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Indigenous Knowledge of Shea Processing and Quality Perception of Shea Products in Benin

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Indigenous Knowledge of Shea Processing and Quality Perception of Shea Products in Benin

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A survey among 246 people belonging to 14 ethnic groups and living in 5 different parklands in Benin revealed different practices to process shea kernels (namely boiling followed sun drying and smoking) and extract shea butter. A relation between parklands, gathering period, and sun-drying conditions was established. Moisture content and appearance of kernels were the selection criteria for users of shea kernels; color was the main characteristic to buy butter. Constraints to be solved are long processing times, lack of milling equipment and high water requirements. Best practices for smoking, sun drying, and roasting operations need to be established for further improvement.

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KEYWORDS karité, Vitellaria paradoxa*, shea kernels, shea butter, Otamari, forest products*

In Africa, millions of poor people rely on a wide variety of forest products to sustain their livelihood. Among the forest tree species, the shea tree (*Vitellaria paradoxa*, Sapotaceae) has been identified as one of the top ten agroforestry tree species to be conserved and domesticated in West Africa (Eyog Matig, Gaoué, and Dossou 2002), and it constitutes a key economic species used daily in African savannah areas (Kater, Kante, and Budelman 1992; Boffa et al. 2000). The species is known to occupy a 5000 km stretch of African savannah from Senegal to Ethiopia and Uganda (Lovett and Haq 2000). Shea trees commonly occur around human habitations and may sometimes constitute more than 80% of the woody biomass in farmers' fields (Lovett and Haq 2000). The popularity of the shea tree among indigenous people is due to its many uses. The leaves and roots have various medicinal applications (Boffa et al. 2000). The wood is heavy and invaluable in construction works and in the production of household and farm implements. It is also used as a fire wood and its charcoal is particularly valued by blacksmiths (Schreckenberg 2004). Shea fruit pulp is taken for its laxative properties (Soladoye, Orhiere, and Ibimode 1989) aside from containing sugars, protein, calcium, ascorbic acid, and iron (Maranz et al. 2004).

The economic importance of the species is linked to the fat extracted from its kernels, which has a significant role in the local rural and national economy of the regions where the tree is encountered. About 650,000 tons of shea nuts are produced annually from the main producing countries of Ghana, Benin, Burkina Faso, Togo, Côte d'Ivoire, Mali, and Nigeria (Conférence des Nations Unies sur le Commerce et le Développement [CNUCED] 2006), of which an estimated 10% to 30% is exported specifically to Europe, Asia, and America (United States Agency for International Development [USAID] West Africa Trade Hub 2004). A major part of this fat is used in the food industry as a cocoa butter substitute or improver because of its high content of stearic-oleic-stearic triglyceride (16%–45%), and another part is used for cosmetic and pharmaceutical purposes due to the high percentage (5%–17%) and composition of its unsaponifiable fraction, which consists of, among others, triterpenes, tocopherols, polyphenols, sterols, and karitenes (Honfo et al. forthcoming). In African producer nations, shea fat is mostly extracted by the traditional methods described later and is used in cooking, as an illuminant, as well as in soap and pomade preparations (Hall et al. 1996). Besides, cosmetic industries in these countries are also finding it invaluable in skin and hair cream formulations (Boffa et al. 1996).

The techniques to process the shea fruit into butter involve many operations, which vary throughout the regions where shea is produced and influence the quality of the butter. Several authors (e.g., United Nations Development Fund for Women [UNIFEM] 1997; Kapseu et al. 2001; Elias and Carney 2004; CNUCED 2006; Mbaiguinam, Mbayhoudel, and Djekota 2007; Dandjouma et al. 2009), have described technologies to process shea butter. Other authors (Hyman 1991; Bruinsma 1998; Olaoye and Babatunde 2001; Coulibaly et al. 2004) have developed and proposed several labor-saving technologies to facilitate some of the main operations. Moreover, enzyme-assisted aqueous extraction of shea butter was developed to increase fat extraction in rural shea kernel processing (Tano-Debrah and Ohta 1995). However, in spite of efforts to reduce the labor involved in processing and to improve the quality of the shea products, some problems persist. Improvement of traditional techniques and end products, and production of added value products for a larger market, are expected to increase the income of rural, poor populations because of the existing market opportunities. The development of any technology to improve the quality of the main commercially important shea products (i.e., kernels and butter), has to take the indigenous practices into account to ensure dovetailing with local production circumstances. To date, no proper inventory of indigenous knowledge on the processing of shea products in Benin and the quality of end products exists. The present study attempts to complete and update the existing data. Specifically, this research has (1) recorded the different traditional methods to process shea fruits in Benin, (2) assessed their constraints, and (3) analyzed the quality perception of shea products among the actors.

MATERIALS AND METHODS

Study Area and Sampling of Respondents

Studies on the shea tree, in particular those of Gnanglè (2005) and Koumassa (2010), have identified five parklands in Benin—namely Bohicon, Save, Parakou, Bembereke and Kandi—and revealed that 3%, 15%, 27%, 27%, and 28 %, respectively, of the population in these parklands is involved in production and processing of shea products. To determine the adequate sampling size for respondents for our survey among the shea actors per parkland, the following formula was used: $N_i = \frac{4P_i(1-P_i)}{d^2}$ where N_i is the total number of shea actors to be surveyed in parkland i, P_i is the proportion of shea actors found in previous studies in parkland i, and d is the expected error margin in the conclusion, which was fixed at 0.1 (Dagnelli 1998).

According to this formula, 10 people were selected in Bohicon, 42 people in Save, 64 in Parakou, 64 in Bembereke, and 66 in Kandi, giving a total of 246 respondents.

Next, one location in the parkland of Bohicon and two locations in each of the four other parklands were chosen on the basis of the importance of shea fruit collection, butter processing, and their sociocultural diversity

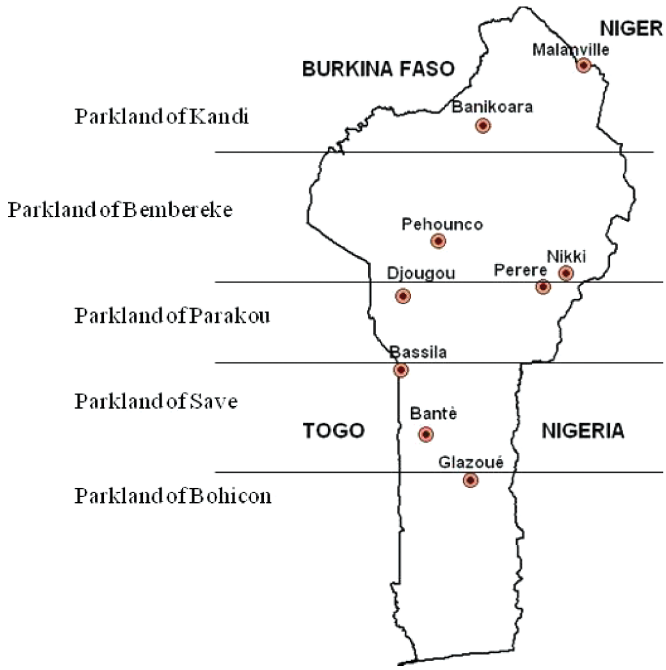

FIGURE 1 Map of Benin showing the parklands and study locations (color figure available online).

(figure 1). The number of respondents needed in each location was calculated on the basis of its population size with the following formula: $T_j = \frac{N_j \times X_j}{\sum X}$ where T_j is the sample size in the location j, N_j is the total number of shea actors to be surveyed in parkland j, X_j is the population size in the location j, and $\sum X$ is the sum of the two population sizes selected in parkland j.

Four types of actors involved in the shea chain were randomly selected in each location (i.e., gatherers of shea fruit in the field, processors of shea butter, traders of butter and users of butter). In summary, for all parklands, 64 gatherers, 66 processors, 60 traders, and 56 users were interviewed.

Data Collection

Surveys were conducted from August to September 2010. Respondents of both sexes (234 women and 12 men) with various ages and diverse educational backgrounds were randomly selected and interviewed from 14 different ethnic groups. One percent of the respondents were younger than 20 years and 27% were older than 50 years; 80% of respondents had no formal education and 17% had finished primary school. Specific questionnaires were developed for each type of actor and tested before the survey.

The questionnaires included the following aspects:

- *At the gatherers' level*: Varieties of shea tree, periods and places of fruit gathering, parameters considered when gathering fruits, constraints in collecting fruits, processes to extract the kernels from the nuts, price variation of the kernels between years, characteristics of good quality nuts, storage conditions of kernels, sales market of kernels, purchasers' preferences, different end uses of the butter.
- *At the processors' level (individual and group)*: Sources of the kernels, parameters considered when purchasing kernels, high and low availability periods of kernels, quality perception of kernels (drying degree, appearance, color, size) characteristics of a kernel of good quality, processing techniques to extract the butter, frequency of butter production, storage conditions of butter, purchasers' preferences (color, odor, texture), different end uses of the butter.
- *At the traders' level*: Places of purchase and sales of butter, periods of high and low availability, quality criteria of butter (color, odor, texture), criteria to determine butter price, storage conditions of butter, purchasers' preferences, knowledge about the norms on shea butter, different end uses of the butter.
- *At the users' level*: Places of purchase, availability of butter, quality criteria for butter (color, odor, texture), different end uses of butter and frequency of use.

Interviews were conducted in the language or dialect that was best understood by the respondents, with translation when necessary.

Data Analysis

Statistical analyses were performed using SAS 9.1 software. Principal component analysis (PCA) was performed to link processing techniques to parklands or ethnic groups. Only data provided by gatherers were used for PCA. Correlations were used to evaluate the relation between different variables such as ethnic group, parkland, and unit operations to extract the kernels from the shea fruit.

RESULTS AND DISCUSSION

Shea Products and Their Characteristics

Among the different ethnic groups involved in the gathering of shea fruits, the Fulani reported to know about trees producing fruits with sweet pulp. The sweet fruit pulp is consumed by the farmers in the fields. Besides, fruits

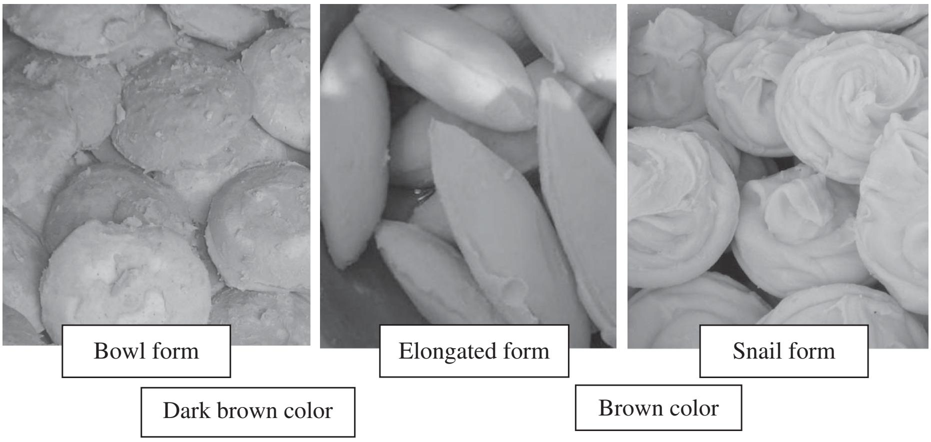

FIGURE 2 Different forms of shea butter.

with sweet pulp are often sold in piles of 10 fruits on the local markets. However, in most cases, the fruit pulp is just removed to get the nuts. Shea kernels are extracted from the nuts and their color is often brown or dark brown, depending on the extraction method. The kernels are sold or stored for export or for further use. Shea butter is the cooking fat of the rural populations in all parklands except Bohicon. It results from the processing of the kernels and is shaped as a ball, in the case of the Yom ethnic group; as an elongated form, in the case of the Bariba ethnic group; and as a snail form, which is specific for the Fulani ethnic group (figure 2). The butter is sold on the local and regional markets in the shapes that are specific for each ethnic group and at prices from 25 FCFA (€ 0.04) to 100 FCFA (€ 0.15), at average weights of 50 g and 150 g, respectively. The price is standard throughout the year, but the weight of a single piece of shea butter increases in periods of abundance and decreases in periods of shortage.

Processing Techniques of Shea Kernels and Shea Butter

Gathering the Shea Fruits

All gatherers and processors interviewed were women. The ethnic groups that were most involved in the production of shea butter were the Bariba (29% of gatherers/processors), Fulani (22%), Yom (14%), and Nagot (11%). Gathering of shea fruits is generally done by women and children early in the morning (6–9 a.m.) between May and September, depending on the parkland. In the parkland of Bohicon, the fruit is less valued and the harvest is in May–July; it takes place in May–August in the parkland of Save, during June–August in the parklands of Parakou and Bembereke, and in June–September in Kandi. The period of abundance is June–July in most of the parklands. Women collect fruits from their personal or their husband's plots and the fields belonging to their family. The fruits are picked up from the ground and 92% of the respondents picked up all of the fruits without sorting.

Preserving the Nuts

After gathering, the fruits are depulped in the field and brought back home where, depending on the quantity of the fruits and the availability of the women, they are stored for 3 to 15 days before giving the nuts a preservation treatment, either by boiling plus sun drying or by smoking (figure 3). The boiling of fresh nuts is widespread in the shea areas and was done by 97% of respondents. Boiling duration varied from 15–60 minutes. This operation is followed by sun drying for 7–21 days. Sun drying consists of spreading the nuts on the ground until the nuts are dry, so the nuts are subjected to the prevailing weather. Smoking was done for 36–48 hours in a traditional cylindrical oven built from sand and wood, and is specific for the Otamari ethnic group. The women, who practice this technique, prefer it because the nuts do not need to be dried before shelling. However, there is no proper control of the heat during smoking, and this may cause the incidence of burned nuts, which subsequently could lead to a final product with a burnt smell.

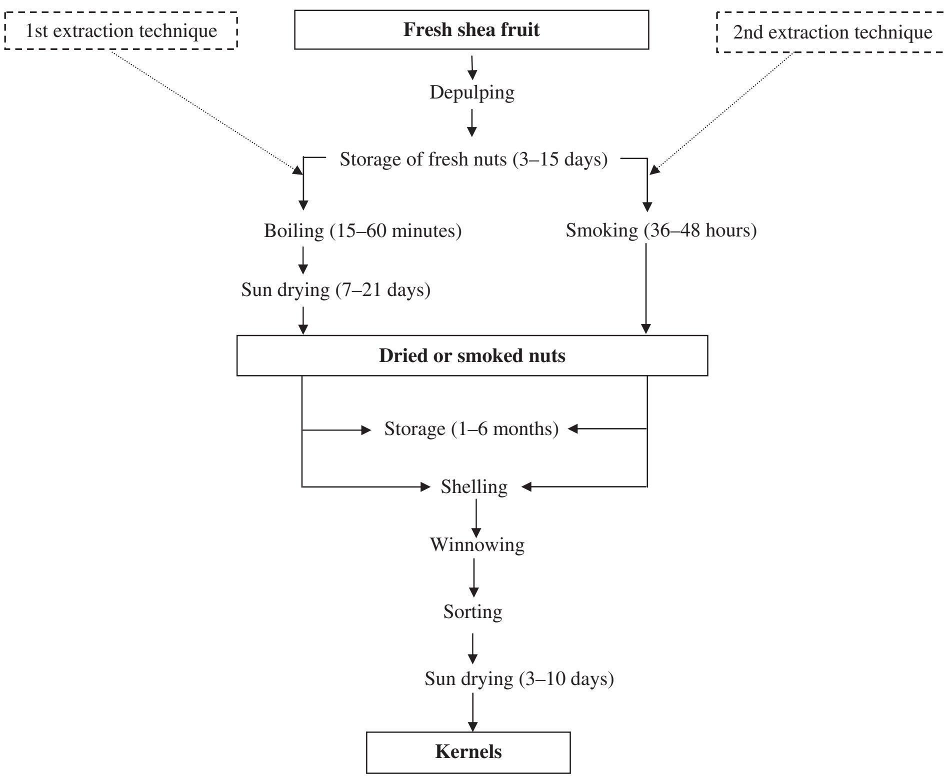

FIGURE 3 Flow chart for the local extraction of shea kernels.

Shelling of the nuts and storage of the kernels

The dried or smoked nuts are stored for 1–6 months by 20% of the respondents, specifically in the Banikoara region (parkland of Kandi), or shelled in 80% of the cases. Different methods are used to remove the shells, including pounding using a mortar and pestle, and cracking between two stones. Shells are also removed by trampling (Hall et al. 1996). Shelling is finished by a winnowing process. If the wind is strong enough, the pieces of shell will be blown away easily. If not, the winnowing operation has to be repeated many times. The kernels obtained are spread on plastic or polyethylene bags or a cement platform for sun drying for 3 to 10 days before storage until further use or export. During this sun drying, the kernels are removed each night or before rainfall. Shea kernels thus obtained are stored for 1–3 months (22% of respondents) to 9–12 months (12%), but most commonly for 4–6 months (41% of respondents). Most of the respondents (80%) stored the kernels in polyethylene or jute bags, while the others used traditional baskets (9%) or a granary (8%). During storage, 13% of the respondents sun dried the kernels at least once a trimester.

The different techniques to produce shea kernels involve several operations, which take place in poorly controlled conditions, leading to variation in the quality characteristics of the kernels. For instance, during the 3–15 days storage period of the fresh nuts, some physiological activities could take place, in particular hydrolysis of triglycerides, which leads to the production of free fatty acids, thereby increasing the acidity level. Guillaumin (1982) reported that during storage of oleaginous plants products at a high relative humidity, frequently an increase of the acidity of the lipid fraction is observed. According to the processors, boiling of the fresh shea nuts is generally done to inactivate the enzymes responsible for hydrolysis of the fatty acids, but also to facilitate shelling. Inadequate boiling could make the shelling difficult due to the occurrence of latex, a sticky substance which binds the shell to the kernels, and could also influence the inhibition of enzymes. The fact that drying of the nuts and the kernels is by direct exposure to the sun without removing at night, makes this operation a vulnerable step in the production chain: all gatherers interviewed found this a critical operation, essential for good kernel quality. The nuts are subjected to the prevailing weather conditions with the risks of germination and oxidation of fatty acids, which leads to an increased rancidity of the extracted fat. Bup and colleagues (2008) showed that shea kernels dried without direct exposure to the sun gave shea butter that meets the international standards for cosmetic and pharmaceutical uses. Drying without direct exposure is generally done in a greenhouse, which offers protection against insects, rains, and other contaminations. Most conditions to store the kernels at present could lead to germination and infestation by microorganisms and birds.

Butter extraction

According to the processors interviewed, most of them (91% of respondents) gather the shea fruits, and extract and store the kernels for butter processing. Processors (92% of respondents) wash and sun dry the kernels after storage for 4–8 hours before grinding or roasting (see figure 4). Two fundamentally different techniques to extract the butter were found. The first technique concerned 5% of the processors and involved the roasting of whole kernels in ash or sand for 30–60 minutes, followed by pounding, and milling. The

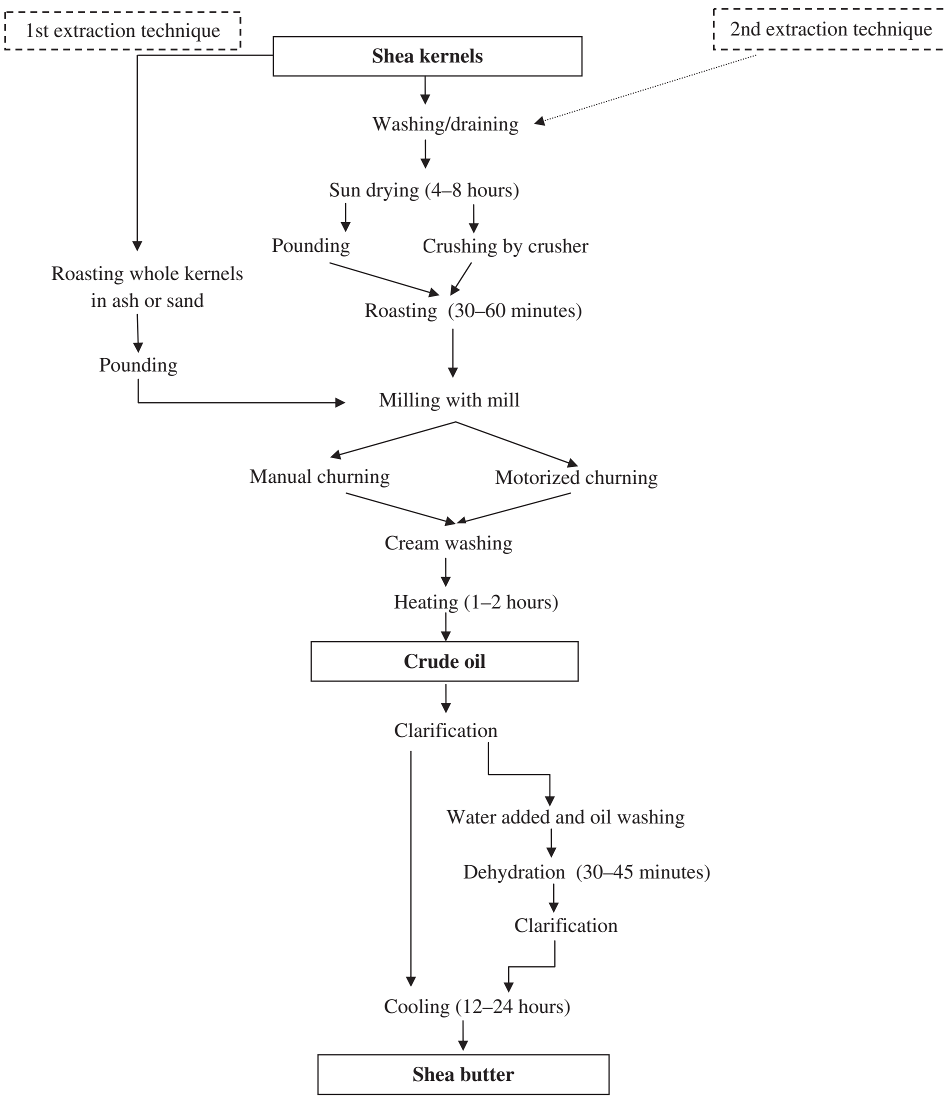

FIGURE 4 Flow chart for local processing shea butter.

second technique implies the crushing of the kernels by a crusher (97%) or their pounding (3%), followed by roasting for 30–60 minutes and milling into a pasty material. The next stage is the mixing of the paste with warm water, followed by manual churning in 98% of the cases, until the water and the fat separate. Subsequently, the water is removed and the creamy fat layer is washed and heated for 1–2 hours until it is clear. The crude oil is then cooled in 74% of the cases. In the other cases, water is added to the crude oil and the mixture is left for 1 hour; the layer is separated by spoon and dehydrated by heating during 30–45 minutes. The resulting oil is clarified by sieving, and cooled for 12–24 hours to get shea butter. The practice of adding water to the oil is generally done to reduce the impurities in the butter, and done by women who have benefited from some training related to shea-butter processing.

With respect to roasting the kernels, a practice to facilitate fat extraction and improve the sensory characteristics of the butter (Shimoda et al. 1996; Krist et al. 2006), it is known that insufficient heating may reduce the yield of oil (Krysiak and Motyl-Patelska 2005), and too-high temperatures lead to undesirable volatile compounds (Krist et al. 2006). Bail and colleagues (2009) compared the volatile profile of different shea butters and reported that processing steps including drying of kernels before producing the fat and additional roasting procedures influence the volatile compounds in shea butter significantly. The effect can be either positive or negative, indicating the necessity to monitor and control the processing of the butters carefully.

Storage of shea butter

The storage conditions of shea butter vary among the actors, with respect to packaging material as well as duration of storage (table 1). Baskets lined with teak (*Tectona grandis*) leaves, paper bags that previously contained cement, or jute bags are used by 45% of the processors and by 65% of the traders as packaging material to store the butter, while plastic containers with a cover are used by 38% of the processors, 23% of the traders, and the majority (66%) of the users. Calabash containers with a cover are used to store the butter by the three types of actors; butter was also immersed in water by certain users during storage. The butter thus packaged is kept in a room or stored in market places. Traders exposed shea butter directly on their display to sell it in local markets. This presentation of shea butter was seen as a problem by some users because of the exposure to sun and dust.

Users stored shea butter for one week up to 6 months to have enough until the next production period. Most processors (77%) store the butter for 1–4 weeks before selling it, and traders for 1–4 weeks (68%) or for 2–3 months (28%). When the butter is used as cooking fat, the storage duration is short; less than one month. However, when it is used as body or hair ointment, in soap making, and in traditional medicine, the butter is stored for 2 to 6 months.

TABLE 1 Packaging Materials and Duration for Butter Storage (as % of Respondents)

	Processors ($n = 66$)	Traders ($n = 60$)	Users ($n = 56$)
Storage packaging			
Aluminum container	3*	13	13
Basket	45	65	0
Calabash container	24	15	16
Plastic container	38	23	66
Water immersion	0	9	15
Storage duration			
< 1 week	5	2	13
1–4 weeks	77	68	39
2–3 months	18	28	32
4–6 months	0	2	9
> 6 months	0	0	7

*Sum > 100 because several answers were possible for packaging materials.

Quality degradation of shea butter was observed during storage. Honfo and colleagues (2011) found that color, acid value, peroxide value, and iodine value of shea butter changed during storage; the color of butter turned to white; acid and peroxide values were increased while iodine value decreased during storage; these observations were more pronounced when the storage duration was long; after 3 months for example. Undesirable volatile compounds can also be produced in shea butter during storage. Most of these volatile compounds in shea butter are degradation products of fatty acids, such as acetic and hexanoic acid; carbonyl compounds (hexanal, heptanal, trans-2-heptenal, 2,4-heptadienal), 2-pentylfurane; and processing compounds like furfural as well as glycerol (Bail et al. 2009). Honfo and colleagues (2011) also reported that the degradation of shea butter quality was more pronounced in baskets lined with different materials. Plastic containers seemed to be the best packaging material, and this observation was corroborated by the respondents in the survey.

Use of Butter

The majority of users (84% of respondents) of shea butter interviewed were women. Shea butter was used for cooking, skin/hair care, medicinal applications, and soap making in the survey area. The use of shea butter as a cooking fat for food preparation for the household or for vending purposes (snacks and meals) was observed in 93% of the cases. Some respondents used shea butter as skin/hair care (65%) or as a medicinal ointment (43%). Yellowish or yellow butter was frequently used for food preparation, while white butter was generally used for skincare. Some consumers added onions, spices, or orange peels to shea butter to improve its smell and taste when used as cooking fat. Shea butter meant for skincare was often put into a small container and some perfumes or other body creams were added to improve the smell. Hard butter was commonly used for food preparation, whereas soft butter is easy to smear on the skin. Only 7% of respondents were non-food users; they used shea butter for medicinal purposes, as an ointment against rheumatic and joint pains, and in case of dislocation, swelling, bruising, or muscle ache. Besides, Pereira (1983) reported that shea butter is used to protect cowpeas (*Vigna* sp.) against insect (*Callosobruchus maculatus*) damage. He observed that a treatment with shea butter reduced the life span and fertility of the insects and hence the infestation rate.

Important Quality Criteria of Kernels and Butter

Quality criteria that are important in choosing shea kernels or butter are presented in table 2. Drying degree of kernels and appearance are the major selection criteria mentioned by processors when they want to buy kernels. Drying degree is generally assessed by breaking the kernel and checking whether its interior does not contain any liquids. Appearance describes the integrity of kernel. Color of kernels is another important quality characteristic for all processors, but in different degrees. Of respondents, 32% mentioned it as a very important characteristic, while 29% said it was moderately important. All respondents preferred a brown kernel color. Kernel size and degree of boiling, assessed by the presence or absence of latex, are not the main concerns for most processors. However, 37% of the respondents consider the degree of boiling as a quality attribute of a certain importance.

The color of shea butter is the main quality criterion for traders and users. The color varies from yellow to white, which is considered to be the natural state of the butter. The majority of all respondents (61%) preferred the yellowish or white color (table 3). According to the traders, the yellow

TABLE 2 Important Quality Criteria for Processors of Kernels and for Traders and Users of Butter (as % of Respondents)

	Very important	Important	Moderately important	Not important
Shea kernels ($n = 66$)				
Boiling degree	0	16	21	63
Drying degree	96	5	0	0
Appearance	70	26	5	0
Color	32	39	29	0
Size	0	9	14	77
Shea butter ($n = 116$)				
Color	70	25	5	0
Taste	0	7	5	88
Odor	45	36	18	0
Texture	8	49	17	25
Shape	3	14	29	54

TABLE 3 Preferences with Respect to Butter Color (as % of Respondents)

Actors	No preference	Yellowish	Yellow	Gray	White
Gatherers ($n = 64$)	8	38	27	11	16
Processors ($n = 66$)	12	35	12	9	32
Traders ($n = 60$)	3	45	13	12	27
Users ($n = 56$)	6	27	26	18	23
Total ($N = 246$)	7	36	20	12	25

color is more popular among end users. Certain respondents find yellow butter attractive. To satisfy their preferences, certain processors (12%) used some roots or bark to get the yellow color or to improve the butter color. For this purpose, *Cochlospermum tinctorium* roots are usually used in the parklands of Parakou, Bembereke, and Kandi by certain processors; the roots are dried and ground to a powder, to be added during the boiling of shea cream. Gray butter is generally obtained during the rainy season, as the result of the darkness of kernels, when the nuts are not properly sun dried. However, some buyers pointed out that the color preference also depends on the end use by the consumers and on the availability of shea butter on the market. Odor is another important selection criterion when buying shea butter; 45% of buyers judge it as very important. The smell is a quick discriminating quality criterion that buyers use for a rapid choice when they agree with the butter color. Shea butter generally has a nutty smell and should be free from rancid odor. Another quality characteristic is the texture (hard or soft) of shea butter; 49% of buyers state that it is important to them. Hard butter is considered to have a low water content, which means better preservation and a higher fat content, whereas soft shea butter is chosen because it melts easily and is cheaper than hard butter. Certain buyers (25%) do not consider the texture, and are more interested in external factors such as availability. All of the butter quality criteria depend on the way the butter has been processed, the processing period (rainy or dry season), and the storage conditions (Womeni et al. 2007; Bup et al. 2008).

Relations between Kernel and Butter Extraction, Parklands, and Ethnic Groups

Most practices to obtain the shea kernels from the fruits are similar throughout the parklands and among the ethnic groups. Principal component analysis (PCA) performed on the unit operations to extract shea kernels, parklands and ethnic groups showed 60.9% of variation on the first three main axes (figures 5 and 6). Axis 1 explained 29.4% of the variation and mainly represented the relation between parkland, gathering period, duration of kernel sun drying and sun-drying material (table 4). The second

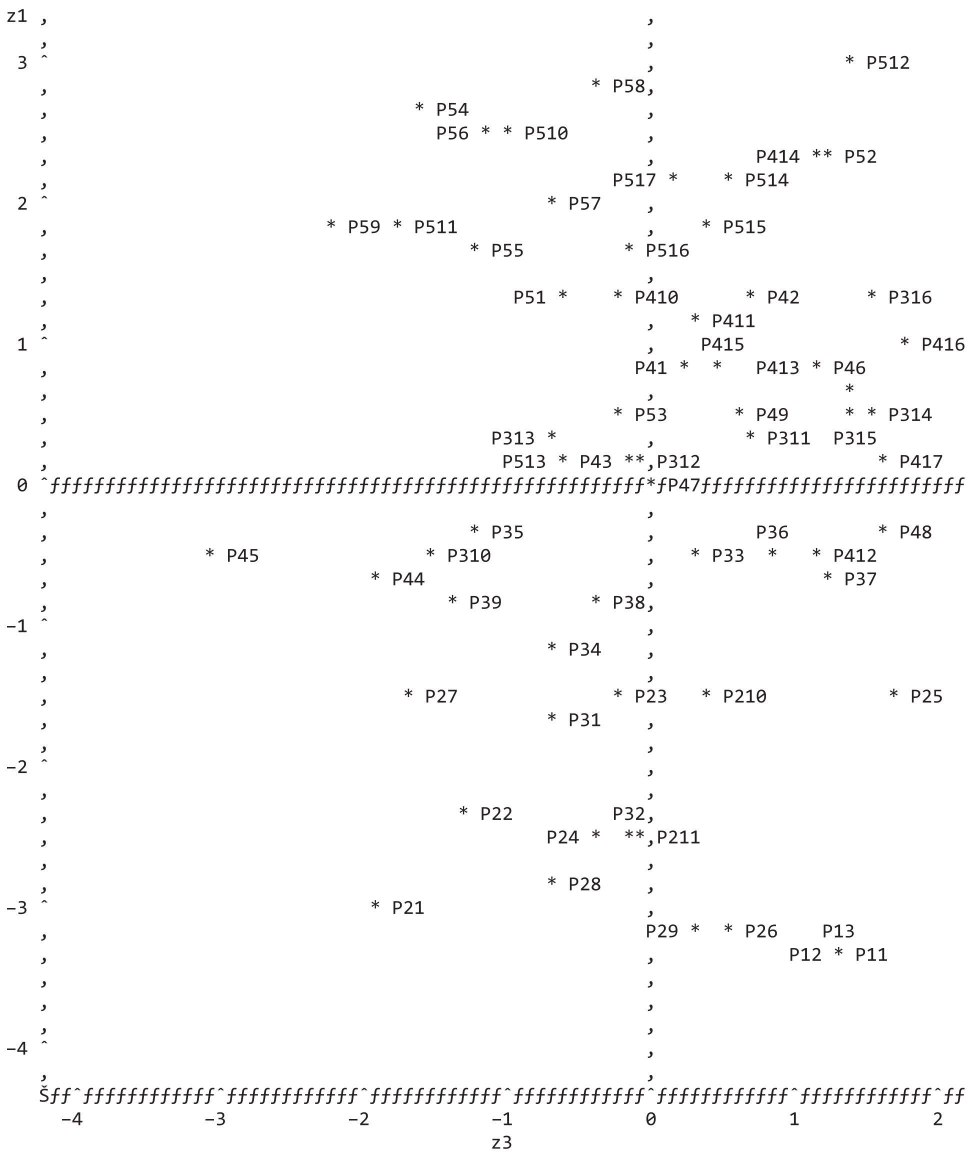

FIGURE 5 Principal component analysis to reveal relations between shea parklands and unit operations of kernel extraction on axes 1 and 3. The figure shows the relationships between the gathering period and unit operations (sun drying conditions and kernel storage conditions) in five parklands. Parklands with similar gathering period and extraction technique are grouped together with respect to the two axes. Parklands with different gathering periods and sun-drying conditions are opposed. *Note*. P = Parkland; P1 = Parkland of Bohicon; P2 = Parkland of Save; P3 = Parkland of Parakou; P4 = Parkland of Bembereke; P5 = Parkland of Kandi; P11–P13 = Number of respondents in P1; P21–P211 = Number of respondents in P2; P31–P316 = Number of respondents in P3; P41–P417 = Number of respondents in P4; P51–P517 = Number of respondents in P5.

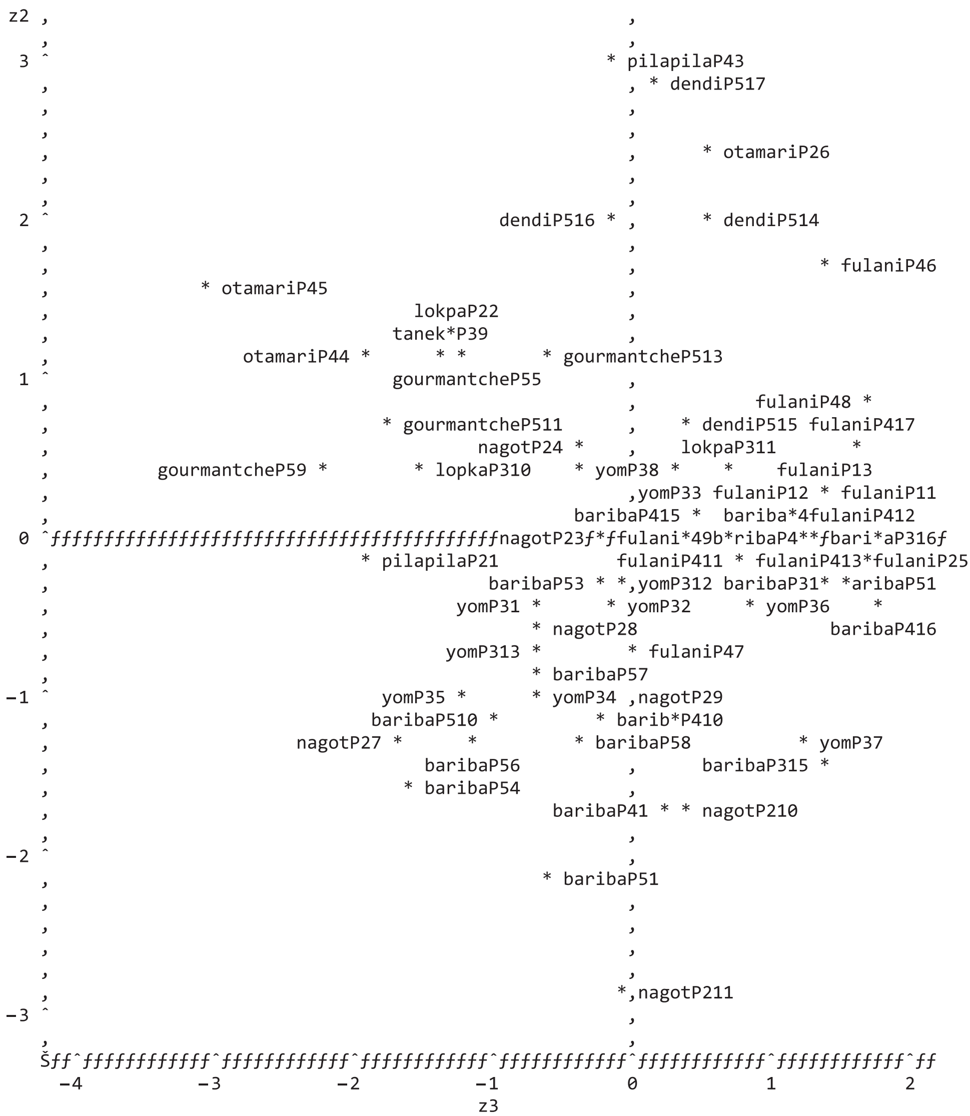

FIGURE 6 Principal component analysis to reveal relations between ethnic groups and unit operations of kernel extraction on axes 2 and 3. The figure shows the relationships between unit operations (storage duration of fresh nuts, boiling and storages conditions of dried kernels) by ethnic groups. Ethnic groups with similar boiling duration and storage conditions are grouped together with respect to the two axes. Ethnic groups with different boiling duration and storage conditions are opposed. *Note*. P11–P13 = Number of respondents in parkland of Bohicon; P21–P211 = Number of respondents in parkland of Save; P31–P316 = Number of respondents in parkland of Parakou; P41–P417 = Number of respondents in parkland of Bembereke; P51–P517 = Number of respondents in parkland of Kandi.

TABLE 4 Weight of Main Variables for Each Axis of PCA

Variable	Weight
Axis 1	
Parklands	0.89228
Gathering period	0.91452
Sun drying of kernels	0.82860
Sun-drying material	0.66647
Axis 2	
Ethnic group	0.56874
Storage duration of fresh nuts	0.63949
Boiling duration of nuts	0.55030
Axis 3	
Sun drying of nuts	0.50266
Storage duration of kernels	0.55004
Packaging material for kernels	0.46086

Note. Only weights above 0.4 are reported here.

axis (16.6% of variation) concerns the relation between ethnic groups, storage conditions for fresh shea nuts and their boiling, while the third axis explained 14.9% of the variation and mostly reflected the duration of sun drying of nuts and the storage conditions of the kernels. The variable related to the sun drying of nuts is present on axes 1 and 3; this variable is very important in the extraction of shea kernels.

Figure 5 represents the axes 1 and 3. It shows a gradual evolution of the parklands from the parkland of Bohicon (P1) to the parkland of Kandi (P5). All of the respondents of P1 are grouped at the bottom of the graph while the respondents of P5 are concentrated in the top of the graph. This means that when we move from the center of Benin to the North, the duration of certain units of operation increases. This observation refers to the gathering period, the sun drying of nuts and kernels, and the storage of the kernels, and is supported by positive correlations between parkland and gathering period ($r = .8904$, $p = .0001$); parkland and duration of sun drying of the nuts ($r = .2976$, $p = .0106$); and parkland and duration of sun drying of the kernels ($r = .7331$, $p = .0001$).

Axes 2 and 3 in figure 6 demonstrate that the Bariba, Fulani, Yom, and partially also the Nagot have similar knowledge and habits with respect to certain unit operations to extract shea kernels, namely the storage of the fresh nuts, boiling, and sun drying and storage of kernels. Most of these ethnic groups are found in all five parklands and dominate in producing shea products. They generally store shea fruits for 3–7 days, boil the nuts for 15–30 minutes, sun dry the kernels for 3–7 days, and store the kernels in polyethylene or jute bags.

The Otamari ethnic group is totally isolated in the graph because of the specific technique used to extract the kernels from the fruits.

Constraints in Shea Kernels and Butter Processing Operations

Traditional shea kernel and butter extraction operations were reported to be arduous, labor-intensive and time consuming (Kar and Mital 1981; Kapseu et al. 2001; Alonge and Olaniyan 2007). They also require large amounts of water and firewood, which are both scare and valuable commodities in the arid regions where the shea tree grows. From the collection of the shea fruits to the production of one kg of shea butter, 20–30 hours are spent by the processor and 8.5–10 kg of fire wood is used (Bruinsma 1998). Gatherers complain about gathering, sun drying, and shelling. Women wake up early in the morning and trek up to 5–15 km, then carry loads of 20–30 kg back in head pans. They are exposed to hazards like scorpions and snakes, especially beyond the cultivated areas. Shelling is very tedious and when the gatherers use the stones as equipment, their hands sometimes get grazed by the stone. Some of the nuts are destroyed during the shelling process and this leads to losses of raw material for butter extraction. In addition, the shelling process includes a winnowing operation, which requires winds to blow away the pieces of shell, and wind supply is not reliable.

Processors complain about pounding, milling, kneading, and churning during butter extraction. To circumvent the constraints related to pounding and milling, most of the processors (97%) use cereal mills to coarsely grind kernels. Millers often refuse grinding or leave the kernels during 2–3 days before grinding because of the undesired shea kernel color on products milled later. Mills need to be cleaned thoroughly after milling shea kernels, and so the millers tend to charge extra to cover cleaning costs. Processors also complain about the time needed for extracting the butter and the low yield of butter. Shea kernels contain 40%–57% fat (Di Vincenzo et al. 2005; CNUCED 2006); the traditional techniques extract about half of the fat of the kernel, namely 20%–30%. According to Olaoye and Babatunde (2001), the fat-extraction yield of the artisanal method, including the use of some equipment such as a mill and press, could be increased to 35%–45%.

Equipment like a crusher, mill, roaster, and mixer have been developed for shea production, but several constraints are associated with the use of such equipment. For example, no processor uses a mixer for churning because of the high water consumption. According to the processors, the mixer utilizes 3–4 times the quantity of water used for manual churning and the butter yield does not increase. Thus, they prefer the manual churning because of water scarcity. During the manual churning, approximately two volumes of water are used for one volume of kernel paste. Other problems associated with the use of equipment are the constant fuel scarcity and the absence of financial resources to support the installation of the equipment. In addition, the equipment is destined to women's associations; single processors, who are more numerous, usually have no access.

However, and irrespective all of the constraints, the production of shea kernels and butter remains traditional and unique, in that they can be done only by women who possess knowledge of the location and history of the shea trees, the timing, and process of harvesting. All of these aspects represent a knowledge that is passed through successive generations of women (Chalfin 2004). This system gives them a level of respect, authority, and control over resources that they do not possess in other sectors, as well as providing a source of cash income and fat for domestic use.

CONCLUSION

This study highlighted indigenous knowledge of shea production and processing in Benin. Many ethnic groups are involved in shea butter production, especially the Bariba, Fulani, Yom, and Nagot. Apart from the Otamari ethnic group, who smoke the shea kernels before fat extraction, all other ethnic groups use boiling followed by sun drying. Some constraints are linked to certain unit operations. Most of the butter extracted is used as kitchen fat and skin ointment in the production zones and as care pomade in all parklands. The degree of drying and kernel appearance are the most important quality criteria mentioned by the processors, while the color of butter is the main quality criterion that traders and users utilize when buying the butter. With the exception of the use of a mill for crushing and milling the kernels, the processing operations remain traditional and variations in quality are often observed by the users. Research is advocated to reduce the arduousness and the constraints of processing by introducing reliable and adapted equipment, and also to improve the quality of shea products. As a follow-up to this survey, experimental research will be conducted to assess the quality characteristics of shea kernels and shea butter processed by the different technologies, with the ultimate objective to determine in which way the quality of shea kernels and butter can be improved under local conditions.

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REFERENCES

Alonge, A. F., and A. M. Olaniyan. 2007. Problems of shea butter processing in Africa. In *Proceedings of the American Society of Agricultural and Biological Engineers, International Conference on Crop Harvesting and Processing*, February 11–14 Louisville, KY, 69–91.

Bail, S., S. Krist, E. Masters, H. Unterweger, and G. Buchbauer. 2009. Volatile compounds of shea butter samples made under different production conditions in western, central and eastern Africa. *Journal of Food Composition and Analysis* 22 (7–8): 738–744.

Boffa, J. M., G. Yameogo, P. Nikiema, and D. M. Knudson. 1996. Shea nut (*Vitellaria paradoxa*) production and collection in agroforestry parklands of Burkina Faso. In *Shea nut (Vitellaria paradoxa) production and collection in agroforestry parklands of Burkina Faso*, ed. R. Leakey, A. Temu, M. Melnyk, and P. Vantomme, 110–122. Rome: FAO.

Boffa, J. M., S. J. B. Taonda, J. B. Dickey, and D. M. Knudson. 2000. Field-scale influence of karite (*Vitellaria paradoxa*) on sorghum production in the Sudan zone of Burkina Faso. *Agroforestry Systems* 49 (2): 153–175.

Bruinsma, D. 1998. La fabrication du beurre de karité. Quelles technologies pour les femmes? *Echo du Cota, Bulletin de Réseau technologie et partenariat en agroalimentaire* 79:12–15.

Bup, D. N., C. Kapseu, D. Tenin, A. Kuitche, C. F. Abi, and C. Tchiegang. 2008. Variation of the physical properties of sheanut (*Vitellaria paradoxa* Gaertn.) kernels during convective drying. *International Journal of Food Engineering* 4 (7): 62–78.

Chalfin, B. 2004. *Shea butter republic: State power, global markets, and the making of an indigenous commodity*. New York: Routledge.

Conférence des Nations Unies sur le Commerce et le Développement (CNUCED). 2006. Le karité: Production, consommation et marché [The shea tree: Production, consumption and market]. http://www.unctad.org/infocomm/francais/karité/marché.htm (accessed September 22, 2010).

Coulibaly, Y., S. Ouédraogo, N. Nuculescu, and N. Konaté. 2004. Extraction de beurre de karité par centrifugation [Shea butter extraction by centrifugation]. *Sud Sciences and Technologies* 13:4–12.

Dagnelli, P. 1998. *Statistiques théoriques et appliquées* [Theoretical and applied statistics]. Brussels, Belgium: De Boeck.

Dandjouma, A. K. A., H. Z. Adjia, A. Kameni, and C. Tchiegang. 2009. Traditionnal production and commercialization of shea butter in North-Cameroon. *Tropicultura* 27 (1): 3–7.

Di Vincenzo, D., S. Maranz, A. Serraiocco, R. Vito, Z. Wiesman, and G. Bianchi. 2005. Regional variation in shea butter lipid and triterpene composition in four African countries. *Journal of Agricultural and Food Chemistry* 53 (19): 7473–7479.

Elias, M., and J. Carney. 2004. La filière féminine du karité: productrice burkinabée, “éco-consommatrices” occidentales et commerce équitable [The feminine sector of the shea tree: The Burkinabe producer, occidental “eco-consumers” and fair trade]. *Cahier de Géographie du Québec* 48 (133): 71–88.

Eyog Matig, O., O. G. Gaoué, and B. Dossou. 2002. Réseau “espèces ligneuses alimentaires” [“Woody food species” network]. Compte Rendu de la Première Réunion du Réseau, Espèces Ligneuses Alimentaires, Institut International des Ressources Phytogénétiques, CNSF Ouagadougou, Burkina Faso.

Gnanglè, P. 2005. *Parcs á karité (Vitellaria paradoxa Gaertn. C.F.) (Sapotaceae) au Bénin: Importance socio-culturelle, caractérisations morphologiques, structurale et régénération naturele* [Shea tree (*Vitellaria paradoxa* Gaertn. C.F.) (Sapotaceae) parklands in Benin: Socio-cultural importance, morphological and structural characterization and natural regeneration]. Benin: Aménagement et Gestion des Ressources Naturelles, FSA/UAC.

Guillaumin, R. 1982. Evolution des lipides: Oxydation enzymatique et auto-oxydation non enzymatique. [Lipid evolution: Enzymatic oxidation and non-enzymatic auto-oxidation]. In *Conservation et stockage des grains et graines et produits dérivés: céréales, oléagineux, protéagineux, aliments pour animaux*, ed. J. L. Multon, 913–936. Paris: Technique et Documentation Lavoisier.

Hall, J. B., D. P. Aebischer, H. F. Tomlinson, E. Osei-Amaning, and J. R. Hindle. 1996. *Vitellaria paradoxa*: A monograph. Banghor, Wales: University of Wales School of Agricultural and Forest Sciences.

Honfo, F. G., K. Hell, N. Akissoe, O. Coulibaly, P. Fandohan, and J. D. Hounhouigan. 2011. Effect of storage conditions on microbiological and physicochemical quality of shea butter. *Journal of Food Science and Technology* 48 (3): 274–279.

Honfo, F. G., N. Akissoe, A. Linnemann, M. Soumanou, and M. A. J. S. van Boekel. Forthcoming. Nutritional composition of shea products and chemical properties of shea butter: A review. *Critical Reviews in Food Science and Nutrition*.

Hyman, E. L. 1991. A comparison of labor-saving technologies for processing shea nut butter in Mali. *World Development* 19 (9): 1247–1268.

Kapseu, C., C. Tchiegang, M. Parmentier, A. Fomethe, and R. Kamga. 2001. Evolution du Choix technologique par les femmes [Evolution of technology choice by women]. http://www.uni-bayreuth.de/afrikanistik/mega-tchad/Table/Colloque2002/Kapseu.pdf (accessed April 21, 2011).

Kar, A., and H. C. Mital. 1981. The study of shea butter. VI: The extraction of shea butter. *Plant Foods for Human Nutrition* 31 (1): 67–69.

Kater, L. J. M., S. Kante, and A. Budelman. 1992. Karité (*Vitellaria paradoxa*) and néré (*Parkia biglobosa*) associated with crops in South Mali. *Agroforestry Systems* 18 (2): 89–105.

Koumassa, L. 2010. Contribution à l'amélioration de la chaîne de valeur karité au Bénin [Contribution to the improvement of the shea value chain in Benin]. Cotonou, Benin: IITA-Benin.

Krist, S., S. Bail, H. Unterweger, M. B. Ngassoum, A. M. Mohagir, and G. Buchbauer. 2006. Volatile compounds of original African black and white shea butter from Tchad and Cameroon. *European Journal of Lipid Science and Technology* 108 (7): 583–588.

Krysiak, W., and L. Motyl-Patelska. 2005. Effects of roasting conditions on the degree of lipid migration from cocoa bean kernel. *Inzynieria Chemiczna i Procesowa* 26 (4): 817–829.

Lovett, P. N., and N. Haq. 2000. Evidence for anthropic selection of the Sheanut tree (*Vitellaria paradoxa*). *Agroforestry Systems* 48 (3): 273–288.

Maranz, S., W. Kpikpi, Z. Wiesman, A. De Saint Sauveur, and B. Chapagain. 2004. Nutritional values and indigenous preferences for shea fruits (*Vitellaria paradoxa* C.V. Gaertn. F.) in African agroforestry parklands. *Economic Botany* 58 (4): 588–600.

Mbaiguinam, M., K. Mbayhoudel, and C. Djekota. 2007. Physical and chemical characteristics of fruits, pulps, kernels and butter of shea *Butyrospermum parkii* (Sapotaceae) from Mandoul, Southern Chad. *Asian Journal of Biochemistry* 2 (2): 101–110.

Olaoye, J. O., and O. O. Babatunde. 2001. Development and testing of a milled shea nut mixer. *Journal of Food Science and Technology* 38 (5): 471–475.

Pereira, J. 1983. The effectiveness of six vegetable oils as protectants of cowpeas and bambara groundnuts against infestation by *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). *Journal of Stored Produce Research* 19:57–62.

Schreckenberg, K. 2004. The contribution of shea butter (*Vitellaria paradoxa* CF Gaertner) to local livelihoods in Benin. In *Forest products, livelihoods and conservation*, ed. T.Sunderland and O. Ndoye, 91–113. Bogor Barat, Indonesia: Center for International Forestry Research.

Shimoda, M., H. Shiratsuchi, Y. Nakada, Y. Wu, and Y. Osajima. 1996. Identification and sensory characterization of volatile flavor compounds in sesame seed oil. *Journal of Agricultural and Food Chemistry* 44 (12): 3909–3912.

Soladoye M O., S. S. Orhiere, and B. M. Ibimode 1989. Ethnobotanical study of two indigenous multipurpose plants in the Guinea savanna of Kwara State, *Vittellaria paradoxa* and *Parkia biglobosa*. Paper presented at the biennal conference of the Ecological Society of Nigeria, Foresetry Research Institute, August 14, Ibadan.

Tano-Debrah, K., and Y. Ohta. 1995. Enzyme-assisted aqueous extraction of shea fat: A rural approach. *Journal of American Oil Chemistry Society* 72:251–256.

United Nations Development Fund for Women (UNIFEM). 1997. Le karité: L'or blanc des Africaines [The shea tree: The white gold of the Africans]. Dakar, Senegal: UNIFEM.

United States Agency for International Development (USAID) West Africa Trade Hub. 2004. The shea value chain: Production, transformation and marketing in West Africa. Osu Accra, Ghana: USAID West Africa Trade Hub.

Womeni, H. M., R. Ndjouenkeu, C. Kapseu, F. Tchouanguep Mbiapo, M. Parmentier, and J. Fanni. 2007. Séchage des amandes de karité et qualité du beurre: Impact du séchage traditionnel au soleil [Drying of shea kernels and butter quality: The impact of drying]. *Tropicultura* 25:240–247.