Variations in the traditional processing methods of *Pentadesma butyracea* butter in northern Benin

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Pentadesma butyracea *is used in the North of Benin to produce a type of butter similar to shea butter. The present work was carried out to investigate the traditional processing of butter from* P. butyracea *through a survey among 192 traditional butter processors from 14 sociocultural groups in five different parklands in northern Benin. Three different pre-treatments of* P. butyracea *kernels have been identified as the basis of the butter extraction process. The pre-treatment more frequently used (69.7 per cent of processors) consists of depulping the fruit to get fresh kernels which are first boiled for 1–2 h before sun drying for 14–30 days to get cooked and dried kernels which are involved in the next steps of the extraction process. The extraction itself involves two main steps, heating and kneading, which also vary according to processors. Ten methods of processing of* P. butyracea *including six new methods have been reported. Two of the newly identified methods are mostly used by Boo, Anii, and Mokolé sociocultural groups from northern Benin. The identified methods of butter processing need to be optimized and the quality of the derivate butter should be assessed, using a well-known variety of* P. butyracea *as the raw material.*

Keywords: *Pentadesma butyracea*, kernels, northern Benin, traditional butter processing, sociocultural groups

TROPICAL FORESTS ARE IMPORTANT SOURCES of non-timber forest products (NTFPs) which play important roles in traditional livelihood systems (de Beer and Mcdermott, 1989;

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Sills et al., 2003). Among the forest tree species, *Pentadesma butyracea* (*P. butyracea*) has been identified as one of the top ten agroforestry tree species to be conserved and domesticated in West Africa (Eyog-Matig et al., 2002). *P. butyracea* has been identified as a species generally located in dense forest with a large distribution area reaching from Sierra Leone to the Congo (Bamps, 1971; Vivien and Faure, 1985). Phenotypically, *P. butyracea* is a tree with a height of about 20 m, which is found in the North of Benin in forest galleries and along waterways (Natta, 2003).

In most African countries, *P. butyracea* presents some economic and sociocultural interest: it is recognized for its economic (Avocevou-Ayisso et al., 2009), nutritional (Dencausse et al., 1995; Tchobo et al., 2007, 2013), medical (Zelefack et al., 2009; Wabo et al., 2010; Alitonou et al., 2010; Noudogbéssi et al., 2013), social, cultural, cosmetic, and pharmaceutical utilization (Sinsin and Sinadouwirou, 2003; Natta et al., 2010; Avocevou-Ayisso et al., 2011). Several studies have shown the biological activities of the extracts of various parts of *P. butyracea* (Zelefack et al., 2009; Wabo et al., 2010). In Gabon and Côte d'Ivoire, for example, the macerated bark of *P. butyracea* is used in lotions for treatment of parasitic diseases of the skin and as an antidiarrhoeal (Raponda-Walker and Sillans, 1961). In Ghana, the decoction of the roots is used to fight intestinal worms (Abbiw, 1990). In Benin, the bark and the roots are utilized to treat digestive system disorders, infections, genitourinary and circulatory system disorders (Sinsin and Sinadouwirou, 2003). Moreover, xanthone and stem bark isolated from *P. butyracea* Sabine roots present some antiproliferative, cytotoxic, and antiplasmodial activities (Zelefack et al., 2009; Wabo et al., 2010).

However, the most important way of adding value to *P. butyracea* is the processing of its kernel into butter (Adomako, 1977; Houngbédji, 1997; Sinsin and Sinadouwirou, 2003; Avocevou-Ayisso et al., 2009; Natta, 2003; Natta et al., 2010; Aissi et al., 2011). The kernels contain about 50 per cent fat in which many of the free fatty acids have several characteristics that are better than those of shea butter, particularly concerning slip point, saponification number, solidification point, and fatty acid composition (Adomako, 1977).

Shea (*Vitellaria parodoxa*) butter processing is one of the main well-known traditional activities generating substantial income for the rural population in Africa, particularly in northern Benin (Avocevou-Ayisso et al., 2009). Unfortunately, the exploitation of *Vitellaria parodoxa* for butter production and the Loranthaceae parasitic attack of shea trees (Avocevou-Ayisso et al., 2009) in most forests zones in Africa, including Benin, are presently identified as the major constraints for shea butter production. It is possible that in the near future there could be shortage of shea butter on the international market. Consequently, *P. butyracea* presents a good alternative source for butter production based on the know-how of traditional processors in Benin.

In northern Benin, there are many processors who produce *P. butyracea* butter using traditional methods (Houngbedji, 1997). These traditional methods of processing *P. butyracea* have the advantage of generating what is called biobutter (Aissi et al., 2011). This biobutter processing involves some pre-treatments of the kernels of *P. butyracea* including crushing, roasting, grinding, churning, heating, and oil cooling (Houngbédji, 1997; Aissi et al., 2011). However, with traditional processing, the biobutter yield is rather low (less than 25 per cent) with a quality yet to be assessed (Houngbédji, 1997; Aissi et al., 2011). Moreover, there are many differences between the traditional processing methods of *P. butyracea* to biobutter in northern Benin which have not yet been documented (Aïssi et al., 2011). The present work aims to identify and characterize the traditional methods of processing *P. butyracea* into butter in northern Benin. This is the baseline study which can be followed by research upgrading traditional butter processing.

Materials and methods

Sampling of respondents for the survey

P. butyracea processors from five parklands (grassland including sparse trees) located in Bassila, Tchaourou, Kandi, Natitingou, and Toucountouna were surveyed. These are the parklands where *P. butyracea* is intensively processed into butter in Benin (Natta, 2003; Ewédjè et al., 2012). The respondents sample size for the survey was determined on the basis of the following formula: $Ni = 4Pi\ (1\text{–}Pi)/d2$ (Dagnelie, 1998; Chadare et al., 2008) where:

Ni = total number of processors to be surveyed in parkland I;
Pi = proportion of processors found in previous studies in parkland I;
d = expected error margin, which was fixed at 0.05.

Using this formula, 11 respondents were selected in Tchaourou, 27 in Kandi, 31 in Natitingou, 60 in Toucountouna, and 63 in Bassila to get a total of 192 respondents. The number of respondents in each location was calculated on the basis of its population size using the following formula: $Tj = Nj \times Xj\ /\mathrm{X}$ where:

Tj = sample size in location j;
Nj = total number of P. butyracea processors to be surveyed in parkland j;
Xj = population size in location j;
X = population size in parkland j.

Data collection and analysis

The questionnaire designed for processors was pre-tested. The questionnaire included mainly information related to the profile of the sociocultural groups of the processors, the pre-treatments applied to *P. butyracea* kernels prior to the butter processing, and the details of butter processing by the different sociocultural groups involved in butter production in northern Benin. Furthermore, information related to the quality of the raw material and the storage conditions as well as the processing frequency was collected.

Descriptive statistics were calculated using the Sphinx plus 2 software (SphinxSurvey plus 2, Eureka). Factorial correspondence analysis (FCA) was performed with software R to relate parklands of processors to butter processing methods.

Table 1 Local names of *P. butyracea* tree, main organs, and butter

Sociocultural groups	*Tree*	*Kernels*	*Fruits*	*P. butyracea butter*
Anii	Ewonronme	EwonronmeGuiguipié	Guewonronmi	EwonronmeMissi
Nago	EguiKpangan	Oman Kpangnan	KpokpoKpangnan	OhiKpangnan
Kotokoli	Koolou	KoolouChoona	-	KoolouNou
Peulh	Légaiidropii or Akpotohi	Dropiho or Akpotodji	Kortowaor	
BiganAkpoto	NébamDropii or			
NébamAkpoto				
Lokpa	Buchunu	BuchunuPilé	Buchunu Toho	BuchunuNime
Wama	Koumboma	KoumboKuifa	KoumboKounma	Koumbotaor
KoumboBidé				
Natimba	Kontobiri	-	-	Kontobirikouama
Boo	Soiluku or Soluku	SoikuWèna or SolukuWèna	-	SoikuNissi or SolukuNissi
Mokollé	Sécéido	-	-	IkpoSécéido
Otamari	Yêkotchêpouomou	Yêkotchêpouo	Dikotchêpouoni	Yêkotchepouomkouo

Results and discussion

Sociocultural characteristics of the P. butyracea *butter processors*

The survey showed that *P. butyracea* butter processing is mainly carried out by illiterate women aged between 20 and 70 years old (with 53 per cent of the respondents from 20 to 50 years old). A total of 14 sociocultural groups were involved in the production of *P. butyracea* butter among which the most important were Wama, Otamari, Anii, Natimba, Peulh, Boo, and Nagot women (86.3 per cent of the respondents). This distribution confirms what has been reported by Sinsin and Sinadouwirou (2003) and Aissi et al. (2011) who carried out a tentative geographic classification of processors. Anii, Nagot, and Peulh are the predominant sociocultural groups of *P. butyracea* butter processors from Bassila whereas Wama, Otamari, and Natimba are the predominant sociocultural groups in Natitingou and Toucountouna. The local names given to the tree and its different parts (tree, kernels, and fruits) vary according to the sociocultural group (Table 1). These names may encompass useful information. For instance, the local name s*oiluku* given to the *P. butyracea* tree by the Boo sociocultural group means 'shea tree of the river' indicating its similarity to the shea tree and habitat (Table 1). Natta et al. (2002) and Natta (2003) reported that, in Benin, the natural stands of *P. butyracea* occur mostly in endangered ecosystems of riparian forests that stretch along rivers into areas with a diversity of people and cultures. The Otamari sociocultural group calls the *P. butyracea* kernel *Yêkotchêpouo* (Table 1) which means 'hard kernels like coconuts', which probably indicates not only the hardness of the kernels, but also the phenotypic characteristics of the resource.

Traditional methods of processing **P. butyracea** *to produce butter*

Pre-treatments of kernels. Before extracting the butter from *P. butyracea* kernels, different pre-treatments are performed depending on the know-how and the period of utilization of the kernels.

Depulping of the fruit is the initial step for all processes. *P. butyracea* fruits are generally collected early in the morning (6–9 a.m.) during the period from April to July. Ripened fruits are collected when they fall down from the tree. Two depulping techniques were observed:

- Most processors (80 per cent) use a stone to hit the fruit and remove the pulp.
- The fresh fruit is allowed to ferment naturally. The natural fermentation facilitates easy removal of the pulp (20 per cent of the processors).

Kernels obtained after depulping may be subjected to any of the three pre-treatments shown in Figure 1 as follows:

- boiling for one to two hours and sun drying for 14 days to one month (pre-treatment 1, P1; 69.7 per cent of surveyed processors);
- sun drying immediately for 4–14 days depending to the season (dry or rainy) (pre-treatment 2, P2; 15.4 per cent of surveyed processors); this pre-treatment consists of a direct exposure of kernels to the sun for the whole exposure period;
- smoking for 36 to 48 hours in a traditional oven (pre-treatment 3, P3; 14.9 per cent of surveyed processors).

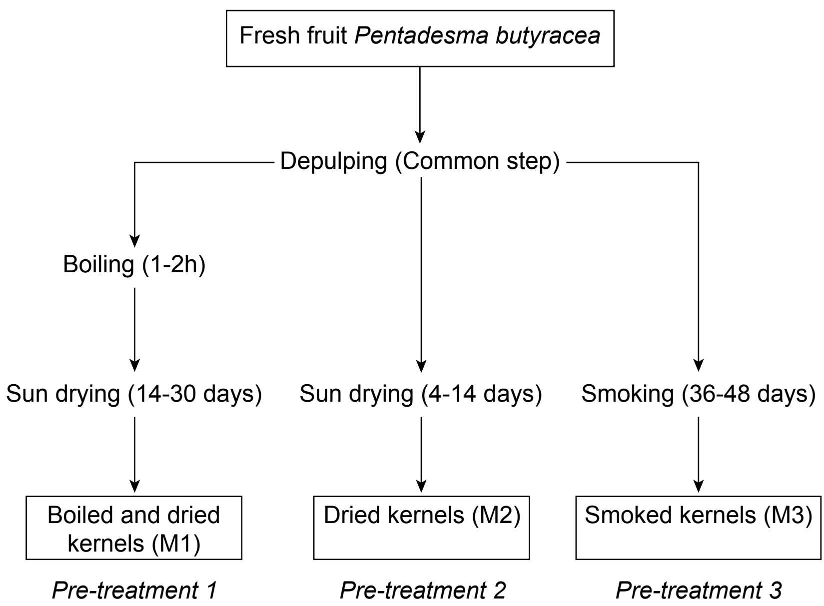

Figure 1 Main pre-treatments of *P. butyracea* kernels occurring during butter processing in northern Benin

The duration of pre-treatment 1 is longer than that of pre-treatment 2 but according to the processors, boiling of the fresh kernels prevents their germination and results in higher butter quality. The lack of protection of the kernels against insects, rain, and contaminants probably renders sun drying vulnerable. Bup et al. (2008) reported that shea kernels dried without direct exposure to the sun gave a shea butter whose quality meets the international standards for cosmetic and pharmaceutical uses. Pre-treatment 3 is the shortest but lack of control over the smoking temperature and duration can result in kernel burning. Aissi et al. (2011) reported that boiled and dried kernels are better inputs than smoked kernels. However, the quality of the butter (acidity and peroxide values) extracted from smoked kernels was reported to be better than the butter from boiled and dried kernels (Aissi et al., 2011). We can conclude that the butter yield of production seems to be the main criterion of choice of these processors. According to Nawar (1996), uncontrolled heat treatments applied to the kernels (boiling, sun drying, and smoking) can negatively modify the chemical and sensory characteristics of the resulting butter. Therefore, the optimal processing pre-treatment conditions (temperature and time) need to be determined for the processing of good quality butter. The pre-treated kernels are used as raw material for butter processing.

The pre-treated kernels are processed immediately into butter, sold on the local markets, or stored for processing later on. Most of the respondents (88 per cent) store the kernels in polyethylene or jute bags, while the others use traditional baskets (7 per cent) or a granary (5 per cent). Kernels of *P. butyracea* store longer than shea kernels (94 per cent of respondents). Whereas processors reported a minimum storage period of 6 months for *P. butyracea* kernels (89 per cent of respondents), Honfo et al. (2012) reported that the storage duration of shea kernels was between 4 and 6 months. In addition, Ahouansou et al. (2012) reported that *P. butyracea* kernels have rupture strength and density higher than those of shea kernels that could confer on *P. butyracea* kernels a greater resistance to rodent attacks and better storage behaviour.

P. butyracea *butter extraction*. Pre-treated *P. butyracea* kernels are processed into butter as follows: pre-treated kernels (M1, M2, or M3; see below) are heated, crushed in a mortar, milled, and churned to produce a crude oil. This oil is cooled to obtain butter.

Heating and churning operations vary according to the processor. Heating is done by roasting (T1) or by frying (T2) whereas churning is done by kneading and addition of hot water without cooking (CH1) or by addition of cold water followed by cooking (CH2) (Figure 2).

The combination of the type of kernel pre-treatments with the type of heating (T1 or T2) and the type of kneading (CH1 or CH2) leads to a total of 10 *P. butyracea* butter processing methods which are used by *P. butyracea* kernel processors.

- *Method 1*. Boiled and dried kernels (M1) are crushed and roasted (T1), crushed a second time, and milled into a paste. This paste is churned vigorously using cold water and the derived oil cooked for one hour (CH2). This crude oil (O1) is decanted, and cooled for 12–48 hours to get the butter (B1).

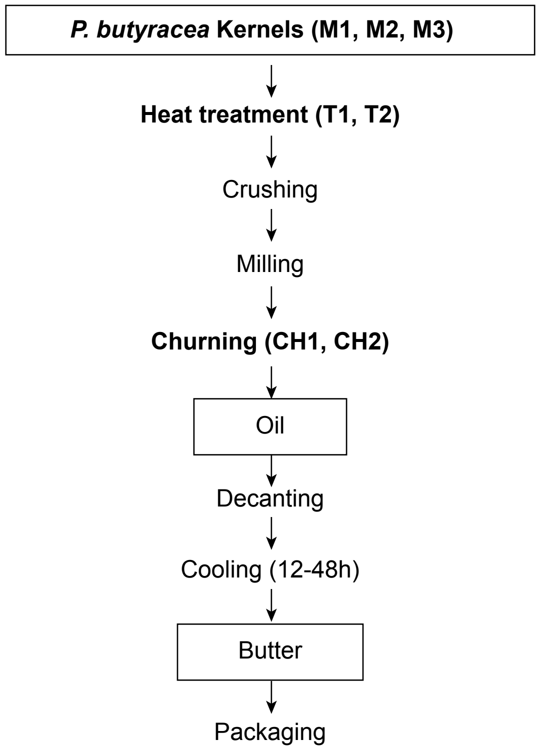

Figure 2 Flow sheet of *P. butyracea* kernel processing into butter

- *Method 2*. Boiled and dried kernels (M1) are crushed and roasted (T1), crushed a second time, and milled into a paste. This paste is churned using hot water (CH1). The derived oil (O2) is decanted and cooled down immediately to obtain the butter.
- *Method 3*. Boiled and dried kernels (M1) are fried (T2) using palm oil, shea or *P. butyracea* butter, then crushed and milled into a paste. This paste is churned vigorously using cold water and the derived oil cooked for one hour (CH2). This crude oil (O3) is decanted and cooled for 12–48 hours to get the butter (B3).
- *Method 4*. Boiled and dried kernels (M1) are fried (T2) using palm oil, shea or *P. butyracea* butter, then crushed and milled into a paste. This paste is churned using hot water (CH1), then the derived oil (O4) is immediately cooled to obtain the butter.
- *Method 5*. Boiled and dried kernels (M1) are boiled once again, crushed and sun dried immediately for one or two days. These crushed and dried kernels are roasted (T1), crushing once again, and milling into a paste. This paste is churned vigorously using cold water and the derived oil cooked for one hour (CH2). This crude oil (O5) is decanted and cooled for 12–48 hours to get the butter (B5).

- *Method 6*. Sun-dried kernels (M2) are crushed, roasted (T1), and crushed again. The double-crushed kernels are milled into a paste. This paste is churned vigorously using cold water and the derived oil cooked for one hour (CH2). This crude oil (O6) is decanted and cooled for 12–48 hours to get the butter (B6).
- *Method 7*. Sun-dried kernels (M2) are crushed, roasted (T1), and crushed once again. The double-crushed kernels are milled into a paste. This paste is churned using hot water (CH1), then the derived oil (O7) is immediately cooled to obtain the butter (B7).
- *Method 8*. Sun-dried kernels (M2) are fried (T2) using palm oil, shea or *P. butyracea* butter, then crushed and milled into a paste. This paste is churned using hot water (CH1), then the derived oil (O8) is immediately cooled to obtain the butter (B8).
- *Method 9*. Sun-dried kernels (M2) are boiled, crushed, and sun-dried immediately for one or two days. These crushed and dried kernels are roasted (T1), crushing once again, and milling into a paste. This paste is churned vigorously using cold water and the derived oil cooked for one hour (CH2). This crude oil (O9) is decanted and cooled for 12–48 hours to get the butter (B9).
- *Method 10*. Smoked kernels (M3) are crushed and roasted (T1), crushed a second time, and milled into a paste. This paste is churned vigorously using cold water and the derived oil cooked for one hour (CH2). This crude oil (O10) is decanted and cooled for 12–48 hours to get the butter (B10).

The percentage of processors applying each method is shown in Table 2. Method 1 is the most used (44.88 per cent of processors). It is used mainly by the Wama, Otamari, Natimba, Lokpa, and Fulani sociocultural groups. Method 3 is used exclusively by the Anii (11.02 per cent of processors) and method 10 by the Wama and Otamari (12.20 per cent of processors) sociocultural groups. All the others methods are practised by a minor group of processors.

Table 2 Proportion of sociocultural groups from northern Benin using different methods to process *P. butyracea* kernels into butter

Method	*Proportion of users (%)*	*Main sociocultural groups*
Met 1	44.88	Wama, Otamari, Natimba, Lokpa, Fulani, Anii
Met 2	6.3	Anii and Kotocoli
Met 3	11.02	Anii
Met 4	5.91	Anii
Met 5	7.09	Boo and Mokole
Met 6	1.18	Nagot
Met 7	2.76	Nagot
Met 8	5.12	Nagot and Kotocoli
Met 9	3.54	Boo and Mokole
Met 10	12.20	Wama and Otamari
Total	100	

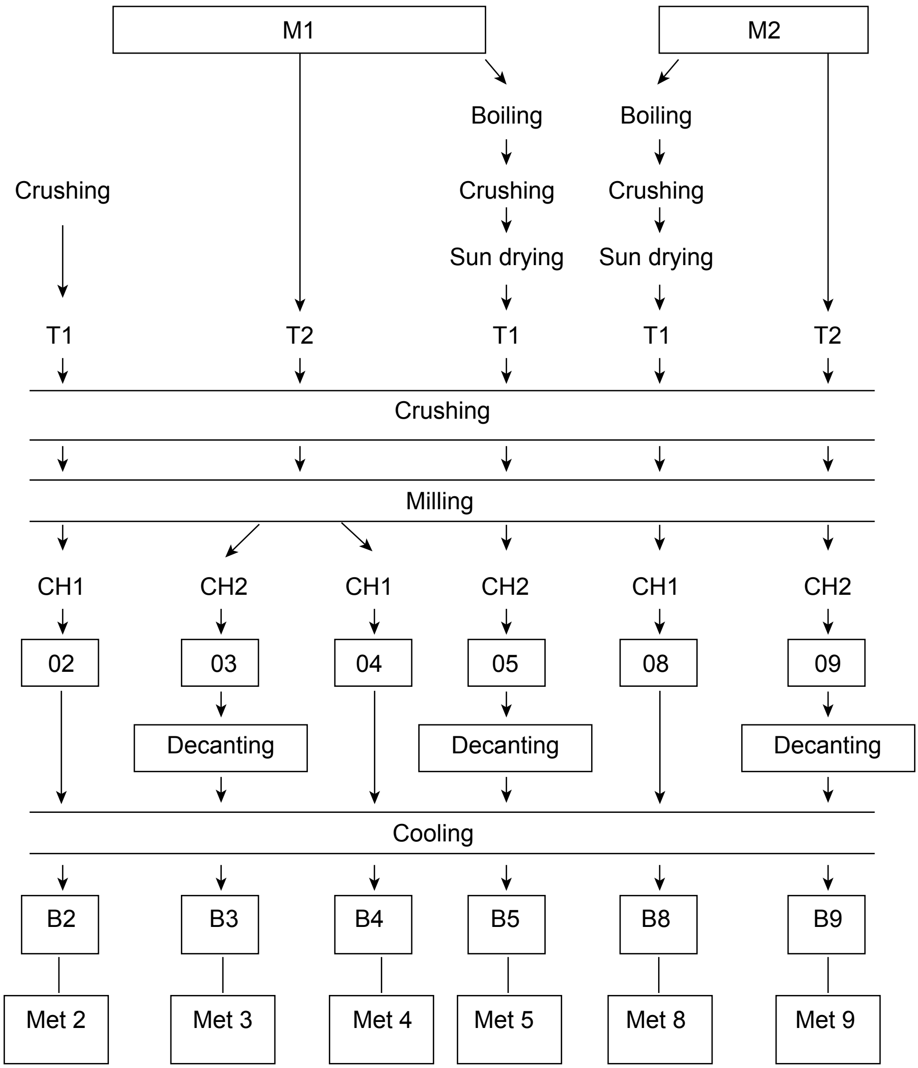

Figure 3 New processing methods of *Pentadesma* butter in northern Benin

Among all the methods identified, only methods 1, 6, 7, and 10 have been reported previously (Houngbedji, 1997; Aissi et al., 2011). The variants 2, 3, 4 5, 8, and 9 (Figure 3) are newly identified and reported for the first time. According to the processors, treatments such as heating and churning were critical unit operations that influence fat extraction yield and butter quality. At present the data from the preliminary study of the effect of the pre-treatments on the quality of *P. butyracea* butter by Aissi et al. (2011) is the only related information in the literature.

Many authors have reported that some unit operations (blanching, roasting, drying, etc.) affect (positively or negatively) the quality of similar products such as shea and cacao butters: Louppe (1995) showed that blanching improved shea butter quality, while Hall et al. (1996), Semmelroch and Grosch (1998), and Megnanou et al. (2007) reported that the characteristics of shea and cocoa butters are affected by the roasting time. Also Kapseu et al. (2005) and Womeni et al. (2006) showed that shea kernel drying and roasting time affects the physicochemical quality of the butter. Roasting of the kernels is a key operation which facilitates fat extraction and improves the sensory characteristics of the butter (Shimoda et al., 1996; Krist et al., 2006). However, insufficient heating may reduce fat yield (Krysiak and Motyl-Patelska, 2005) while high temperatures lead to undesirable volatile compounds in shea butter (Krist et al., 2006). Depending upon the combination of these unit operations, the quality of the derived butter could vary. Indeed, most of the *P. butyracea* processors are also shea processors. They apply numerous and uncontrolled traditional processing techniques to shea nuts to extract shea butter. It was shown that this diversity in processing techniques induced a wide variability in shea butter quality (Louppe, 1995; Hall et al., 1996; Womeni et al., 2006; Honfo et al., 2011). Therefore, it could be assumed that the observed variations in *P. butyracea* processing methods could lead to diversity in butter quality. The traditional processing methods of *P. butyracea* butter therefore needs to be optimized.

The *P. butyracea* butter production was an entirely manual operation. Crushing and grinding were the most labour-intensive operations according to the processors due to the hardness of *P. butyracea* kernels. These operations required much energy. Indeed, the rupture strength was 2.65 kN for dried kernels, 0.75 kN for smoked kernels, and 1.35 kN for the boiled and dried kernels (Aissi et al., 2011). The processors hope that this difficulty could be overcome by mechanizing both operations using a crusher and a mill adapted for the purpose. It is thus advisable to make investigations into the design of the required equipment for the processing of *P. butyracea* butter. Churning was also labour intensive and required mechanization. With roasting and frying, control of the open fire was a priority. The processors proposed the use of improved mud stoves or preferably a cooker.

The *P. butyracea* butter is yellow, has no odour and is similar to groundnut oil when it is in its liquefied state (100 per cent of respondents). Sinsin and Sinadouwirou (2003) reported that rural households use *P. butyracea* butter to avoid the strong odour of shea butter. According to the consumers (97 per cent of respondents), *P. butyracea* butter has better sensory properties than shea butter. Several uses of *P. butyracea* butter have been reported by Natta et al. (2010).

Analysis of the data also revealed that *P. butyracea* butter processing varies from one parkland to another, and that groups of the same geographical area generally used the same methods. Sociocultural groups who live together exchange knowledge through friendships, kinship, and inter-ethnic marriages, which are frequent among the studied groups, as described by Avocevou- Ayisso et al. (2011). According to the results obtained, Boo and Mokole, who lived on the parkland of Kandi, were the only user groups of methods 5 and 9. Nagot, the only sociocultural group who lived in the parkland of Tchaourou, was the only user of methods 6 and 7. The methods

2, 3, 4, and 8 were the speciality of the women who lived in the parkland of Bassila. Wama and Otamari of the parklands of Natitingou and Toucountouna were the only users of method 10. Except for the women of the parkland of Tchaourou and Kandi, several women of other parklands used method 1.

Conclusion

Many variations have been identified in the traditional methods of processing *P. butyracea* to extract butter in northern Benin. The processing methods vary from one sociocultural group to another. These operations are performed generally using rudimentary equipment and utensils. The variations in the processing methods result from the combination of unit operations used for the pre-treatment of *P. butyracea* kernels and the methods the processors use for heating and kneading the butter during processing. In a further investigation the identified variants of butter processing from *P. butyracea* should be evaluated in order to select the methods to be used to improve the yield and the quality of extracted butter. For this investigation we can suggest a good experimental design to optimize the traditional methods of *P. butyracea* butter processing using a well-known *P. butyracea* variety as a raw material.

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