

African Crop Science Journal by African Crop Science Society is licensed under a Creative Commons Attribution 3.0 Uganda License. Based on a work at [www.ajol.info/](http://www.ajol.info/) and [www.bioline.org.br/cs](http://www.bioline.org.br/cs)  
DOI: <http://dx.doi.org/10.4314/acsj.v24i1.3>



## PRODUCTIVITY CHARACTERISTICS AND DEVELOPMENT STRATEGIES OF *Sclerocarya birrea* IN BURKINA FASO

P. BATIONO-KANDO, B. SAWADOGO, Z. KIEBRE, P. KIENTEGA, N. SAWADOGO,  
K.R. NANEMA, E.R. TRAORE, M. SAWADOGO and J.D. ZONGO

Laboratoire Biosciences, Unité de Formation et de Recherche en Sciences de la Vie et de la Terre, Université de Ouagadougou, 03 BP 7021, Ouagadougou 03, Burkina Faso

**Corresponding author:** [bationopauline@yahoo.fr](mailto:bationopauline@yahoo.fr)

(Received 18 June, 2015; accepted 23 February, 2016)

### ABSTRACT

*Sclerocarya birrea* is a major component of agroforestry parks of Sudano-Sahelian zones, which is exploited by rural populations in Burkina Faso. Recently, *Sclerocarya birrea* kernel marketing has increasingly developed in Ouagadougou (capital of Burkina Faso). This study aimed at evaluating the productivity, understanding the socio-cultural uses and socio-economic importance of *S. birrea* among local populations of Burkina Faso. The study has shown that *S. birrea* is a very fructiferous plant. The number of fruits yielded per tree ranges from 136 to 4256, with mean fruit weight and diameter that are respectively 12.66 and 26.71 mm. The number of kernels per fruit ranged from 1 to 3, with a mean diameter of 4.75 mm. All is not clearly separated to multi-purpose uses. All organs are used in 36 different ways. The pulp and kernels of the fruit are the only by-products marketed by women and mainly girls who dropped out of school.

**Key Words:** Agroforestry, Burkina Faso, local perception, productivity, socioeconomic species

### RÉSUMÉ

*Sclerocarya birrea*, composante majeure des parcs agro-forestiers des zones soudano-sahéliennes, est bien connue et exploitée par les populations rurales au Burkina Faso. Ces dernières années, la commercialisation des amandes de *S. birrea* est de plus en plus développée à Ouagadougou (capitale du Burkina Faso). L'objectif de cette étude est d'évaluer les paramètres de la productivité et à connaître les usages socio-culturels et l'importance socio-économique de *S. birrea*, afin d'utiliser l'exploitation des fruits comme stratégie de sa domestication et de sa valorisation. L'étude a montré que *S. birrea* est une plante très fructifère, le nombre de fruits par arbre varie de 136 à 4256 avec un poids et diamètre moyens de fruit respectivement de 12,66 et 26,71 mm. Le nombre d'amandes varie de 1 à 3 par fruit. L'espèce a des usages multiples. Tous les organes sont utilisés avec 36 utilisations différentes. La pulpe du fruit et l'amande sont les seuls commercialisés par les femmes et surtout les jeunes filles déscolarisées. Les revenus engrangés servent à l'achat de vivre, aux soins médicaux, à payer la scolarité, les fournitures scolaires etc. La production fruitière étant importante, il existe donc un recours économique pour les populations locales comme incitation à protéger l'espèce.

**Mots Clés:** Agroforesterie, Burkina Faso, perception locale, productivité, espèce socio-économique

## INTRODUCTION

Africa prunus, *Sclerocarya birrea*, (A. Rich.) Hochst, of the *Anacardiaceae* Lindl family is one of the common large trees, representative of Sahelo-Sudanian formations. It is one of the indigenous fruit trees with important traditional interest in west Africa (Hall, 2002). The plant has multiple uses and offers many business opportunities. According to Kokwaro (1986), *S. birrea* comprises three sub species; namely: subsp. *birrea*, endemic to western Africa; subsp. *multifolialata*, from Tanzania; and subsp. *caffra*, from southern Africa, where it is also known as *marula*. In Burkina Faso, subsp *birrea* is found in all climatic zones, sometimes in pure and dense stands (Séréfé, 1996). The plant is used by populations of some areas as a priority woody species (Ouedraogo et Belem, 1998; Belem-Ouedraogo, 2008). Furthermore, subsp *birrea* is one of the most exploited spontaneous woody because of its multi-purpose uses. The absence of spontaneous regeneration of the plant, the lack of conservation strategies, and its unregulated exploitation can lead to the decline of its populations.

In Burkina Faso, due to the combined impacts of successive years of droughts, overexploitation, demographic, migratory and climatic pressures, the natural formations have been declining every year at an alarming rate. According to Newton (2008), for biodiversity loss rates to slow down, economic incentives should play a central role in political measures. Recently, *S. birrea* kernel marketing has been developing rapidly in Ouagadougou, Burkina Faso. The challenge is how to use fruit exploitation as a strategy for its domestication and development. Such strategies require the determination of both parameters of productivity, and knowledge of the socio-cultural and socio-economic importance of the plant for local populations. In general, studies of wild food plants in Burkina Faso are partial.

Wild food uses have been addressed in comprehensive work by several authors (Ganaba *et al.*, 2005; Belem-Ouedraogo, 2008). However, studies to date, have focused on genetic diversity (Bationo-Kando *et al.*, 2012), morphology (Bationo-Kando *et al.*, 2008), anatomy (Séréfé,

1996; Diallo *et al.*, 2006), or on the physico-chemical composition of *S. birrea* the fruit (Bationo-Kando *et al.*, 2009). On the other hand, data on the production and exploitation of the plant, by rural and urban populations, are still basic or non-existent. Thus, this study aimed at assessing the characteristics of fruit production and the relationship between the dendrometric traits of the tree and fruit production,

## MATERIALS AND METHODS

**Morphologic and phenotypic description of *S. birrea*.** The study was conducted from 2012 to 2014 on two *S. birrea* populations, during the period of reproduction of the species within two *S. birrea* populations. One is a natural site identified in Gampela and the other, is an anthropised area (fields) in Loumbila, in the vicinity of Ouagadougou, with 1°21'9,6" West longitude and 12° 24' 29" North latitude and W 1°24' 12.9" and N 12°30' 18.5".

Monitoring of all adult individuals of *S. birrea* along four transect of one kilometer each, allowed to determine the sex ratio and periods of flowering, fructification and fruit ripening. In each population, gender, flowering dates, fruiting and maturation of each tree were collected.

To establish the relationship between the number of styles and number of cavities per vegetative nucleus, five individuals were randomly selected in each site. The counting process was done on 20 flowers per individual.

The assessment of dendrometric characteristics of trees and fruit involved, 30 adult hermaphrodite individuals (females) selected only in the *S. birrea* population of Gampela in 2012. For each individual, the following parameters were measured :

- (i) trunk diameter at 1.30 m from the ground;
- (ii) Total tree height, crown diameter, number of main branches;
- (iii) total number of pieces of fruit yielded (daily collection and systematic counting), individual diameter,
- (iv) individual height and individual weight of 10 pieces of raw fruit;
- (v) diameter and individual weight of 10 kernels.

The productivity was measured in terms of number of pieces of fruit yielded per tree, fresh fruit weight, kernel number per fruit, and kernels weight per fruit.

**Uses and socio-economic impacts.** A survey based on a semi-structured interview was conducted in Ouagadougou and eleven villages in Burkina Faso in May 2012, during fruit maturation season. It was structured in three steps, namely, tree-farm management, the marketing kernel and socio-economic impact of *S. birrea* by-products sale in Ouagadougou. The interviews conducted involved 104 people in the capital, including wholesalers and street vendors aged from 14 to 76 years (Table 1). The data were used as a basis for identifying the different fields that supplied the capital and villages with kernels which constitute potential markets.

Thus, 11 villages in the Mouhoun, Kossi, Sourou and Yatenga provinces were selected based on the following criteria: (a) *S. birrea* is very abundant in pure and dense populations; (b) *S. birrea* is traditionally highly exploited (fruit, kernels); and (c) villagers' perceptions of local forest species vary depending on whether or not there is a natural forest formation, *i.e.* biodiversity, near their village. According to phytogeographical divisions (Thiombiano and Kampmann, 2010), these provinces are in the sub-Saharan and North-Sudanian areas of Burkina Faso, which are characterised by rainfalls ranging from 550 to 600 mm in the North and 1000 mm in the southern part.

The targeted audience, as far as the management of the plant in rural area was concerned, consisted of 204 men and women, with average age of 53 (Table 1); with 20 people per village (10 men and 10 women).

To better understand the socio-economic impact of *S. birrea* by-products exploitation and marketing in the villages, this part of the study focused exclusively on women and children aged from 12 to 65 years, since non-ligneous forest products are mainly gathered and exploited by this social group (Table 2).

The survey on the pulp processing technique and the socioeconomic impact of juice marketing has concerned 50 women in the villages where the juice is mainly produced.

The data collected included plant materials (vernacular name of the species, fruit, and kernel; flowering and fruit times), various uses (food, medicinal, artisanal, cultural uses), fruit-based beverage processing techniques, kernel marketing routes and socio-economic impacts.

**Data analysis.** A generalised linear model was used to assess the interactions between the characteristics of the tree and the productivity ones through the JMP software (Statistical discovery from SAS). The survey data were grouped by village, and by ethnicity in order to determine the "interviewees' response rates" (f) per type of use:

$$f = S/N \times 100$$

Where: S = number of people who provided a response in relation to any given use; N = total number of interviewees.

## RESULTS

**Phenology and productivity.** Details on the number of trees identified by sex and site are displayed in Table 3. The sex ratio was 0.5 and 0.33, respectively; for Gampela and Loumbila sites.

TABLE 1. Distribution of respondent farmers by ethnic group and sex in Burkina Faso

Sex	Ethnic group					Total
	Dafing	Samo	Bwaba	Nunuma	Mossi	
Men	14	49	13	0	26	102
Women	10	48	15	3	26	102
Total	24	97	28	3	52	204

TABLE 2. Distribution of *S. birrea* kernels marketing respondents in rural areas and in Ouagadougou, Burkina Faso by age and sex

Zone	Sex	Age					Total
		12-15	16 - 24	25 - 40	41 -50	50 >	
Rural	Men	9	11	0	0	0	20
	Women	8	6	12	6	9	37
	Total	17	17	12	6	9	57
Ouagadougou	Men	0	0	0	1	0	1
	Women	8	38	27	17	13	103
	Total	8	38	26	18	13	104

The distribution of sex and flowers permitted identification of four types of individuals (Table 3):

- (i) female hermaphroditic individuals (50 and 62%), with monoclone flowers, (endowed with both androecium and gynoecium);
- (ii) male individuals giving only dichinous unisexual male flowers (47.8 and 33.3%);
- (iii) male-dominated polygamous individuals (2.2%) bearing mainly dichinous male flowers and a few monoclone flowers on some branches that barely yield fruit (Fig. 1a) and
- (iv) female-dominated polygamous individuals (4.7%) bearing mainly monoclone flowers and one or two dichinous male flowers on some branches (Fig. 1b).

The initial flower buds appeared as soon as early January. Fruiting stage occurred in late January - early February, and fruit maturation took place in May. Male flowering period spread over May. The number and styles per carpel ranged from 1 to 3. Carpels with 2 styles were the most common (Fig. 2). Carpels with 3 styles were rare. The productivity characteristics (Table 4) show that the number of fruit yielded per tree ranged from 136 to 4256, with fruit weights varying from 7.36 to 12.66 g, and had an average diameter of 26.71 mm. The number of kernels ranged from 1 to 3 per fruit, with an average diameter of 4.75 mm. Tree heights varied from 4.67 to 9.6 m, with an average diameter of 26.7, of which 57% of trees having

less than 25 cm trunk diameter. There was a significant relationship between tree trunk characteristics and productivity parameters (Table 5).

**Local names and perceptions.** *Sclerocarya birrea* was known to people under many common names, depending on ethnic groups. All respondents (100%) were aware of sex differences within *S. birrea*. There were plants that bore fruits and others that did not, which were called male plants. Five percent (5%) of men had ever seen some male plants that produced some fruit in certain seasons. In all dialects, the name of male plants consisted of the name of the plant followed by the *male* epithet. For example: manlu-biele in *Nunuma* (*manlu* = *Sclerocarya* and *biele* = Male) or nob-raogo (*nob* = *Sclerocarya* and *raogo* = male) in *Moore*. Such a name as “female plant” did not exist in any of these ethnic groups. Only 7.8% of respondents were able to differentiate the two sexes morphologically outside the reproduction period. Male individuals were larger, with thin leaflets, early leafing, long branches, long bole and small flowers. However, female plants had a short and sturdy trunk, with small leaves. Nonetheless, all of responders affirmed that the bark of old trees were rough whereas that of young plants was smooth.

**Habitat and *S. birrea* decline.** *Sclerocarya birrea* grew spontaneously in the wild. It was said to grow on all soil types (clay, sand, sandy clay, silt,

TABLE 3. Distribution of tree by sex and periods of phenological stages in Burkina Faso

Zone	Sex	Flowering period			Fruiting period			
		Beginning	100%	End	Beginning	Maturation 50%	End	
Gampela	Hermaphrodite			February	May	February	April	May
	Male Polygamous	23						
Loumbila	Hermaphrodite			January	Late January	February	May	
	Male Polygamous	26 14 2						

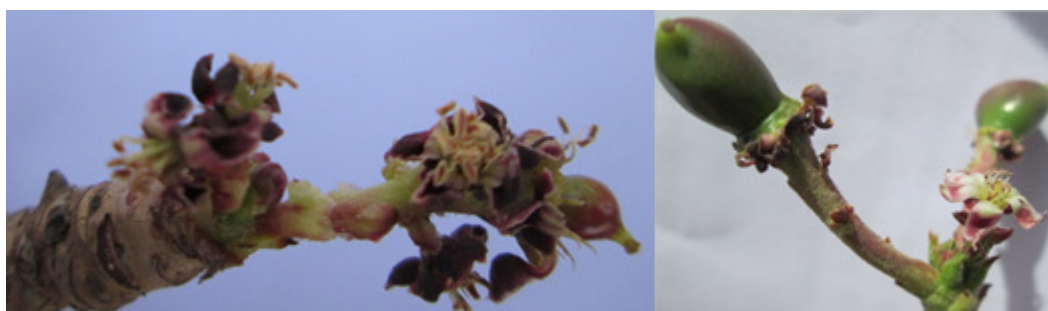
laterite and gravelly). It was found in farms as natural vegetation. It was mainly kept on farms for shade (100%), pharmacopoeia (95%) and fruit (100%). All respondents (100%) agreed that *S. birrea* populations had declined in recent years. Factors allegedly responsible for this decline were both anthropic (agriculture, logging for carving and grazing, debarking, bush fires, abusive woodcutting) and natural (drought, decrease in soil fertility, attack by black and white termites, storms).

**Uses.** Over 36 uses of *S. birrea* were recorded (Table 6), of which 21% were deemed important (FL > 5%) = Fidelity level in Table 6. Ten categories of uses were outlined (food, medicine, firewood, sculpture, tanning and dyeing, construction, trade and personal care). All organs of the plants were used.

The bark, especially that of male plants was the most used organ as traditional medicine, to treat primarily diseases of bacterial origin (Anal fissures, stomach aches, cough, diarrhoea, chronic wounds, dog bites, etc.). The leaves were used as fodder, only in the dry season for non-pregnant animals, because they are said to cause spontaneous abortions (53%). Fruit pulp and kernels were the only by-products marketed in these areas. The pulp was traditionally transformed into fermented beverage “*S. fruit water*,” and sold in the neighbourhood of Nouna and Dédougou. Alcohol level in this drink was as high as in any other local beverage, such as sorghum beer. Liquor was made out of its juice. Kernels were exploited in the same way as peanuts and sold in local markets.

In addition to direct and raw consumption, kernels were used as a flavour to sauces, or processed into a sort of pastry known as “*deguê-deguê*”. The oil extracted from kernels was used for body care. The wood was used either as a domestic fuel, for construction or crafts to make plowing and kitchen tools.

**Kernel extraction and pulp processing.** Gathering fruit under trees was done by women and children, who extracted kernels. Shepherds also collected fruit kernels from ruminants’ faeces, and sold them to women. Kernel extraction was done manually, using two stones, one as a hammer

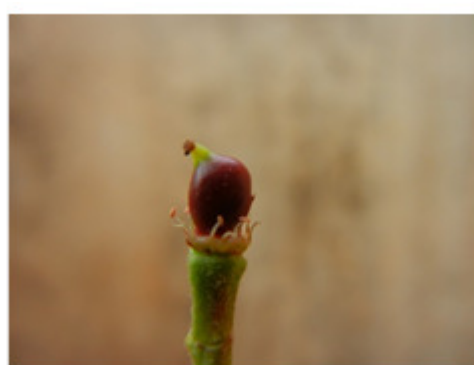


(a) male-dominated twig

(b) Hermaphrodite-dominated twig

Figure 1. Twigs from polygamous individuals of *S. birrea* in Burkina Faso.

(a). Pistils with 2 and 3 styles



(b) Pistils with 1 style

Figure 2. Pistils and different styles of *S. birrea* in Burkina Faso.TABLE 4. Tree characteristics and *S. birrea* productivity in Burkina Faso

Productivity	Values				
	Minimum	Maximum	Average	Standard deviation	CV(%)
Trunk diameter (cm)	14	38	24.36	6.55	26.88
Tree height (m)	4.81	9.6	7.2	1.24	17.2
Number of branches per tree	1	3	2	0.55	25
Number of fruits per tree	136	4256	1500	1127.79	75.2
Fruit weight (g)	7.36	19.23	12.66	3.17	25
Fruit diameter (mm)	14	30.752	26.71	2.26	8.5
Number of kernels per fruit	1	1.9	1.36	0.33	23.9
Kernel weight per fruit (g)	0.1	0.42	0.19	0.07	36.6
Kernel diameter (mm)	3.55	5.56	4.75	0.56	11.9



TABLE 5. Analysis through the linear model testing the effect of trunk diameter on productivity variables (N= 30)

	Number of fruits per tree				Number of kernels per fruit				Fruit weight				Fruit diameter				Kernel weight per fruit			
	df	SM	MS	F-value	df	SM	MS	F-value	df	SM	MS	F-value	df	SM	MS	F-value	df	SM	MS	F-value
Trunk diameter	5	187503	375061	0.93	5	1.82	0.075	0.0189	5	30.99	6.2	0.72	5	17.71	3.54	0.66	5	0.033	0.007	0.233

and the other as millstone (Fig. 3). In Mouhoun province, gathering fruit was allowed annually by the land chief, after rituals sacrifice to avert any maledictions. All of them vowed to gather up fruits under the tree, because it was forbidden to pick it from the tree. There was a proverb in that respect stating that: “*Sclerocarya* fruit cannot fall down without any help from the wind”.

The transformation process is schematically represented by Figure 4. Because of its high water content, the pulp was extracted directly from the fruit through a mechanical process.

**Marketing channel of kernels sold.** Kernels were sold in local markets to wholesalers, who transported them to Ouagadougou, the capital city of Burkina Faso. The major kernel routes to Ouagadougou were such roads as: Sourou-Ouagadougou, Ouahigouya -Yako-Ouagadougou, Dédougou-Ouagadougou, Nouna- Tugan-Ouagadougou, Nouna- Dédougou-Ouagadougou and Bobo-Ouagadougou.

In Ouagadougou, vendors were structured in three categories: wholesalers who brought kernels from producing villages, semi-wholesalers who are in markets and sold kernels with plates (Fig. 5a); and female retailing peddlers (mostly girls) who in turn repackaged the kernels in plastic bags and sold them at toll bridges, in bus stations and bars (Fig.5b). The main markets of Ouagadougou, where retailers stocked up with kernels were Sankar-yaar, Baskuiyaar and Gounghin-yaar, all of which were located at the entrance of the supply roads.



Figure 3. Kernel cracking technique used in Burkina Faso.

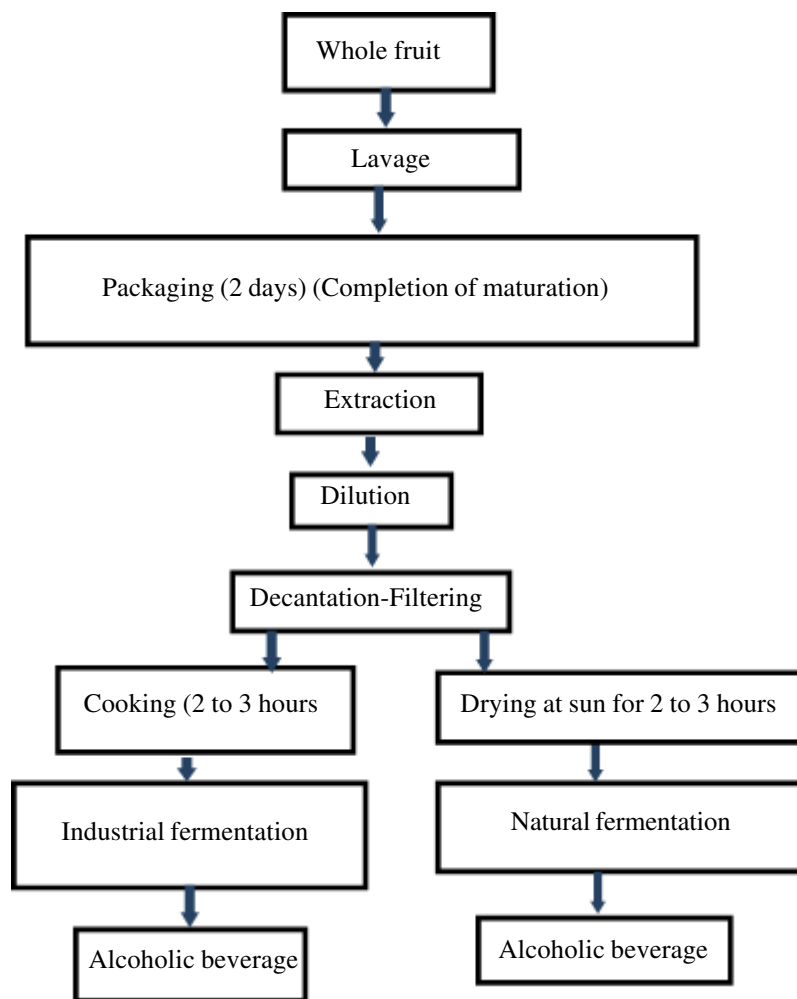
TABLE 6. Different organs used, usage purposes of and fidelity level (FL) of uses of *Sclerocarya birrea* in Burkina Faso

Organ	Use category	Usage purposes	Fidelity level (%)
	Medicine	Antiseptic ruminants (wound disinfection)	23
	Food	Fermented beverage	100
Pulp		Liquors	2.5
	Market	Source of income	68%
	Food	Peanut	100
Kernel		Ingredient	45
	Oil	body care	0.5
	market	Source of income	76.5
	Medicine	Anal fissures/Haemorrhoids	39.8
		Ulcer	22.5
		Conjunctivitis	4.5
		Child diarrhoea	25.6
		Tetanus	1.5
		Dysentery	24.8
		Diabetes	0.7
		Voltage	4.5
		Toothache	1.5
		Cough	9.8
		Animal bites (dog, agouti, rodents)	3
Bark		Constipation	1.5
		Colonitis	0.7
		General malaise	3
		Chronic wound	47.4
		Stomach ache	3.7
	Leather tanning	Dyeing	34
	Food	Potash production	2
		Hypertension	0.5
		Ulcer	1
		Wounds	2
		Anal fissures	1.5
Roots	Medicine	Cough	1
		Diabetes	0.5
		General malaise	0.5
	Medicine	Diarrhoea	0.5
		Dysentery	1.5
		Conjunctivitis	1.5
		Vomiting pregnant women	0.5
		General malaise	1
		Appetite stimulant in ruminants	0.5
		Cough	1
		Wounds	1.5
Leaves	Pastoral	forage (in dry season for non-pregnant animals)	53
	Agriculture	Soil protection (not as a fertilizer)	94
	Culture	Maskcloth-making	8.8
	Medicine	Animal delivrance	0.4



TABLE 6. Contd.

Organ	Use category	Usage purposes	Fidelity level (%)
		Heart disease	0.4
	Firewood	Energy	99
	Carving	Art object	87
	Agricultural tools	Handle hoe, timber hitch	74.5
Wood	Cooking tools	Manufacturing mortars, pestles, dishes	74.5
	Fender	Keep evil spirits off	0.1
	Structure	door, stool, frame	25.5

Figure 4. Traditional *S. birrea* fruit beverage making process in Burkina Faso.



(a) Plateful packaging

(b) Packaging in plastic bags

Figure 5. Kernel packaging and retailing in Ouagadougou markets and bus stations in Burkina Faso.

### Socio-economic impacts of *S. birrea* kernels.

*Sclerocarya birrea* kernels and fruit juice-based beverage marketing was a source of income for local populations in the fermented beverage produced once to twice a week for a quantity of 2 to 3 earthen ware jars per production. The price of an earthen ware jar beverage ranged from US\$ 0.33 to 0.5. Kernels prices varied from US\$ 0.04 to 0.17, depending on the size of the plastic bag, and from US\$ 2 to 3.76 for plateful packaging. In 2012, kernel marketing yielded US\$ 0.5 to 3.34 per market day and per individual in rural areas. In Ouagadougou, daily revenues ranged from US\$ 3.34 to 66.8 for whole salers, and US\$ 0.84 to 5 for female retailers.

**Constraints.** The following constraints to better selling kernels and fruit-based beverage were identified:

- (a) kernels got rancid after 2 to 3 months, which caused a change in taste;
- (b) kernels got rotten, and this did not allow stockpiling;
- (c) kernel extraction was still manual, which resulted in poor yield with high residues, hence lower profitability and higher cost to consumers after sorting; and
- (d) non-availability of fruit and kernels all year-long.

### DISCUSSION

The populations interviewed had deeper perceptions and broader views of *S. birrea*. The sexual dimorphism described by botanists (Aubreville, 1950; Maydell, 1983; Weller *et al.*, 1998; Arbonnier, 2000) was also noted by farmers, even though it was not easy for all farmers to differentiate male and female plants outside the reproduction period. The use of characteristics such trunk, foliage and phenology to describe morphotypes in wild fruit-trees by Burkinabe farmers was earlier reported by Compaoré (2010). The use of the bark appearance by farmers to differentiate *S. birrea* adult plants from the young ones was noted by Hall (2002).

Field observations of hermaphrodite flowers and fruit on rare male plants, corroborated the allegation of some farmers that male plants produced rare fruits in some seasons. Gouwakinnou *et al.* (2011) also noted that male plants of hermaphrodite flowers bore fruits. This study has specifically shown that there exist hermaphrodite plants that bear a few male flowers. This study has ranked *S. birrea* among species with multipurpose uses. All plant organs were used. Ten uses were identified with a variety of diseases treated in human pharmacopoeia.

Belem-Ouedraogo (2008) also ranked *S. birrea* among multipurpose plants but with three uses.

At the medicinal level, *S. birrea* can be said to be important, first for its wide range of applications (18 diseases listed), and secondly, for the diversity of its organs used (twigs, leaves, bark and pulp). These findings confirm that in African rural areas, traditional medicine is the primary source of care, ahead of modern medicine (Belem-Ouedraogo, 2008). It has been shown in several countries that good management of ecosystems for the sake medicinal plants was more profitable than if they were cleared for cultivation or livestock (Balick and Cox, 1997). However, in *S. birrea*, the most harvested organ for medicinal use is the bark (including the roots). According to Belem-Ouedraogo (2008) and Nacoulma (2012), the species when subjected to debarking, undergo serious physiological trauma that can sometimes be fatal. Similarly, preference for the use of the bark for the medicinal preparations has a more negative impact on fruit production, compared with leaf use practices. This is the case for *S. birrea*, since it is the male plants, pollen providers, which are mostly debarked (Bationo-Kando *et al.*, 2008). Populations should therefore, be sensitised on barking secondary branches and substituting leaves for roots if both have the same virtues. Besides, Belemtougri *et al.* (2001) reported the effectiveness of unprocessed decoction of *S. birrea* leaves on calcium signaling in skeletal muscles of rats, accounting therefore for the presence of active ingredients in the leaves.

At the economic level, *S. birrea* is praised for its fruit whose pulp and kernels are eaten and are marketed (Okole *et al.*, 2004; Ganaba, 2005). Similarly, the sale of objects carved in wood (not practiced in this area) can be a source of income for sculptors. According to Newton (2008), when a resource becomes economically important, the concept of copyright can occur and may contribute to its preservation. In the case of *S. birrea*, there is currently an economic appeal for local populations, which can be used as an incentive to protect the species. Indeed, the US\$ 1 to 1.25 market value of pulp beverages shows that there is improvement compared to what was found by Lamien and Bayala (1995), which was US\$ 0.67 to 0.84 a week, and per women within the same area. Furthermore, not only does the

sale of kernels generate more income, but it stands the major activity mostly practised by girls who have dropped out of the school system. The production of kernels and pulp-based beverages can be a hopeful business and a source of income for both rural and urban populations. Preserving the integrity of the kernel by good hulling technique will bring more substantial revenue to local people who exploit. This will require using a kernel shelling machine that will not only reduce kernels extraction difficulties, but will contribute to a better sale. Similarly, improving kernels conservation conditions for long periods will allow gradual selling without altering the taste.

Currently, only wholesalers and semi-wholesalers in the capital city make the most profit of *S. birrea* kernels trade. In fact, because of the presence of many residues, retailers lose much, in profits. However, considering the multitude of services provided by sale of the *S. birrea* non-ligneous products, it can be assumed that their contribution to household incomes is noticeable. Indeed, financial incomes earned by households help to ensure their children's education and meet their food needs. Guinko et Pasgo (1992) reported the contribution of non-ligneous products to households in Burkina Faso.

*Sclerocarya birrea* is a fruit-bearing plant, evidenced by the number of fruits per plant regardless of the size and age of the tree (the diameter of a tree is always positively correlated with age). At least, two kernels are extracted per fruit (Bationo-Kando *et al.*, 2008). The higher productivity of this fruit species and its presence in the form of plant communities, account for the commercial and industrial exploitation of its fruit. Bationo-Kando *et al.* (2009) showed that the mean sugar content of the fruit pulp was comparable with industrially exploited mangoes in Burkina Faso. Additionally, when compared with the reference seeds such as peanut, shea nut (Leakey, 1999), *Sclerocarya birrea* kernels had a more lipid content.

The height of trees which ranges from 4.81 to 9.6 m is not regarded as an obstacle, because the harvest is facilitated by fruit dropping and being gathered beneath trees. Additionally, implementing its exploitation will require only minor investments. The 0.5 sex ratio found in the

natural population indicates that pollination is ensured if there are pollinators. Fisher (1930) showed that this ratio was a strategy for diploid organism populations to be stable where each individual has exactly one father and one mother. Finally, although it ranks 9<sup>th</sup> in the list of major fruit species, *S. birrea* is not a protected like other multipurpose species with significant economic importance such as *V. paradoxa*, *P. biglobosa*. Therefore, better promotion of its fruit can accelerate its domestication, its popularisation, and ensure its survival.

### CONCLUSION

*Sclerocarya birrea*, as a major component of Sudano-Sahelian zone agroforestry parks, is well known and exploited by the populations in Burkina Faso. The main challenge is with using the commercial exploitation of its fruit as a strategy for its preservation as in South Africa where *S. birrea* is industrially exploited. The diversity of the desired by-products is a pledge for promoting its conservation for sustainable use. *Sclerocarya birrea* fruit production is significant, and conditions for industrial exploitation of the fruit are also met. Currently, the amount of fruit consumed is far below the amount of fruits produced each season. All the unused pieces of fruit are doomed to rot, and some of them are eaten by sheep, goats and wild animals. Organising the production and management of the sector, and providing for adequate means for kernels shelling and packaging will allow local populations to make the most of these products marketing and, by the same token, contribute to alleviate poverty in rural areas. Similarly, training women in pulp processing techniques will allow setting up an *S. birrea* fruit industrial processing unit, so as to generate more substantial economic benefits. Effective promotion of this natural resource could be an opportunity for selling its by-products in the sub-region markets and even beyond.

### ACKNOWLEDGEMENT

We thank the people of Sourou, Mouhoun, Yatenga and Kossi provinces. Also, the wholesalers and street vendors of *Sclerocarya*

kernels in the markets, stations and toll booths of Ouagadougou city are acknowledged.

### REFERENCES

- Aubreville, A. 1950. Flore forestière soudano-guinéenne A.O.F. Cameroun-A.E.F. Société d'éditions géographiques maritimes et coloniales-Paris. pp.392-407.
- Arbonier, M. 2000. Arbres, arbustes et lianes des zones sèches d'Afrique de l'Ouest. CIRAD-MNHU-UICN. 541 p.
- Balick, M.J. et Cox, P.A. 1997. Ethnobotanical research and traditional health care in developing countries. In: Bodeker, G., Baht K.K.S., Burley, J. and Vantomme, P. (Eds.), *Noon-wood forest product*, Vol. 11. FAO, Rome, Italy.
- Bationo-Kando, P., Hilou, A., Traore, E., Nanema, R. and Zongo, J.D. 2009. Variabilité de quelques caractères biochimiques des fruits de *Sclerocarya birrea* (A. Rich.) Hochst au Burkina Faso. *Fruits* 64:351-360.
- Bationo-Kando, P., Zongo, J.D., Nanéma, K.R. and Traoré, R.E. 2008. Étude de la variation de quelques caractères morphologiques d'un échantillon de *Sclerocarya birrea* au Burkina Faso. *International Journal of Biological and Chemical Sciences* 4:549-562.
- Bationo-Kando, P., Bisseye, C., Nanéma, K.R., Traoré, R.E., Yé, H., Diallo, O.B., Compaoré, R.T., Simporé, J. and Zongo, J.D. 2012. Genetic diversity of *Sclerocarya birrea* subspecies *birrea* populations in Burkina Faso detected by RAPDs. *African Journal of Biotechnology* 11 (1): 99 -108.
- Belem-Ouedraogo, M. 2008. Les galeries forestières de la Réserve de la Biosphère de la Mare aux Hippopotames du Burkina Faso: Caractéristiques, dynamique et ethnobotanique. Thèse de 3<sup>ème</sup> Cycle, Université de Ouagadougou. 262p.
- Belemtougri, R.G., Constantin, B., Cognard, C., Raymond, G. and Sawadogo, L. 2001. Effects of *Sclerocarya birrea* (A. rich) hochst (anacardiaceae) leaf extracts on calcium signaling in cultured rat skeletal muscle cells. *Journal of Ethnopharmacology* 76: 247 -252.
- Compaoré, I. 2010. Identification et caractérisation biométrique des variétés

- forestières du karité (*Vitellaria paradoxa* C.F. Gaertn) au Burkina Faso. Mémoire de DEA, Université de Ouagadougou, Burkina Faso 37p.
- Diallo, O.B., Bastide, B., Poissonnet, M., Dao, M., Sanou, J. and Hossaert-Mc Key, M. 2006. Mise en évidence d'une androdioécie morphologique et d'une « hétérostigmatie » chez *Sclerocarya birrea* (A. Rich.) Hochst. *Fruits* 61: 259-266.
- Fisher, R.A. 1930. The Genetical Theory of Natural Selection. Clarendon Press, Oxford, UK. 318p.
- Ganaba, S., Ouadba, J.M. and Bognounou, O. 2005. Exploitation traditionnelle des végétaux spontanés en région sahélienne du Burkina Faso. *La revue en sciences de l'environnement Vertigo* (2) 6.
- Gouwakinnou, G.N., Lykke, A.M., Djossa A.B. and Sinsin, B. 2011. Folk perception of Sexual dimorphism, sex ratio and spatial repartition: implications for population dynamics of *Sclerocarya birrea* [(A. Rich) Hochst] populations in Benin, West Africa. *Agroforestry Systems* 82:25-35. DOI 10.1007/s10457-011-9371-x
- Guinko, S. and Pasgo, L.J. 1992. Harvesting and marketing of edible products from local woody species in Zitenga, Burkina Faso. *Unasylyva* 43: 16-19.
- Hall, J.B. 2002. Ressources végétales de l'Afrique Tropicale. Précurseur-Programme PROTA, Wageningen, Pays-bas. pp. 144-148.
- Kokwaro, 1986. Anacardiaceae: In: Polhill, R.M. (Ed.), Flora of tropical East Africa. Balkema A A, Rotterdam, The Netherlands. pp. 42-45.
- Lamien, N. and Bayala, J. 1995. Caractérisation du parc à Karité dans le système de production à base de cotonnier du terroir de Yasso, INERA/CNRST, Bobo-Dioulasso, Burkina Faso *Burkina Faso*, 52 p. Kenya. INERA/RSP West Zone Bobo-Dioulasso. Burkina Faso. 13 p.
- Leakey, R.R.B. 1999. Potentiel for novel food products from agroforestry trees: A review. *Food Chemical* 66: 1-14.
- Maydell, V.H.J. 1983. Arbres et arbustes du sahel : Leurs caractéristiques et leurs utilisations, GTZ, Eschborn, Allemagne. pp. 344 -346.
- Nacoulma, B.M.I. 2012. Dynamique et stratégies de conservation de la végétation et de la phytodiversité du complexe écologique du parc national du W du Burkina Faso. Thèse, Université de Ouagadougou, Burkina Faso. 151p.
- Newton, A. 2008. Conservation of tree species through sustainable use: how can it be achieved in practice *Oryx* 42(2): 195-205.
- Okole, B.N. and Odhav, B. 2004. Commercialisation of plants in Africa. *South African Journal of Botany* 70 : 109-115
- Ouédraogo, S.J. and Belem, M. 1998. Prioritisation ou préférence paysanne et amélioration de la production des espèces agroforestières du Burkina Faso. In: Ouedraogo, A.S. and Boffa, J.M. (Eds.), Vers une approche régionale des ressources génétiques forestières en Afrique sub-saharienne. Ouagadougou Burkina Faso.
- Séréomé, A. 1996. Les Anacardiaceae du Burkina Faso : Paramètres botaniques et concentration en tanin. Thèse, Université de Ouagadougou, 130 p.
- Weller, G.S., Sakai, A.K., Rankin, A.E., Golonka, A., Kutcher, B. and Ashby, K.E. 1998. Diocy and the evolution of pollination system in *Schiedea* and *Alsinidendron* (Caryophyllaceae: *Alsinidendron*) in the Harvarian islands. *American Journal of Botany* 85 (10):1377-1388.