty leaves	0.83		
Hairy capsule and good taste	0.79	Precocious or tardy maturity of capsules and tasty pulp	0.81		
Striped capsule and good taste	0.73				
Insect attack importance and taste	0.68				
Sliminess of pulp and tasteless pulp	0.64				
Leaf form and good taste	0.60				
Hard capsule and good taste	0.53				

capsules to tasty pulp. Adults and old men from the Mossi group also use the above links combined with the following additional correlations: pulp yield and capsule size, sliminess of pulp and tastelessness of pulp. The Wolof and Sérére ethnic groups, especially adult Wolof men, draw these correlations: taste of pulp and leaves to easy bark harvest; good taste to thin capsule end; leaf taste to existence of filament in leaves and pulp; pulp taste to pulp color; good taste to leaf form; hard, hairy, striped capsule and tasteless pulp to sliminess of the pulp. The ethnic groups from Ghana as well as the Gourmantché from Burkina Faso are not well represented in Fig. 2A and b. But the analysis of the data matrix suggests that most of the individuals in these groups link "male" tree to tasteless leaves and "female" tree to tasty leaves, leaf form to good taste, and the sliminess of the pulp to its tastelessness. In addition to these links, the Gourmantché ethnic group observes that pulp yield and capsule size appear to be linked.

Discussion and Conclusions

Traditional Knowledge and Genetic Improvement of Baobab

In order to provide the basis for an efficient strategy for the domestication and improvement of baobab (*Adansonia digitata*) in the West African region, the current study provides important information on the perceptions and traditional knowledge of local ethnic groups from four West African countries. Domestication has been defined as human-induced change in the genetics of the species to conform to human desires and agroecosystems (Harlan 1975). The participatory domestication of indigenous fruit trees, like baobab, is an appropriate means to alleviate poverty (Poulton and Pool 2001), and could also have positive benefits on the environment since new plantings of baobab will help to restore the declining resources of this important tree.

Within the species, there is evidence indicating the existence of a number of local types differing in habit, vigor, size, and quality of the fruits, leaves, and seeds. In previous studies, focused on Benin (Assogbadjo et al. 2005a, 2006b), we observed a link between the known morphometric diversity of baobab and both abiotic, environmental factors and genetic determinism. As, at least in Benin, morphological features are to some degree linked with genetic diversity (Assogbadjo et al. 2006b), there appears to be considerable potential for selecting or breeding desirable baobabs to suit local people's preferences.

In general, this ethnobotanical survey showed that indigenous knowledge of baobab trees varies according to ethnic group, sex, age, and country. Women in general and old people in particular have greater knowledge than youths and men to allow them to distinguish baobabs, and therefore it will be more suitable mainly to involve old women in the research/development programs related to germplasm sampling and baobab improvement.

Selection or breeding programs, if targeting the whole West African region, should mainly focus on the baobabs having desirable traits as generally identified by the local people in the studied countries. This study shows that baobabs having delicious leaves, sweet or slightly acidic pulp, nonslimy pulp, yellowish or white pulp color, capsules producing high yields of pulp, fatty and delicious kernels, easily -harvestable bark, and high fruit production (i.e., "female" trees) are generally preferred in all studied rural areas of West Africa. The undesirable baobabs are the "male" trees (not in the sense of biologically male, but a term used by local people to define nonproductive trees), the ones producing bitter leaves, acidic pulp, tasteless kernels, slimy pulp, scarcely harvestable bark, and low pulp yield in the capsule.

In addition, this study revealed that there are some specific traits which are desired only in some countries. Consequently, it will be more relevant to define for each country a specific selection and improvement program of baobab, taking into account the most important and desired traits for local people in that country. For instance, baobabs producing small capsules are only desired in Benin, while those producing big capsules are preferred in Ghana, Senegal, and Burkina-Faso. Thus selection and breeding programs yielding the propagation of baobabs producing big capsules will be more applicable in Ghana, Senegal, and Burkina-Faso than in Benin.

Preference for certain baobab characteristics mainly depends on their importance (economic, food, cultural, etc.) and uses for local people. For instance, "male" baobabs are not preferred because they cannot provide fruits/capsules, which are considered to be economic products by local

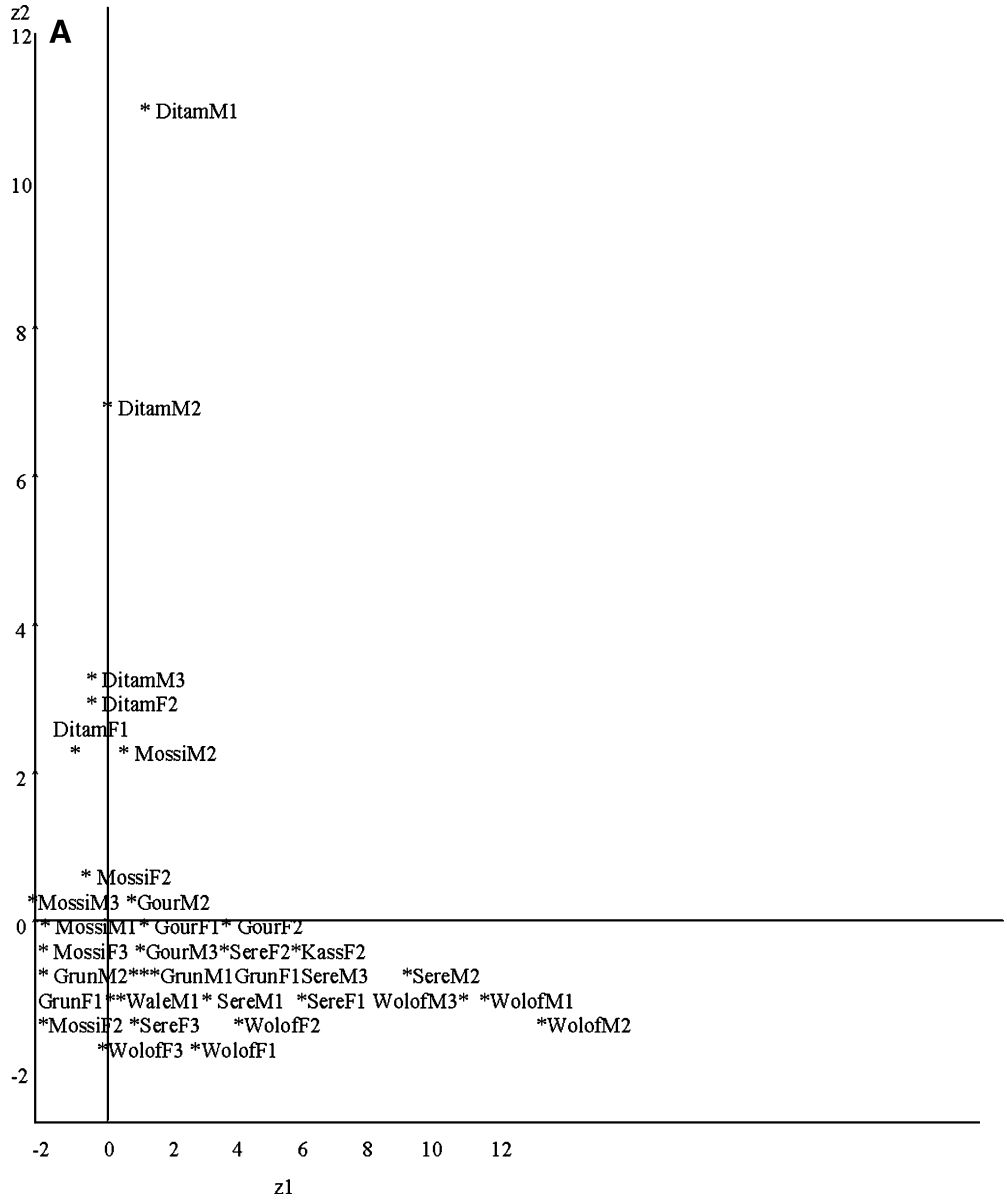

Fig. 2. PCA to reveal linkages between baobab traits according to local populations. Projection of socioethnic groups in three axes: **A** 1 and 2; **B** 1 and 3.

people. At the same time, delicious leaves are preferred because they are tasty (food use) and can be easily sold on the market (economic importance).

Indigenous Knowledge and Valorization of Baobab Products

The use of differentiation criteria of baobab individuals in rural areas shows that the species has high cultural and economic value in West Africa. Since local people have the knowledge to correlate different criteria characterizing baobab individuals, farmers are able to guide researchers in collecting germplasm from superior trees. Therefore, the potential for selecting or breeding desirable baobabs for local people seems to be promising. This can allow selecting the "plus tree" for propagation, and planning a domestica-

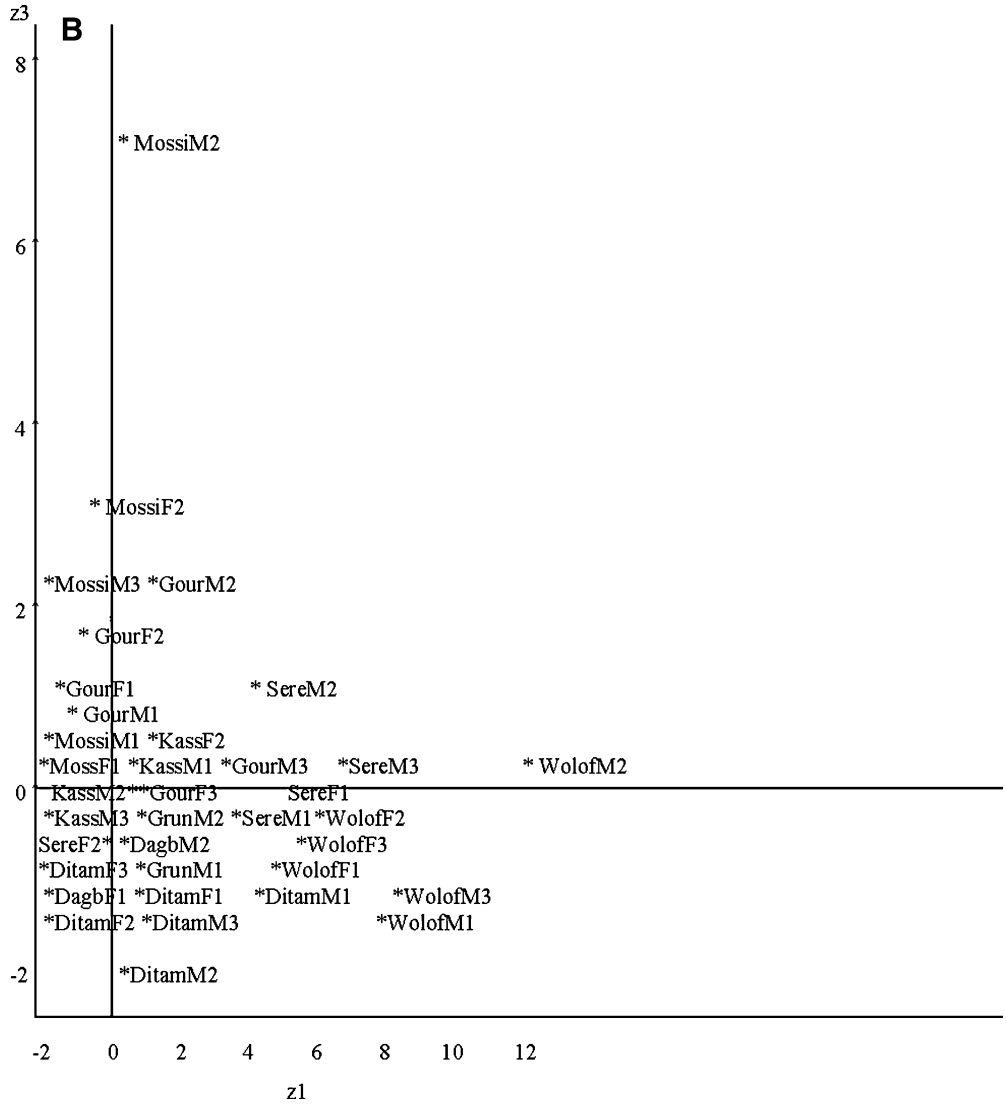

Fig. 2. (continued).

tion program based on the indigenous knowledge. For instance, high-yield pulp production of baobab is desired in Burkina Faso. Since local people in this country have observed a link between capsule size and shape, on one hand, and its pulp yield, on the other hand, a selection program targeted at high-yield pulp production can base sampling strategies on baobabs producing big capsules in the traditional agroforestry systems in this country.

All plant parts of the baobab are being used by local people for a wide range of purposes, from food, medicine, and marketing to other domestic uses. The current and potential markets for baobab fruit products can be divided into three segments: food and beverages, botanical remedies and nutraceuticals, and natural cosmetics (Gruenwald and Galizia 2005). It is important to identify potential market niches and to determine which product characteristics as perceived by local people need to be improved through genetic selection.

Moreover, leaves and fruits from the baobab are locally consumed on a frequent basis through-

out the year and make a significant nutritional contribution to diets (Assogbadjo et al. 2006a; Glew et al. 1997; Sidibé and Williams 2002). However, knowledge of the nutritional content is far from complete. For instance, no information is available on the bioavailability of specific baobab nutrients and their direct effect on human health (Sidibé and Williams 2002). Hopefully, the great potential of baobab in regional and even international markets will be a strong stimulus for further research and development efforts towards better understanding and utilization of the species.

Indigenous Knowledge and Conservation of Baobab Genetic Resources

Having indicated above the great opportunities (e.g., for breeding) arising from the identification and capture of intraspecific variation in *Adansonia digitata*, it is also important to consider the conservation and maintenance of the morphological and genetic diversity present within the species. Nowadays, traditional agroforestry systems already imply some kind of selection process through the specific planting of baobab individuals with preferred traits by local farmers. Intensification of such domestication of this species may lead in a few years to a progressive elimination of baobab individuals of "bad quality" while preserving the ones producing good quality fruits, seeds, barks, and leaves. Nonpreferred genotypes will be less and less numerous in baobab populations; their genes will be transferred with a lower frequency over generations and hence the population structure will change. Consequently, the risk of a substantial decrease of the genetic diversity within baobab population is high. Therefore, it is essential that domestication activities are undertaken with the realization that it is important to retain and maintain as much variation as possible in specific conservation programs. Since desirable traits of baobab vary according to country and ethnic groups, conservation strategies should also be specific to each country.

At present, no conservation areas in West Africa are specifically set aside for the protection of the baobab. This can only be established through traditional agroforestry systems and protected areas. Conservation strategies for baobab in West Africa should target not only the various morphotypes as defined by local people, but should also incorporate information on genetic variation and population genetics identified by using molecular techniques. In the case of Benin, it was shown that some morphometric variables were genetically determined (Assogbadjo et al. 2006b). However, since no large-scale information is available on baobab tree variation combining both molecular data and local perceptions, it is not known whether the desired or nondesired traits are purely genetically defined. To avoid the negative impact that can result from artificial selection in traditional agroforestry systems, we recommend conserving the less desirable baobabs *ex situ* in gene banks. At the same time, desirable baobabs can be preferably conserved *in situ* as natural gene pools in traditional agroforestry systems.

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