Research Article

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Profiling the quality characteristics of the butter of *Pentadesma butyracea* with reference to shea butter

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Abstract

BACKGROUND: *Pentadesma butyracea* is a tropical plant species. Its kernels are rich in edible butter similar to shea butter. This study evaluated the quality characteristics of the *Pentadesma* butter produced by cottage enterprises in Benin, using a quantitative survey approach and physicochemical and sensorial analysis methods.

RESULTS: The butter of *Pentadesma* is mostly used for food preparation, cosmetic and therapeutic applications. It is characterized by a yellow colour, a hard texture, a relatively sweet taste and a bright appearance. Consumers preferred *Pentadesma* butter to shea butter for colour, taste, texture and appearance. Instrumental analysis showed that the average water content (6.5 g kg^{-1}) and peroxide value (0.74 mEq O_2 kg^{-1}) of *Pentadesma* butter were lower than those of shea butter, for which average water content and peroxide values were 20.7g kg^{-1} and 2.09 mEq O_2 kg^{-1} respectively. The fatty acid profile of *Pentadesma* butter is similar to that of shea butter.

CONCLUSION: This study showed that the *Pentadesma butyracea* butter produced by cottage enterprises in Benin exhibited quality characteristics which are better than that of shea butter. The data generated can be used for a better exploitation of the butter in food and cosmetic industries.
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Keywords: *Pentadesma butyracea*; quality; cosmetic; butter; therapeutic; *Vitelaria paradoxa*

INTRODUCTION

Forest products contribute significantly to the health and food security of millions of people worldwide while providing substantial resources to the national economy.[1] To our knowledge, little research has been conducted on these products in Benin despite their high potential added value.[1,2] *Pentadesma butyracea* Sabine (Clusiaceae) is a ligneous forest species with multipurpose uses. It is widely distributed in Africa from Guinea-Bissau to the west of the Democratic Republic of Congo. The plant is known as 'tallow tree' or 'butter tree' in English, 'arbre à suif' or 'arbre à beurre' in French, 'Krinda' in Côte d'Ivoire, 'Abotoasebie' in Ghana, 'Agnuhé' in Gabon and 'Kpangnan' or 'Sesseido' in Benin. *Pentadesma butyracea* is found in the centre and northern part of Benin in forest galleries and along waterways.[3,4] The fresh kernels, consumed like kola,[5] are rich in edible butter similar to shea butter.[6] *Pentadesma butyracea* butter is used in traditional medicine such as massage oil, in skin and hair care and in the manufacturing of soap because of its softening, lubricating and healing qualities.[7] In Central Africa, notably in Gabon, the sweet mesocarp of mature fruits is used to make fruit juice.[8] In spite of its potential application in food and cosmetic industries, very little is known about the quality attributes of *P. butyracea* butter. Previous studies showed that the composition of fatty acids and triglycerides of *P. butyracea* butter is similar to that of shea butter.[6,7] Tchobo *et al.*[9] evaluated the physicochemical characteristics of *P. butyracea* butter and reported that the oil content was 419.0 g kg^{-1}, crude protein content was 44.0 g kg^{-1}, lysine content was 3.2 g kg^{-1} dry matter, methionine content was 1.6 g kg^{-1} and cysteine was 1.5 g kg^{-1}. Evrard[10] reported that the oil cakes of *P. butyracea* kernels are very poor in proteins, particularly in essential amino acids. The colour characteristics of the butter of *P. butyracea* kernel are reported to be: $L^* = 53.07$; $a^* = 11.77$; and $b^* = 7.76$.[11] Moreover, the technical itinerary of the traditional processing of the kernels from *Vitellaria paradoxa* and *P. butyracea* is nearly the same.[10] The present study evaluated the quality of the butter of *P. butyracea* in comparison to that of *V. paradoxa* using a quantitative survey approach and physicochemical and sensorial analysis. The results serve to define the scope in terms of consumers' preferences and to establish the comparative advantage of the butter in order to supply useful data for a better exploitation of *P. butyracea* in the food and cosmetic sectors.

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MATERIALS AND METHODS

Rapid appraisal investigation

A rapid appraisal investigation was conducted in seven communities of northern Benin, i.e. Tchaourou, Bassila, Djougou, Natitingou, Kouandé, Toucountouna and Kandi, which have been reported to be the predominance zones of *P. butyracea* species in Benin.[4,12] The aim was to capture current knowledge on *P. butyracea* butter and its various uses by processors and consumers. The items discussed were related to the period of availability of fruits and seeds during the year, the processing methods of the kernels, and the different uses and quality attributes of the butter. The survey was carried out as an in-depth individual discussion with a sample of 40 subjects selected from different geographic and ethnic origins, i.e. Nagot, Waama, Boco, Anii, Fulani, Kotocoli and Otamari. The results were used to design a questionnaire for a quantitative survey.

Quantitative survey

The quantitative survey was conducted in three communities of northern Benin: Tchaourou (department of Borgou), Bassila (department of Donga) and Natitingou (department of Atacora). One hundred and twenty subjects participated in the interviews. Participants were producers or consumers of *P. butyracea* and shea butters. They were randomly chosen and differed from each other in terms of standard of living and socio-cultural background.

Subjects

The socio-demographic characteristics of the participants in the quantitative survey were as follows. Subjects were 90 females and 30 males. They were processors and consumers of *P. butyracea* butter. They are also familiar with shea butter. Their socio-cultural origin was diverse. Most of them were *Nago* (34.2%), *Waama* (2.8%), *Anii* (21.7%), *Kotocoli* (5%), *Ditamari* (30%) and *Fulani* (6.7%). Sixty-two percent of the respondents were 35–50 years old, 31.66% between 20 and 34 and 6.66% over 51. Their educational background was poor, as 87.5% of them were illiterate and only 12.5% had attended primary school. This reflects the general education level in the country. They practise different religions, being animists (2.5%), islamists (33.3%) and christians (64.2%).

Questionnaire

The questionnaire included the following aspects:

- different uses of the *P.butyracea* and the shea butters;
- factors affecting the quality of *P. butyracea* butter;
- quality preferences of *P. butyracea* butter in terms of texture, appearance, taste and colour. The preference for *P. butyracea* butter was evaluated in comparison to shea butter in terms of 'like more/less than'. In addition, consumers preferring one butter to the other for a specific quality attribute were asked to specify which kind of texture (hard, very hard, moderately hard, not hard), taste (slightly sweet, sweet, acid, bitter, no pronounced flavour), colour (yellow, red, white, orange, dark), appearance (bright, dull, clear, transparent) they preferred.

The protocols used for rapid appraisal and quantitative survey were approved by the Faculty of Agronomic Science of the University of Abomey-Calavi; informed consent was obtained from all respondents.

Butter processing and sampling

Pentadesma butter samples used for fatty acid analysis were collected from three processing sites. The processing trials took place in Penessoulou, a village of the Bassila community in northern Benin, where *P. butyracea* butter is commonly produced and consumed. One batch of boiled and dried kernel of *P. butyracea*, purchased from a local market, was processed into butter at three processing sites according to traditional processing practices, as follows. On average, 5 kg of kernels were roasted, crushed, ground, churned to collect cream, heated and cooled to allow butter solidification. At the end of the processing, *Pentadesma* butter samples were collected and transported to the laboratory for analysis. *Vittelaria paradoxa* butter samples (shea butter) were collected from local markets.

Sensory evaluation

Six samples of butter (three from *P. butyracea* and three from *V. paradoxa*) were subjected to a sensory evaluation using a hedonic test by a panel of 60 students aged between 20 and 25 years, selected at the University of Abomey-Calavi.[13] All of them are familiar to sheanut butter. The evaluation was carried out under ambient room conditions (25 °C). The six butter samples (40 g each) were coded with three-figure random numbers and presented simultaneously, but in random order, to each evaluator on white paper plates. The subjects evaluated the different types of butter for their quality attributes on the basis of a nine-point scale. In addition, the subjects evaluated the total acceptability of the butters using a nine-point hedonic scale, from 'dislike extremely' to 'like extremely', according to the method described by Meilgaard *et al.*[14]

Physicochemical analysis

The water content was determined according to International Standard IS0 662. Colour characteristics were determined using a chromameter (Minolta CR410) and the results were expressed as L^* (brightness), a^* (redness), b^* (yellowness), and ΔE (gap of colour in relation to the white reference ceramic). Acid value, refractive and peroxide indexes were determined using the international methods NF T60-220, NF T60-212 and NF T60-220, respectively.

Fatty acid analysis

The fatty acid composition of *P. butyracea* butters was analysed by gas chromatography (GC) following the method described by Tchobo *et al.*[6] In a 25 mL round-bottom flask, oil samples (10 mg) were added to sodium methylate solution (3 mL) containing phenolphthalein. The mixture was refluxed for 10 min and 3 mL methanolic HCl were added until phenolphthalein discoloration occurred. The mixture was refluxed again for 10 min and cooled to room temperature. Hexane (8 mL) and water (10 mL) were added and the recovered organic phase, dried over anhydrous sodium sulfate and filtered for subsequent GC analysis. An Agilent 6890 series gas chromatograph provided with a Supelcowax 10 capillary column (SGE, Courtaboeuf, France) with the following characteristics – length, 30 m; internal diameter, 0.32 mm; film thickness 0.25 µm – was used. Fatty acid methyl esters were directly injected into the gas chromatograph. The carrier gas was helium with a flow rate of 1 mL min^{-1}, and a split ratio of 1/80. The injector temp was 250 °C and that of the flame ionization detector was 270 °C. The temperature settings were as follows: 150–225 °C at 5 °C min – 1; then held at 225 °C for 2 min. Fatty acids were identified by comparison with commercially available fatty acid standards.

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Statistical analysis

Survey data were analysed using Sphinx Survey Plus 2 (version 4.5) software. The sensorial and physicochemical data were analysed using the Minitab 16 statistical program (Minitab Inc., Pennsylvania, PA, USA). Differences among means were compared by one-way analysis of variance (ANOVA) with Tukey's post hoc test and significance level at $P < 0.05$.

RESULTS AND DISCUSSION

Significance of *P. butyracea* butter for rural households in Benin

The different uses of *P. butyracea* butter by rural households in the study zones are presented in Table 1. The butter of *Pentadesma* is used mainly in the food sector and to a lesser extent in cosmetic and therapeutic applications. All the socio-cultural groups interviewed use the butter for food preparation, mainly as cooking oil. Moreover, 48.1% and 27.4% of the subjects interviewed use *Pentadesma* butter for cosmetic and therapeutic applications, respectively. More specifically, *Pentadesma* butter is used by Waama (100% of respondents), Otamari (94.4%) and Fulani socio-cultural groups (75% of respondents) for hair and skin care and even for soap manufacture. An important reason mentioned for this preference was that the butter of *Pentadesma* had a more pleasant aroma. The same observation was made by Sinsin and Sinadouwirou.[5] However, only19.2% of the respondents from the Anii community used *Pentadesma* butter for cosmetic purposes, and the butter was not used at all in Nagot community for cosmetic applications. Interestingly, users mentioned that it is not necessary to add other aromatic ingredients to the butter of *Pentadesma* before one can use it as a skin or hair ointment, in contrast to shea butter, to which some perfumes or other body creams were added to improve its aroma.[15] With regard to therapeutic treatments, it is mainly the Waama (66.7% of respondents) and the Otamari (63.9% of respondents) communities who use the *Pentadesma* butter for massage and in the pharmacopeia (chest pains, children's cough, ache, childbirth, etc.). Processors from the study zones indicated that *Pentadesma* butter is much better than shea butter for soap manufacture.

Table 1. Food, cosmetic and therapeutic uses of *P. butyracea* butter by different socio-cultural groups (percent of producers surveyed, $N = 120$)

	Type of use		
Socio-cultural group	Food	Cosmetic	Therapeutic
Nago ($n = 40$)	100	0	2.4
Anii ($n = 26$)	100	19.2	19.2
Otamari ($n = 36$)	97.2	94.4	63.9
Others ($n = 18$)	100	55.6	22.2
Total ($N = 120$)	99.53	48.1	27.45

Users' perception of the quality of *Pentadesma* butter

The important quality attributes of *Pentadesma* butter in comparison to shea butter are presented in Fig. 1. The colour is the main factor affecting the choice of butter. Eighty percent of the respondents preferred *Pentadesma* butter for its yellow colour because it was more attractive. Only 20.5% of respondents liked the white colour of shea butter. To meet consumer demand for colour, a number of processors make use of the roots or bark of certain plant species to confer a yellow colour to the shea butter. Postharvest handling of the seeds affects the colour of *Pentadesma* butter. In particular, dark butter is generally obtained when the nuts

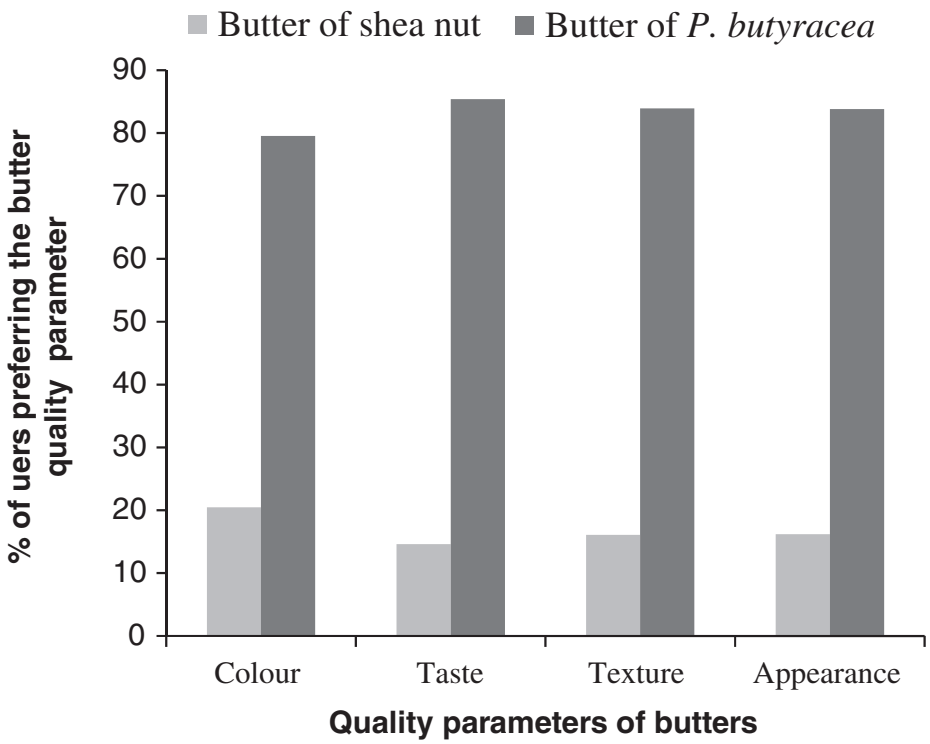

Figure 1. Preferences of users for various quality characteristics of the butters of *P. butyracea* and sheanut during a field survey in northern Benin (percent of respondents, $N = 120$ subjects).

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Table 2. Sensory scores of *P. butyracea* and Shea butters based on their quality attributes

Butter type	Colour	Aroma	Hardness	Total acceptability
Pentadesma butter				
Tchaourou ($n = 60$)	6.9 ± 1.99b	7.40 ± 2.18a	7.73 ± 1.71c	7.34 ± 1.82b
Natitingou ($n = 60$)	4.97 ± 1.18a	7.02 ± 1.77a	6.78 ± 1.34b	6.31 ± 1.51a
Bassila ($n = 60$)	5.50 ± 1.33a	7.07 ± 1.73a	6.10 ± 1.43a	6.65 ± 1.52a
Average	5.79 ± 0.99a	7.16 ± 0.20a	6.87 ± 0.81a	6.76 ± 0.52a
CV	17.22	2.88	11.91	7.75
Sheanut butter				
Tchaourou ($n = 60$)	3.77 ± 2.03a	4.80 ± 2.08a	3.91 ± 1.92a	3.80 ± 1.94a
Natitingou ($n = 60$)	6.52 ± 1.60b	6.42 ± 1.38b	5.60 ± 1.46b	6.56 ± 1.46b
Bassila ($n = 60$)	7.46 ± 1.51c	6.64 ± 1.74b	5.78 ± 1.86b	6.98 ± 1.40b
Average	5.91 ± 1.91a	5.95 ± 1.00b	5.09 ± 1.03b	5.78 ± 1.72b
CV	32.4	16.87	20.24	29.88

Mean ± standard deviation; n = number of subjects who evaluated the butter; values with the same letter in the same column are not significantly different at $P < 0.05$. Comparison is made between averages of the two types of butters; values with the same letter are not significantly different at $P < 0.05$. CV, coefficient of variation.

are not properly sun dried (e.g. during the rainy season). According to some consumers, the colour preference depends on end use. Thus the majority of respondents (78%) preferred to use the butter of *Pentadesma* for food preparation because of its yellow colour, which conferred an attractive appearance to the derived product. For cosmetic and therapeutic uses, colour is not a determining factor in butter choice. The taste of the butter also appears as an important quality characteristic for all processors. The taste of *Pentadesma* butter is preferred to that of shea butter (85.4% *vs.* 14.62% of respondents). Consumers indicated that *Pentadesma* butter possesses a slightly sweet and pleasant taste and a flavour similar to that of peanut oil. Another interesting and advantageous quality characteristic of the *Pentadesma* butter is its relatively hard texture compared to shea butter. For this particular characteristic, about 84% of subjects preferred *Pentadesma* butter to shea butter. Finally, the appearance of *Pentadesma* butter is bright and transparent and, owing to this characteristic, 82% of respondents preferred *Pentadesma* butter to shea butter.

Sensorial characteristics of the butters

The sensorial characteristics of the six butters as evaluated by the 50 consumers are presented in Table 2. The sensory descriptors used are colour, hardness, aroma and total acceptability. ANOVA showed that there was a significant difference ($P < 0.001$) between the two types of butter in terms of hardness and aroma (Table 2). This is in accordance with the users' perception as described above. Clearly, the members of the panel noticed that *Pentadesma* butter was harder than shea butter. They preferred the aroma of *Pentadesma* butter. As far as the aroma is concerned, shea butter was not as pleasant as *Pentadesma* butter. This result is in agreement with the perception of the interviewed users during the field survey. The preference of the panel members for the two types of butter in terms of colour is not significantly different ($P > 0.05$). However, there is a significant difference ($P < 0.001$) between the overall acceptability of the two types of butter and the panel members preferred *Pentadesma* butter to shea butter.

Incidence of processing on the quality of *Pentadesma* butter

The quality of *Pentadesma* butter depends on the way the butter has been processed, the processing period (rainy or dry season) and the storage conditions.[16,17] Table 3 shows the effects of process unit operations on the quality of *Pentadesma* butter as perceived by the processors. More than 90% of the respondents thought that the drying process affected the colour and taste of *Pentadesma* butter. Also, the appearance of the butter could be affected by the drying process, according to 27.5% of the interviewed processors. Thus, when sun drying of almonds is not well conducted (e.g. short-duration exposure to sunlight), the butter obtained had a dark-yellow colour and a bitter taste. For some processors, this could also lead to a rancid aroma in the butter. A report by Aïssi *et al.*[11] indicated that the normal colour of *Pentadesma* butter is light-yellow. Undesired butter colour may also derive from the presence of black solid residues, which mainly occurred during the cooking process. These characteristics alter the end-use quality of the butter, particularly in the food and cosmetic sectors. All the processors interviewed indicated that roasting affected the colour and flavour of *Pentadesma* butter and 64.2% of them thought that roasting also affected the appearance of the butter. According to them, a short roasting duration resulted in a butter with an unpleasant taste, while too long a roasting duration led to a butter with a dark colour. Basically, the roasting process of the kernels is applied to facilitate fat extraction and to improve the sensory characteristics of the butter.[18] This operation is a critical step, which is usually conducted by experienced women processors. Some interviewed processors mentioned that it may also affect oil recovery from the kernel. Indeed, in shea butter extraction, it is known

Table 3. Effects of process unit operations on quality attributes of *P. butyracea* butter as perceived by processors (percent of respondents, $N = 120$)

Operation	Colour	Texture	Taste	Appearance
Sun drying	92.5	0	90.8	27.5
Roasting	100	0	100	64.2
Baking	99.2	0	99.2	63.3
Churning	2.5	15	3.3	1.7
Crushing	0	17.5	0	0
Grinding	2.5	15.8	2.5	1.7
Storage	43.3	0	50	10.8

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Table 4. Physico-chemical characteristics of the butters of *P. butyracea* and shea collected from producers in Northern Benin

Provenance	Watercontent (g kg^{-1})	Refractiveindex	Peroxide index (mEq O_2 kg^{-1})	Acidity (% oleic acid)
Pentadesma butter				
Tchaourou ($n = 4$)	6.6 ± 5.8b	1.462 ± 0.00a	0.97 ± 0.03b	18.44 ± 0.84b
Natitingou ($n = 4$)	5.2 ± 8.9a	1.460 ± 0.00a	0.56 ± 0.07a	15.58 ± 0.20b
Bassila ($n = 4$)	7.6 ± 2.3b	1.462 ± 0.00a	0.69 ± 0.03a	6.01 ± 0.13a
Average	6.5 ± 1.2a	1.461 ± 0.00a	0.74 ± 0.20a	13.34 ± 6.50a
CV	0.12	0.08	27.02	48.72
Sheanut butter				
Tchaourou ($n = 4$)	15.1 ± 4.2a	1.467 ± 0.00a	1.92 ± 0.05a	14.50 ± 0.17b
Natitingou ($n = 4$)	26.4 ± 9.7c	1.468 ± 0.00a	2.24 ± 0.03b	13.27 ± 0.01b
Bassila ($n = 4$)	20.9 ± 4.7b	1.465 ± 0.00a	2.13 ± 0.01b	3.69 ± 0.60a
Average	20.8 ± 5.6b	1.466 ± 0.00a	2.09 ± 0.16b	10.48 ± 5.91a
CV	0.57	0.07	7.65	56.39

Mean ± standard deviation; n = number of replication; values with the same letter in the same column are not significantly different at $P < 0.05$. Comparison is made between averages of the two types of butters; values with the same letter are not significantly different at $P < 0.05$. CV, coefficient of variation.

Table 5. Colour characteristics of the *P. butyracea* butter and sheanut butter collected from producers in northern Benin

	Colour characteristics			
Provenance	lightness(L^*)	Redness(a^*)	Yellowness(b^*)	Total colour difference (ΔE)
Pentadesma butter				
Tchaourou ($n = 4$)	61.04 ± 0.01	0.31 ± 0.01	23.98 ± 0.00	38.81 ± 0.01
Natitingou ($n = 4$)	65.52 ± 0.02	−3.98 ± 0.00	24.04 ± 0.03	26.12 ± 0.04
Bassila ($n = 4$)	63.41 ± 0.02	−1.9 ± 0.01	26.16 ± 0.06	38.03 ± 0.02
Average	63.32 ± 20.00a	−2.06 ± 1.64a	24.73 ± 1.11a	34.32 ± 6.36a
CV	3.16	80.02	4.49	18.53
Sheanut butter				
Tchaourou ($n = 4$)	77.89 ± 0.01	−0.52 ± 0.00	9.73 ± 0.00	39.24 ± 0.02
Natitingou ($n = 4$)	65.43 ± 0.00	−2.93 ± 0.00	14.64 ± 0.01	30.88 ± 0.00
Bassila ($n = 4$)	70.11 ± 0.04	−3.39 ± 0.01	19.02 ± 0.02	28.63 ± 0.02
Average	71.14 ± 5.62b	−2.28 ± 1.37a	14.46 ± 4.15b	32.92 ± 4.99a
CV	7.91	60.4	28.73	15.18

For each parameter (in column), mean ± standard deviation; values with the same letter are not significantly different at $P > 0.05$. CV, coefficient of variation.

that insufficient heating may reduce the oil yield,[19] and too high temperatures during roasting would also lead to the generation of undesirable volatile compounds.[18] Definitively, there is a need to establish optimum roasting conditions under the traditional processing practices. Cooking the crude fat extract also affects the colour (99.2%), taste (99.2%) and appearance (63.3%) of *Pentadesma* butter. The storage conditions of the kernel affect the colour (43.3% of respondents), taste (50%) and appearance (10.8%) of *Pentadesma* butter. Users indicated that the storage of almonds in a wet environment could result in a butter with less attractive characteristics.

Physicochemical properties of the butters

ANOVA revealed that there was a highly significant difference ($P < 0.001$) between the water content of the two types of butter (Table 4). The average water content was 6.5 g kg^{-1} for *Pentadesma* butter and 20.7 g kg^{-1} for shea butter. The high dry matter content of *Pentadesma* butter may explain its relatively high hardness as perceived by consumers (Table 4) and would also be favourable to a longer shelf-life of the product. The West African regional standard for unrefined shea butter exists for various quality criteria.[20] Thus, in the food industry, the norm required for the unrefined shea butter in terms of water content is in the range 2.0–20.0 g kg^{-1}. Clearly, *Pentadesma* butter is in close agreement with this quality criterion. Nevertheless, in cosmetic and pharmaceutical sectors, there is still an important gap between the standard and the characteristics of both types of traditional butter in terms of water content. According to Fashina,[21] refractive index is used for rapid sorting of fats and oils to test their diversity and purity. The refractive indices at 40 °C of *Pentadesma* (1.461) and shea (1.466) butters are not significantly different ($P > 0.05$). The values obtained are in agreement with the values of various oils and fats from shea seeds.[22] In respect of the peroxide values, a highly significant difference ($P < 0.001$) was observed for the two types of butter (Table 4). The average peroxide value of the *Pentadesma* butter (0.74 mEq O_2 kg^{-1}) was lower than that of shea butter (2.09 mEq O_2 kg^{-1}). This low peroxide value of *Pentadesma* butter may be partly attributed to processing practices, and in particular the longer duration of sun-drying. Indeed, sheanuts are exposed to the sun for a long time (5–21 days). Womeni

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Table 6. Fatty acid composition (%) of *P. butyracea* butter compared to sheanut butter

Fatty acid		*P. butyracea* butter				Sheanut butter			
		Sample 1	Sample 2	Sample 3	Average	Honfo *et al.* (2013)[25]	Bup *et al.* (2011)[28]	Dubois *et al.* (2007)[29]	Dencausse (1995)[7]
Myristic acid	C14:0	0	0	0	0	–	–	–	–
Palmitic acid	C16:0	3.05	2.95	2.94	2.98	3.54	3.65	5.0	3.1
Palmitoleic acid	C16:1	0.05	0.05	0.02	0.04	–	0.31	–	–
Heptadecanoic acid	C17:0	0.16	0.15	0.15	0.15	–	0.07	–	–
Stearic acid	C18:0	42.0	42.0	42.21	42.07	42.65	40.9	41.0	42.8
Oleic acid	C18:1	53.71	53.8	53.65	53.72	45.92	47.0	48.0	46
Linoleic acid	C18:2	0.72	0.75	0.73	0.73	6.01	5.65	5.1	6.3
Linolenic acid	C18:3	0.14	0.13	0.14	0.14	0.13	0.29	0.3	0.1
Arachidic acid	C20:0	0.16	0.16	0.15	0.16	1.41	1.54	0.6	1.4

et al.[16] found that the long exposure (more than 8 days) of shea nuts to sunlight is favourable to the formation of peroxides. The peroxide values in all samples were lower than the maximum value of 10 mEq O_2 kg^{-1} tolerated for cosmetic uses.[23] For food uses, the accepted values are in the range 10^{24}–50 mEq O_2 kg^{-1} for refined butter.[22] Nevertheless, it has been reported that shea butter with a relatively high peroxide value (close to 50 mEq O_2 kg^{-1}) is susceptible to deterioration and is inappropriate for human consumption.[25] Aïssi *et al.*[11] reported that process unit operations like drying, roasting and cooking have positive effects such as reducing the peroxide value of traditionally processed *Pentadesma* butter. Both *Pentadesma* and shea butters have similar acidity values ($P > 0.05$). Butters from the Bassila community showed the lowest acidity values: 6.01 and 3.69 mg KOH g^{-1} for *Pentadesma* and shea butters, respectively. Indeed, sun drying and roasting of the kernel as well as oil cooking are key unit operations that significantly affect butter acidity and peroxide indices.[11] Thus, the low acidity and peroxide values achieved could be assigned to traditional post-harvest treatments. Overall, our data are comparable to values reported by Megnanou *et al.*[26] (10.51–11.94 mg KOH g^{-1}) for shea butters from Côte d'Ivoire. Relatively high water content due to inadequate sun-drying conditions are favourable to chemical and/or enzymatic hydrolysis of fat during storage.[27] Mean values for the colour parameters of shea butter and *Pentadesma* butter samples are presented in Table 5. There were significant differences between *Pentadesma* and shea butters regarding their colour characteristics. In particular, the yellow index (b^*) for *Pentadesma* butter was higher than that of shea butter, which exhibited a higher value for the whiteness index (L^*). No significant difference was detected in the redness (a^*) and the total colour difference (ΔE) of the two types of butter. This result is in agreement with the data recorded during the sensory evaluation of the butters. A yellow colour corresponds to the natural colour of *Pentadesma* butter, and when the butter is also bright the butter is more attractive. Table 6 shows the fatty acid profile of the two types of butter studied. The fatty acid composition of *Pentadesma* butter is similar to that of the shea butter. Stearic acid (C18:0) and oleic acid (C18:1ω9) are the predominant fatty acids and represent more than 96% of the total fatty acids.[6] Other fatty acids are detected in minor quantities. These are palmitic acid (C16:0), linoleic acid (C18:2ω6), linolenic acid (C18:3ω3) and arachidic acid (C20:0). The fatty acid composition of *Pentadesma* butter obtained in this study is in agreement with data reported by Tchobo *et al.* and Dencausse *et al.*[6,7]

CONCLUSION

Pentadesma butyracea butter is locally used and appreciated by people in the food and cosmetic sectors as well as for therapeutic treatments. *Pentadesma* butter and shea butter have very similar fatty acid composition, but *Pentadesma* butter possesses some superior qualities, being harder and having a much more pleasant aroma. Moreover, its natural bright yellow colour could represent an attractive characteristic in the butter market. These differences can be used as comparative advantages in the design and formulation of new products. However, some process unit operations affect the quality of *Pentadesma* butter. In particular, sun drying, kernel roasting and oil cooking are the key affecting factors during butter processing. More attention should be paid to these processing steps.

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REFERENCES

1 Assogbadjo AE, Sinsin B, Codjia JTC and Van Damme P, Ecological diversity and pulp, seed and kernel production of the baobab (*Adansonia digitata*) in Benin. *Belg J Bot* **138**:49–56 (2005).
2 Codjia JTC, Assogbadjo AE and Ekué MRM, Diversité et valorisation au niveau local des ressources forestières alimentaires végétales du Bénin. *Cah Agric* **12**:321–331 (2003).
3 Avocèvou-Ayisso C, Etude de la viabilité des populations de *Pentadesma butyracea* Sabine et de leur socio-économie au Bénin. Thèse de doctorat, Université d'Abomey-Calavi, Benin (2011).
4 Natta A, Sogbégnon R and Tchobo F, Indigenous knowledge and importance of *Pentadesma butyracea* (Clusiaceae) for rural populations in north west Benin. *Fruit Veg Cereal Sci Biotechnol* **4**:18–25 (2010).
5 Sinsin B and Sinadouwirou TA, Valorisation socio-économique et pérennité du *P. butyracea* Sabine en galeries forestières au Bénin. *Cah Agric* **12**:1–5 (2003).
6 Tchobo PF, Natta AK, Barea B, Barouh N, Piombo G, Pina M *et al.*, Characterization of *Pentadesma butyracea* Sabine butters of different production regions in Benin. *J Am Oil Chem Soc* **84**:755–760 (2007).
7 Dencausse L, Nsourankoua H, Artaud J and Clamou JL, Comparaison des compositions lipidiques des beurres de *Pentadesma* et de Karité. *OCL: Oilseeds Fats, Crops Lipids* **2**:143–147 (1995).
8 White L, *Guide de la Végétation de la Réserve de la Lopé*. Traduit de l'anglais par Benoît Fontaine et Anne Rouvière. Multipress-Gabon, Libreville (1996).
9 Tchobo PF, Alitonou GA, Noudogbessi JP, Laguerre M, Barea B, Piombo G *et al.*, Evaluation of the chemical composition of *Pentadesma butyracea* butter and defatted kernels. *Int J Biosci* **3**:101–108 (2013).

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10 Evrard J, Les tourteaux d'oléagineux, source de protéines en alimentation animale *OCL: Oilseeds Fats, Crops Lipids* **12**:224–227 (2005).
11 Aïssi MV, Tchobo PF, Natta AK, Piombo G, Villeneuve P, Sohounhloué DCK *et al.*, Effet des prétraitements post-récolte des amandes de *Pentadesma butyracea* (Sabine) sur la technologie d'extrraction en milieu réel et le qualité du beurre. *OCL: Oilseeds Fats, Crops Lipids* **18**:384–392 (2011).
12 Ewédjè E-EBK, Parmentier I, Natta A, Ahanchédé A and Hardy OJ, Morphological variability of the tallow tree, *Pentadesma butyracea* Sabine (Clusiaceae), in Benin. *Genet Resour Crop Evol* **59**:625–633 (2012).
13 Watts BM, Ylimaki GL, Jeffery LE and Elias LG, *Basic Sensory Methods for Food Evaluation*. International Development Research Centre, Ottawa, ON, pp. 1–160 (1989).
14 Meilgaard M, Civile GV and Carr BT, *Sensory Evaluation Techniques*. CRC Press, Boca Raton, FL (1987).
15 Honfo FG, Linnemann AR, Akissoe N and Soumanou MM, Indigenous knowledge of shea processing and quality perception of shea products in Benin. *Ecol Food Nutr* **51**:505–525 (2012).
16 Womeni HM, Ndjouenkeu R, Kapseu C, Tchouanguep Mbiapo F, Parmentier M and Fanni J, Séchage des amandes de karité et qualité du beurre: impact du séchage traditionnel au soleil. *Tropicultura* **25**:240–247 (2007).
17 Bup DN, Kapseu C, Tenin D, Kuitche A, Abi CF and Tchiegang C, Variation of the physical properties of sheanut (*Vitellaria paradoxa* Gaertn.) kernels during convective drying. *Int J Food Eng* **4**:62–78 (2008).
18 Krist S, Bail S, Unterweger H, Ngassoum MB, Mohagir AM and Buchbauer G, Volatile compounds of original African black and white shea butter from Tchad and Cameroon. *Eur J Lipid Sci Technol* **108**:583–588 (2006).
19 Krysiak W and Motyl-Patelska L, Effects of roasting conditions on the degree of lipid migration from cocoa bean kernel. *Inzy Chemi Proc* **26**:817–829 (2005).
20 Regional Technical Committee comments on draft African regional standards for unrefined shea butter. RTC (2006).
21 Fashina O, Mechanical expression of oil from conophor nut (*Tetracarpidium conophorum*). *J Agric Eng Res* **44**:275–287 (1989).
22 Anwer TB, A comparative characterization of different non- conventional oilseeds found in Pakistan. *J Chem Soc Pakistan* **24**:144–148 (2006).
23 NBF 01–005, Normes Burkinabées pour le beurre de karité non raffiné. ABNOR (Agence Burkinabée de Normalisation) (2006).
24 Codex Alimentarius Commission, Programme mixte FAO/OMS sur les normes alimentaires. FAO, Rome (1999).
25 Honfo FG, Linnemann AR, Akissoe N and Soumanou MM, Characteristics of traditionally processed shea kernels and butter. *Int J Food Sci Technol* **48**:1714–1721 (2013).
26 Megnanou MR, Nianke S and Diopoh J, Physicochemical and microbiological characteristics of optimized and traditional shea butters from Côte d'Ivoire. *Afr J Biochem Res* **14**:41–47 (2007).
27 Womeni HM, Tchagna DT and Ndjouenkeu R, Influence des traitements traditionnels des graines et amandes de karité sur la qualité du beurre. In *Improving Food Systems in Sub-Saharan Africa: Responding to a Changing Environment*. Food Africa, Yaoundé, Cameroun, pp. 1–8 (2003).
28 Bup DN, Kapseu C, Matos L, Mabiala B, Mouloungui Z, Influence of physical pretreatments of sheanuts (Vitellaria paradoxa Gaertn.) on butter quality. *Eur J Lipid Sci Technol* **113**:1152–1160 (2011).
29 Dubois V, Breton S, Linder M, Fanni J, Parmentier M, Fatty acid profiles of 80 vegetable oils with regard to their nutritional potential. *Eur J Lipid Sci Technol* **109**:710–732 (2007).

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