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Technological application of the butter of *Pentadesma butyracea*: A comparative evaluation of its cosmetic behaviour with *Vitellaria paradoxa* butter

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Pentadesma butyracea **butter is a vegetable fat obtained from the kernels of the** ***P. butyracea*** **tree. It is a potential source of fat for the food and cosmetics sectors. This study evaluated the quality characteristics of the cream and soap processed from the butter of** ***P. butyracea*** **in comparison to similar product from the** ***Vitellaria paradoxa*** **butter. The same cosmetic products were produced with** ***P. butyracea*** **and** ***V. paradoxa*** **butters. The two types of butter are extracted using the traditional procedure. The quality characteristics of** ***P. butyracea*** **products are assessed using the** ***V. paradoxa*** **products with reference. The aerobic mesophilic bacteria counts in** ***V. paradoxa*** **cream and** ***P. butyracea*** **cream were different (p≤0.05) being 2.77 and 2.05 log cfu/g, respectively. The yeasts and moulds, total coliforms, faecal coliforms,** ***Staphylococcus aureus*** **and** ***Pseudomonas aeruginosa*** **were below detection level in the two types of creams. Significant differences were observed in the antimicrobial activity of the two types creams (p≤0.001). Consumers preferred the cream and soap of** ***P. butyracea*** **because the cream is yellow, softer on the skin, consistent with high hydrating power. The yellow colour, the pleasant aroma and the hardness of the** ***P. butyracea*** **soap, are key determining factors for its preference.**

Key words: *Pentadesma butyracea,* shea, cream, soap, butter.

INTRODUCTION

Pentadesma butyracea Sabine is among the most important plant species found in the forests Galleries of Benin. *P. butyracea* nut contain approximately 48.66% of oil (Aïssi et al., 2012). 52.81% of the *P. butyracea* nut oil is composed of unsaturated fatty acids of which 49.86% of saturated fatty acids (Ayegnon et al., 2015). The kernel of *P. butyracea* is a good source of minerals and vitamins particularly calcium, phosphorus, potassium and iron (Tchobo et al., 2013). The fatty acid profile of the *P. butyracea* butter shows that it is mainly composed of two fatty acids, namely the oleic acid and the stearic acid, which represent nearly 96% of the total fatty acids

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(Adomako, 1977; Kouadio et al., 1990; Dencausse et al., 1995; Tchobo et al., 2007). Seven saturated and unsaturated fatty acids were found in the *P. butyracea* butter in different proportions. These are (in mol-%) palmitic acid (C16) 3.6, stearic acid (C18) 47.00, oleic acid (C18:1) 52.00, linoleic acid (C18:2) 0.7, linolenic acid (C18:3) 0.2, arachidic acid (C20) 0.1 and others (Tchobo et al., 2009). The acidity level in the *P. butyracea* butter varies from 0.28% oleic acid (Aïssi et al., 2011) to 4.2% oleic acid (Adomako et al., 1977). The iodine value ranges from 47.3 mg I2/100 g (Adomako et al., 1977) to 48 mg I_2/100 g (Dencausse et al., 1995). The *P. butyracea* butter is mainly composed of triglycerides and a large fraction of unsaponifiable components, which are promising active ingredients for new functional cosmetic products (Akihisa et al., 2010). The phytosterols are important compounds in the unsaponifiable fraction of the vegetable oils and their cholesterol lowering properties are largely recognized. The average sterol content of the *P. butyracea* butter is 1.773 µg/g oil. The identification of the different physterols showed that it is essentially composed of Δ^5sterols (97%) (Aïssi et al., 2011; Tchobo et al., 2007). Stigmasterol (59-69%) is the main sterol, followed by campesterol (16–29%), β-sitosterol (3-7%) and brassicasterol (3-6%) (Tchobo et al., 2007). Another important component of *P. butyracea* butter are the tocopherols belonging to the group more commonly known as vitamin E with high added value in the cosmetic sector. Tocopherols content of the *P. butyracea* butter is between 95.3 and 194.7l g/g (Tchobo et al., 2007). Tocopherols molecular play important role in protecting of the low density lipoprotein particles. They also play a role of as protecting agents against oxidative stress and are also the key antioxidants in human cell membranes. The butter of *P. butyracea* is traditionally used in medicine as massage oil, in skin and hair care, and in the soap manufacturing because it possesses softening, lubricating, and healing qualities (Dencausse et al., 1995). Thus the *P. butyracea* butter can also find diverse applications in cosmetic and food industries locally and externally. For example, the *V. paradoxa* butter is commonly used in cosmetics and in the production of cocoa butter equivalents. Currently, up to 5% content of *V. paradoxa* butter is allowed under European Union (EU) regulations on chocolate. It is also used in other confectionaries and margarines (Leakey, 1999; USAID, 2004). Many studies reported on the physicochemical, nutritional and biochemical properties of *P. butyracea* butter. But, studies on the manufacture and characterization of *P. butyracea* butter-based elaborated products are hard to come by Ayegnon et al. (2015); Tchobo et al. (2013); Aïssi et al. (2011); Adomako (1977); Kouadio et al. (1990) and Dencausse et al. (1995). The present study aimed at manufacturing cream and soap using the butter of *P. butyracea.* The quality characteristics of the manufactured products were evaluated and compared to similar products from *V. paradoxa* butter.

MATERIALS AND METHODS

Plant material and butter extraction

Fresh fruits of *V. paradoxa* and *P. butyracea* (30 kg each) were randomly collected from Bassila community (8°30′ - 9°30′ N and 1°00′ - 2°30′ E), located in the Northern part of Benin. Kernels were extracted from the fruits. The kernels are sorted and crushed. Then the crushed kernels were roasted at 120°C during 30 min. The roasted kernels were ground into fine paste. Some tepid water was added and the mixture was churned for 2 h using a mixer (Kenwood KM 280 series, 900W, china). The generated cream is washed with water, to yield the raw butter which was heated at a temperature of 120-130°C. The derived oil was filtered and cooled to generate butters. These butters were transported to laboratory where they are preserved at 4-7°C until use.

Preparation of cream from *P. butyracea* and *V. paradoxa* butters

Cream of *P. butyracea* and *V. paradoxa* butters were made in Natura-Sarl industry (http://www.sites.google.com/site/naturacosm/), located in the town of Cotonou. Hundred grams of each type of butter were heated for 7 min. Different ingredients such as 30.11 g of tefose, 30.17 g of cethilic alcohol, and 21 g of palm oil to obtain a viscous liquid. Distilled water (405.3 g) is added and the mixture is heated at 70°C. Sodium benzoate (4.05 g), potassium solvatate (4.05 g) and acid citric (4.01 g) are added as preservatives. Finally, 400 g of distilled water are added and the mixture is churned during 15 min to obtain the cream (1000 g).

Preparation of soap from *P. butyracea* and *V. paradoxa* butter

Soap was prepared from *P. butyracea* and *V. paradoxa* butters in the Natura-Sarl industry. Three kilograms of each type of butter were weighed into a 5 litres container. The butter was then heated and saponification process was initiated by adding 360 g of 99% NaOH and 660 g of distilled water. For *V. paradoxa* butter, after 25 min of churning the mixture was solidified, while, for *P. butyracea* butter the mixture solidified only after 45 min of churning. The solidified mixture was left in plastic boats for 3 weeks. The soap obtained was cut out of pieces 5 cm broad and 7 cm length.

Microbiological characteristics of butters and creams

The microbiological characteristics of the two types of butter and derived creams were determined following the methods described by Megnanou et al. (2007) and AOAC (2002). Total counts of mesophilic aerobic bacteria were performedon Plate Count Agar (PCA) after incubation at 30°C for 72 h using the international standards ISO 4833. Total coliforms determination was performed on Violet Red Bile Agar (VRBA) at 30°C for 24 h using the standard ISO 4832. (2006). Faecal coliforms were enumerated on VRBA at 44°C for 24 h (ISO 4832. (2006)). Yeasts and moulds were enumerated on malt Extract Agar (MEA) at 25°C for 72 h using the standard ISO 21527-2. Determination of *Staphylococcus aureus* was performed on Baird-Parkerat 37°C for 48 hand *Pseudomonas aeruginosa* on Pseudomonas Agar at 37°C for 48 h using the international standards ISO 6888-1: 1999 and ISO 22717: 2006, respectively.

Physicochemical characteristics of butters and creams

Moisture content was determined following the AFNOR method NF 60-201. Colour measurements were performed using the chromameter (Minolta (CR410). Results were expressed as L* (brightness), b* (yellowness). The colour coordinates of the white ceramic standard are: Y = 86.10, X = 0.3194, y = 0.3369. The acid value, peroxide value, iodine index and the unsaponifiable matter were determined according to the Beninese standards using NB ISO 660 (2006), NB ISO 3960 (2006), NB ISO 3961 (2006), and NB ISO 3596 (2006), respectively. The butter viscosity was determined according to the international standard using NF V03-749 (1999).

Determination of the cream specific density

This was performed according to method reported by John (2003). Ten millilitres (V0) of cream was measured in a pre-weighted measuring cylinder (P0). The weight of the cylinder and cream was measured (P1). The weight of the cream was deduced. The specific density of the oil was obtained using the equation below.

Density of cream = $P1 - P0/V0$

Measurements of pH and temperature

The pH values of different samples were determined at 25°C according to method by Megnanou et al. (2014) and Ze et al. (1997) using a pH-meter (Inolab WTW 730). Prior to analysis, all samples were treated adequately before pH and temperature measurements. Melted butter sample (2 ml) were dissolved in 15 ml of n-hexane. Subsample of soap (2 g) was dissolved in 50 ml of deionised water and ten grams of cream were mixed with 20 ml of deionised water. The pH-meter was standardized with buffer solutions (pH 4.0 and 7.0). All measurements were performed in duplicate.

Foam forming ability of soap

About 2.0 g of soap were added to a 500 ml measuring cylinder containing 100 ml of distilled water (Isah, 2006). The mixture was shaken vigorously to generate foams. After shaking for about 2 min, the cylinder was allowed to stand for 10 min. The height of the foam in the solution was recorded. The commercial antiseptic soap (pharmapur soap) used as reference. Measurements were performed in triplicate.

Measurement of the soap hardness

The soap hardness was determined with a texturomter LF Plus (LLYOD Instruments) fit with a 0.42 cm thick blade with a triangular cover of Warner Bratzler type. Measurements were replicated 10 times and average values were reported.

Free caustic alkali of the soap

Five grams soap was weighed and dissolved in 30 ml of a 95% ethanol solution. Few drops of phenolphthalein indicator and 10 ml of 20% $BaCl_2$ were added. The resulting solution was then titrated against 0.05 M H_2SO_4. The volume (v) of the acid obtained was multiplied by the factor 0.31 and divided by the weight of sample to obtain the percent Na_2O present which account for free caustic alkali (Adu Asante, 1993; Jolly, 1963).

Determination of the antimicrobial activity of creams and soaps

The antimicrobial properties of the soap and cream samples were determined using six clinical isolates of bacteria which were Gram-positive *(Staphylococcus aureus* MR 825), Gram-negative (*E. coli* ATCC 25922*, E. coli* O157:H7 ATCC 700728*, Salmonella typhi* R 30951401, *Klebsiella pneumoniae* ATCC 35657) and one yeast (*Candida albicans* MHMR). The antimicrobial activity of the cream was determined by the disc diffusion method on the medium gelosed Muller-Hinton (NCCLS, 2003). 100 µl of a microbial suspension (indicating stock or pathogenic) in exponential phase of growth (0.5 on the scale of McFarland, is approximately 1.5×10^6 cells/ml) was sown on sterile gelose MH. Forty microlitres of cream or soap solution (10 g of soap in 10 ml of distilled water) are deposited on each disc and a witness made up of sterile distilled water is carried out by box. After a pre-diffusion of 30 min at ambient temperature, the boxes of Petri were incubated 18 to 24 hours at 37°C. After incubation, the plates were observed for evidence of inhibition which appear as a clear zone completely devoid of growth around the well (zone of inhibition). The diameters of the wells were measured using a calibrated ruler in millimeters. The experiment was performed in duplicates and the mean of the zone of inhibition computed.

Sensory evaluation of cream and soap

The two types of creams (*P. butyracea* cream and *V. paradoxa* cream) were subjected to a sensory evaluation using a hedonic test by a panel of sixty subjects of which, thirty hairdressers and thirty ordinary cream users (93% female and 7% male).They were selected in five quarters in Cotonou city and their age ranged from 20 to 35 years. Prior to the evaluation, a pre-investigation was carried out with 15 hairdressers and 15 ordinary panellists to define the quality attributes of the cream by each category of user's that is, hairdressers and ordinary users. The hairdressers defined five quality attributes for cream. These are the colour, the aroma, the brightness, the greasiness and the ability to prevent the hair breaking. The ordinary users established six quality attributes for cream. These are: colour, aroma, greasiness, consistency, hydrating power, softness on the skin tolerance. The two types of cream samples (40 g) were coded with 3-figure random numbers and presented simultaneously to each evaluator in white box. The results were obtained one month afterwards.

A panel of thirty students aged between 20 and 30 years evaluated the soap samples using a hedonic test. The sensorial characteristics used were colour, aroma, hardness, consistency, foam ability, softness on the skin, and effect of itching and overall acceptability of the soaps. These were predefined by thirty judges who are familiar to shea soap. The two samples of soap (50 g) were coded with 3-figure random numbers and presented simultaneously to each evaluator in white box. The colour was assessed by visual inspection and the aroma was detected by smelling. The hardness was determined by finger feeling. The foam producing ability was assessed by vigorously shaking the soap in 200 ml of water for 2 to 5 min.The subjects evaluated the soap and cream for their quality attributes using a 9-point hedonic scale (Meilgaard et al., 1987) from "dislike extremely" to "like extremely".

Statistical analysis

The tests of conformity by Student's t-test were performed to compare the microbiological counts of butter and cream with the international standards. The analysis of variance (one way ANOVA) was used to compare the different parameters measured on the butter, soap and cream. Significant level was set at $p < 0.05$.

Table 1. Microbiological characteristics of *P. butyravea* and *V. paradoxa* butters and creams.

Microorganisms	**Microbiological characteristics of butters**		
(log_{10}UFC/g)	***Pentadesma***	***Shea***	***Norme**
Aerobic mesophilic bacteria	2.01±0.07[a]	2.75±0.23[b]	4.00[c]
Total coliforms	<1	<1	1,4
Faecal coliformes	<1	<1	1,4
Yeast and mould	<1	<1	1
Staphylococcus aureus	Absence	Absence	Absence
Pseudomonas aeruginosa	Absence	Absence	Absence
Germs of contamination	Bacteriological characteristics of cream		
(log_{10}UFC/g)	*Pentadesma*	*Shea*	*Norme
Aerobic mesophilic bacteria	2.05±1.03[a]	2.77±1.43[b]	3.00[b]
Total coliforms	Absence	Absence	Absence
Faecal coliformes	Absence	Absence	Absence
Yeast and mould	Absence	Absence	Absence
Staphylococus aureus	Absence	Absence	Absence
Pseudomonasaeruginosa	Absence	Absence	Absence

*RTC, 2006; NBF 01-005 2006; For each parameter (in line), mean ± standard deviation with the same letter are not significantly different ($p<0.05$).

RESULTS AND DISCUSSION

Quality of butters used for products manufacturing

The count of aerobic mesophilic bacteria is different ($p\leq0.05$) for the two types of butter; *V. paradoxa* butter containing more aerobic mesophilic bacteria than the *P. butyracea* butter (2.75 versus 2.01 log10 CFU/g) (Table 1). *P. butyracea* and *V. paradoxa* butters contents for the other microorganisms investigated (total and faecal coliforms, yeast and mould) are below detection level. No *S. aureus* and *P. aeruginosa* were detected in the two types of butters due to the non exposure of the butters to the atmospheric air. The butter of *P. butyracea* used has low level of moisture content (0.06%) compared to the *V. paradoxa* butter (2.18%). This may explain difference in the microorganisms content of the butters. The two type of butter have similar levels of pH. Clearly, the moisture content of *V. paradoxa* butter is higher than international standards (0.05-2%) for non-refined *V. paradoxa* butters (NBF 01-005, 2006) while the *P. butyracea* complies well with this norm.

The acidity and peroxide value of *P. butyracea* were 0.62% oleic acid and 2.17 meq O_2/kg respectively. The *V. paradoxa* butter exhibited rather higher values for these parameters; 5.67% oleic acid and 3.78 meq O_2/kg respectively (Table 2).This discrepancy could also be assigned to the high humidity recorded in the *V. paradoxa* butter. High moisture content can activate lipase, which can also potentially catalyze the hydrolysis of triglycerides leading to rapid deterioration of *V. paradoxa* butter (Paul et al., 1997). The values obtained in this study are lower than those found by Mégnanou et al. (2013) in shea butter, who reported that the acid index and peroxide value were 16.13 mg KOH/g and 10.30 meq O_2/kg respectively. The values of acidity obtained of *V. paradoxa* and *P. butyracea* butter in this study were also lower than that of *Demettia tripetala* fruit oil (5.34 mg KOH/g) (Nwinuka et al., 2009) and *V. paradoxa* butter 10.3 mg KOH/g (Warra et al., 2009) and palm kernel seed oil 0.834 mg KOH/g reported (Afolabi, 2008). When referring to values of acidity reported for various oils recognized as suitable for soap production, one could argue that the *P. butyracea* butter is also suitable for soap making.

The iodine index, unsaponifiable matter and saponification value of *V. paradoxa* butter were 42.06 mg I_2/100 g, 6.37% and 187.99 mg KOH/g, respectively. In the same way, the iodine index, unsaponifiable matter and saponification value of *P. butyracea* butter were 39.15 mg I_2/100 g, 1.70% and 192.15 mg KOH/g respectively. The iodine index and unsaponifiable matter of *P. butyracea* butter were lower than those of *V. paradoxa* butter (Table 2). However, still the unsaponifiable matter of the *P. butyracea* butter remains higher than those reported for other valuable solid fats in food and cosmetic sectors such as coconut kernel (0.2 - 0.4%), palm kernel (0.3 - 0.5%) and cocoa (0.5 - 1%). Moreover, cosmetic and pharmaceutic industries for instance, exploit *V. paradoxa* butter for its unsapnifiable compounds such as kariten, terpenic alcohols and phytosterols which are able to protect from UV rays and would confer youngness to the skin (Hall et al., 1996). In the same way, the *P. butyracea* butter is rich in terpenic alcohols and phytosterols (Tchobo et al., 2007, 2009); therefore it can use in cosmetic industries. The iodine

Table 2. Physicochemical characteristics of the butters of *P. butyracea* and *V. paradoxa.*

Parameter	Characteristics of butters		*Cosmetic
	Pentadesma	***Shea***	**Use**
pH	7.05±0.05[a]	6.87±0.07[a]	-
Moisture content (%)	0.06±0.00[a]	2.18±1.34[b]	≤0.05
Acidity (% acide oléique)	0.62±3.22[a]	5.67 ±2.70[b]	≤1
Peroxide value (meq O_2/kg)	2.17 ± 0.06[a]	3.78 ± 0.55[b]	≤10
Iodine value (mg I_2/100 g)	39.15±3.05[a]	42.06±0.14[b]	30-70
unsaponifiable fraction (%)	1.70±0.04[a]	6.37±0.72[b]	1-19
Saponification index (mg KOH/g)	192.15±1.54[b]	187.99±3.62[a]	160 -195

*RTC, 2006; NBF 01-005 2006; for each parameter (in line), mean ± standard deviation with the same letter are not significantly different (p<0.05). Measurements were performed in triplicate.

Table 3. Physicochemical characteristics of creams.

Parameter	***Pentadesma***	Shea	*Norme
Moisture content (%)	81.75±0.07[a]	83.24±0.23[b]	
Temperature (°C)	24.4±0.28[a]	24.05±0.07[a]	≤25
pH	4.43±0.03[a]	4.45±0.00[a]	4.0- 8.5
Density (g/ml)	1.01±0.01[a]	1.02±0.00[a]	0.8- 1.2
Viscosity (Cp)	6378±15.55[b]	5609.5±49.85[a]	6000- 20000

*NB 09.01.001, 2006; for each parameter (in line), mean ± standard deviation with the same letter are not significantly different (p<0.05).

values *P. butyracea* and *V. paradoxa* butters are relatively comparable to that of Avocado seed oil which is used in soap making (Sani and Hassan, 2007). These iodine values were less than 100 which is an oil useful value in the production of soap (Asuquo, 2008). The saponification value of *P. butyracea* butter is higher than that of *V. paradoxa* butter. High saponification indicates suitability of butter for soap production. The saponification values obtained for the *P. butyracea* butter is higher than that of olive oil (192.0), sunflower oil (188.7) and beeswax (93.0) which are commonly used in soap making (Mabrouk, 2005).

Quality characteristics of the *P. butyracea* cream

Microbial and antimicrobial characteristics of cream

There is a significant difference in the aerobic mesophilic bacteria counts of the two types of creams (p≤0.05). The highest aerobic mesophilic bacteria count was found in the *V. paradoxa* cream sample (2.77 vs 2.05 log10 CFU/g) (Table 1). Moreover, the creams are free of yeasts and moulds, coliforms, *S. aureus* and *P. aeruginosa*. These results are in agreement with the microbiological data obtained in the butter samples. However, the values of aerobic mesophilic bacteria counts recorded in the creams are in agreement with the Benin standard for cosmetics products which are 3.0 log10 CFU/g (NB 09.01.001, 2006). Significant difference was observed on the antimicrobial activity for two types of cream (p≤0.001) (Table 4). *P. butyracea* cream showed the highest diameter of inhibition zone against different microorganisms. Among the microorganisms tested, *Candida albicans* and *Salmonella typhi* are more sensitive to the effect of the creams.

Physicochemical characteristics of cream

The temperature, pH and density of the *P. butyracea* are similar to that of shea cream and are 24.40°C, 4.43 and 1.01 g/ml, respectively (Table 3). The level of the cream pH is suitable for skin application which is between 4.5 and 5.5 (Giacomoni et al., 2009).The incorporation organic substances such as tefose, citric acid and cethilic alcohol in the *P. butyracea* and *V. paradoxa* butters during the preparation of the creams has contributed to the decrease in their pH values. The specific density of *P. butyracea* is relatively and this is a preferred characteristic for cosmetic production (Afolabi, 2008). The specific density, the temperature and the pH of the *P. butyracea* cream are close to the Benin standards for cosmetics products (NB 09.01.001, 2006). Moreover the *P. butyracea* cream exhibited the highest viscosity (p≤0.05) probably because of its high level of saturated

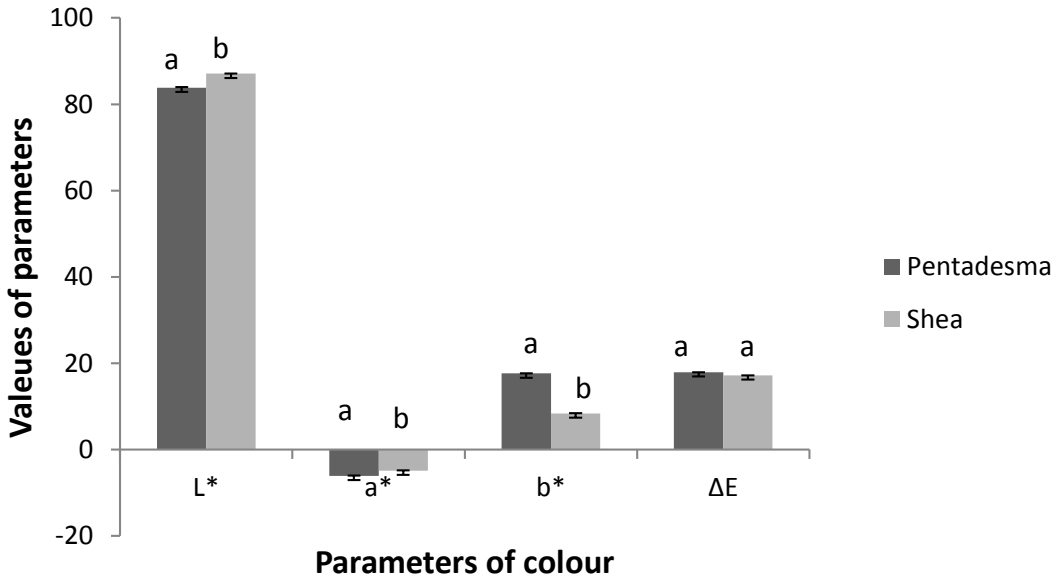

Figure 1. Colour characteristics of *P. butyracea* and shea creams.

fatty acid. Granger et al. (2005b) reported that creams rich in saturated fatty acids, showed a greater apparent viscosity.

The colour characteristics of the *P. butyracea* cream in comparison to *V. paradoxa* cream are presented in Figure 1. The *P. butyracea* cream have an attractive yellow colour which is a distinctive advantage compared to the *V. paradoxa* cream which is whitish. It is most likely that phytochemical pigments such as carotenoids are responsible for this yellow colour of the *P. butyracea* products. In the cosmetic markets, there is an increasing demand of consumers to yellow colour. These results are in agreement with the observation of the sensory panel.

Sensory properties of the P. butyracea cream

The results of the sensory evaluation of the *P. butyracea* cream are presented in Figure 2. The evaluators were 30 ordinary cream users and 30 hairdressers. The *V. paradoxa* cream was used for comparison. There is high preference to the *P. butyracea* cream by the users. Particularly, the ordinary users ranked the *P. butyracea* cream first for important quality criteria such as consistency, brightness, greasiness, hydrating power, softness on the skin, colour and aroma. There is a great preference of users for the aroma of *P. butyracea* cream. The overall acceptability of the creams is largely in favour of the *P. butyracea* cream.

Interestingly, the hairdressers reported that the *P. butyracea* cream was able to prevent the break and fall of the hair. Honfo et al. (2012) indicated that yellow coloured *V. paradoxa* butter (by adjunction of colorants) is much more preferred by 61% of consumers in Benin.

Qualities characteristics of the *P. butyracea* soap

The antimicrobial properties of soap

Inhibition zone diameters (mm) produced by *P. butyracea* soap and *V. paradoxa* soap samples on *the* various microorganisms tested were similar except for *E. coli* O157 on which significant ($p \leq 0.05$) larger inhibition zone diameter was recorded for the *Pentadesma* soap (Table 4). In general, *Candida albicans* and *Salmonella typhi* were the most sensitive to inhibitory activity of *P. butyracea* soap.

Physicochemical characteristics of soap

The *P. butyracea* soap retains less moisture compared to *V. paradoxa* soap ($p \leq 0.05$) (Table 5). In cosmetic products like soap, excess water is responsible for the phenomenon called hydrolysis of soap on storage (Tewari, 2004). In such product, the excess water could react with any unsaponified neutral fat to give free fatty acid and glycerol. The moisture content of the soap samples is close to the Benin standard for soap (NB 09.05.001, 2002) and is also in agreement with the recommended moisture level (10-15%) for soap by the encylopedia of industrial chemical analysis (2007). In product with such level of moisture content, the rancidity phenomenon is minimized.

The *P. butyracea* soap samples are harder than *V. paradoxa* soap ($p \leq 0.001$) (Table 5). Unsaturated triglycerides e.g. triolein, trilinolin and trilinole are liquid at ordinary temperature. Hence, fats containing such components in considerable proportions are oils and

Table 4. Diameter of zones of inhibition (mm) produced by cream and soap of *P. butyracea* and *V. paradoxa* on various pathogenic microorganisms assessed by the disc diffusion method.

Pathogen	Creams		Soaps		Control
	Pentadesma	***Shea***	***Pentadesma***	***Shea***	**Distilled water**
Candida albicans	12.50±0.35^{b}	7.50±0.07^{a}	18.25±0.07^{a}	18.50±0.07^{a}	0.00±0.00
Salmonella typhi	11.50±0.07^{b}	7.50±0.07^{a}	19.50±0.03^{a}	19.25±0.10^{a}	0.00±0.00
E. coli ATCC 25922	7.50±0.07^{b}	5.25±0.03^{a}	16.00±0.00^{a}	16.50±0.07^{a}	0.00±0.00
Staphylococcus aureus	9.50±0.07^{b}	6.00±0.00^{a}	16.50±0.07^{a}	16.25±0.17^{a}	0.00±0.00
E. coli O157: H7	8.75±0.23^{b}	7.88±0.05^{a}	17.20±0.17^{b}	16.50±0.07^{a}	0.00±0.00
Klebsiella pneumoniae	9.85±0.02^{b}	8.87±0.25^{a}	16.50±0.07^{a}	16.00±0.00^{a}	0.00±0.00

For each parameter (in line), mean ± standard deviation with the same letter are not significantly different ($p<0.05$) for each product.

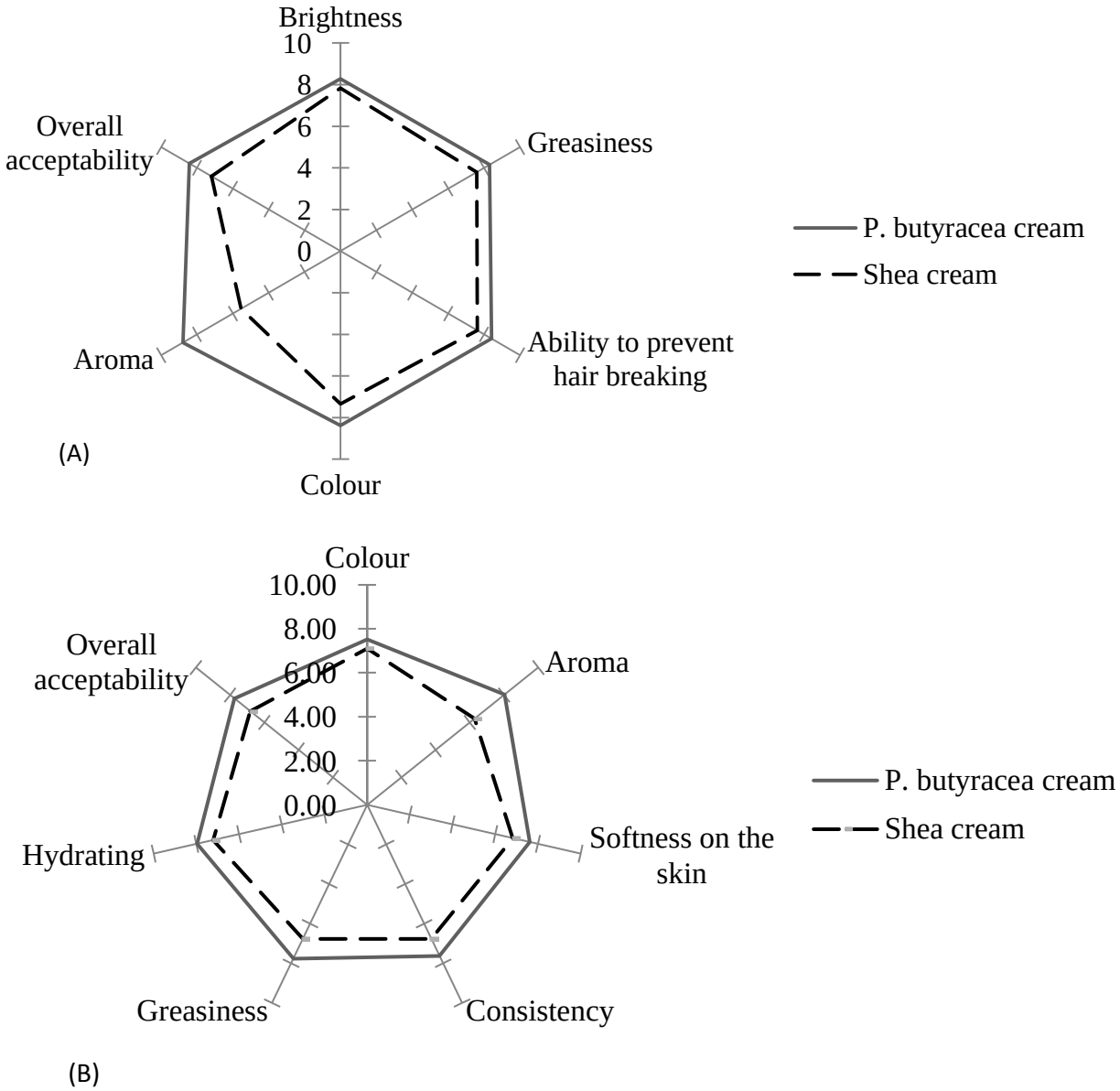

Figure 2. (a) Mean of panel (hairdressers) scores for sensory attributes of the *P. butyracea* and shea cream. (b) Mean of panel (ordinary panellists) scores for sensory attributes of the *P. butyracea* and shea cream.

Table 5. Physicochemical characterization of the soap.

Parameter	Characteristics of soap		
	Pentadesma	***Shea***	***Norme**
Moisture content (%)	9.39±1.07[a]	12.26±0.43[b]	≤14 (a) ≤ 25 (b) ≤20 © ≤ 75 (a)
Total fatty acid (%)	71.10±1.23[a]	71.07±1.03[a]	≤ 60 (b) ≤ 70(c) ≤ 0.15 (a)
Alkalinity (%)	0.13±1.34[a]	0.21±1.47[b]	≤ 0.30 (b) ≤ 0.20(c)
pH	8.74±0.23[a]	8.61±1.07[a]	09-10
Hardness (N)	11.45±1.65[b]	8.30±2.34[a]	-

*NB 09.05.001, 2002; For each parameter (in line), mean ± standard deviation with the same letter are not significantly different ($p<0.05$); (a): toilet soap;(b):Soap of household; (c): standard Soap Marseilles

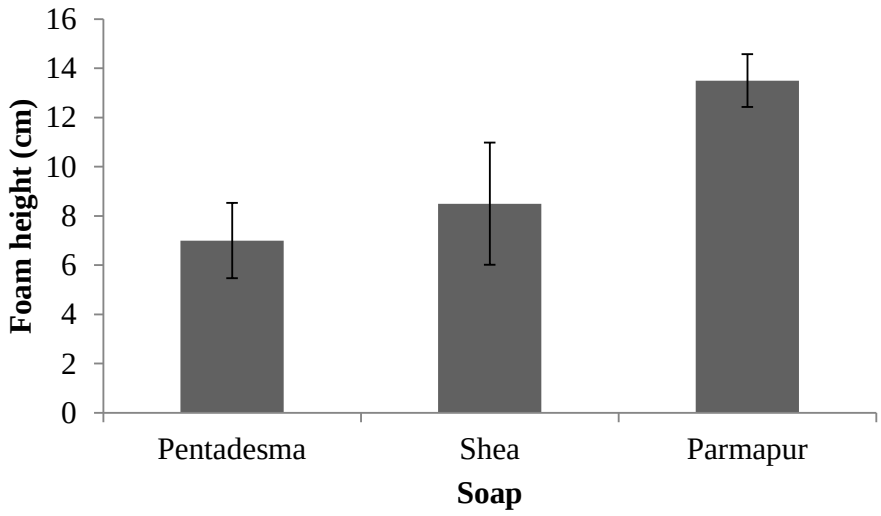

Figure 3. Foam height of soaps prepared.

those containing them in smaller quantities are soft solids (Schuman and Siekman, 2005). Tchobo et al. (2007, 2009) already reported that the *P. butyracea* butter contains a low level of triolein (3%) and that the *P. butyracea* butter is composed principally of triglycerides containing an oleic acid moiety at the 2-position and saturated fatty acids, usually stearic or palmitic acids, at the 1- and 3-positions. Results are in close agreement with the data recorded during the sensory evaluation of the soap.

Free caustic alkali of the *P. butyracea* soap (0.13%) is lower ($p\leq 0.05$) than that of the *V. paradoxa* soap (0.21%) (Table 5). This value is in agreement with the Benin standard for soap (NB 09.05.001 2002) as well as with the norm by the encyclopaedia of industrial chemical analysis (2007). The recommended values by these norms are 0.25% for laundry soap and 0.2% for toilet soap. The *P. butyracea* soap showed relatively low level of free alkali since the *P. butyracea* butter used is highly saponified. The soap pH is 8.74 which is close to the Benin standard for soap (NB 09.05.001, 2002). Indeed, soap with high level of free alkaline (PH 11 -14) can cause damage to skin. Thus, the pH of all soap samples fell within the recommended range for bathing soap of 9 - 11 (Mak-Mensah and Firempong, 2011). Total fatty acids of *P. butyracea* soap are comparable to that of *V. paradoxa* soap and averaged to 71.10% (Table 2).This value indicates that such a soap would be most suitable for bathing rather than for laundry. The foam producing capacity of the *P. butyracea* soap is lower that of *V. paradoxa* soap (Figure 3). This result is in agreement with the data recorded during the sensory evaluation of

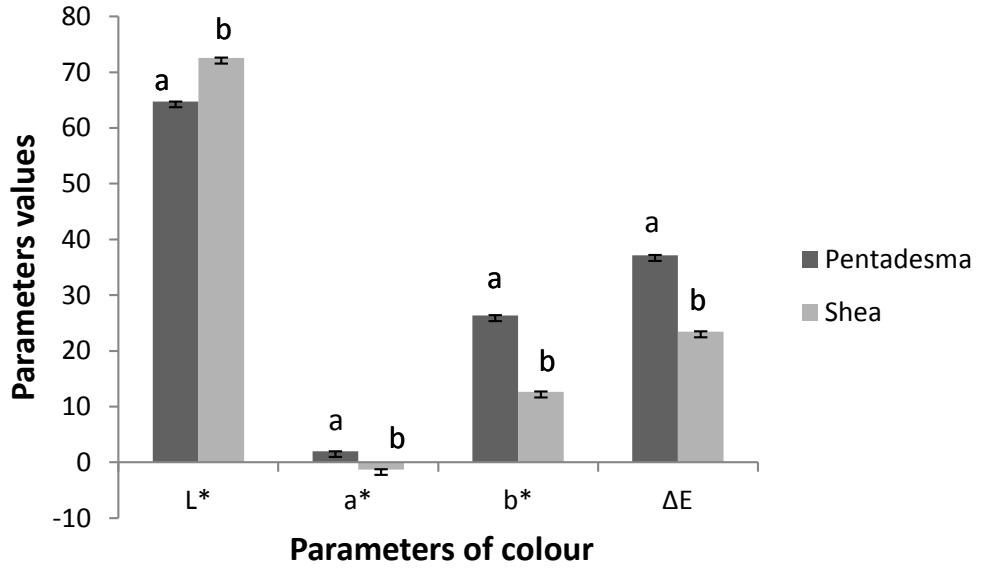

Figure 4. Colour characteristics of soap of *P. butyracea* and shea.

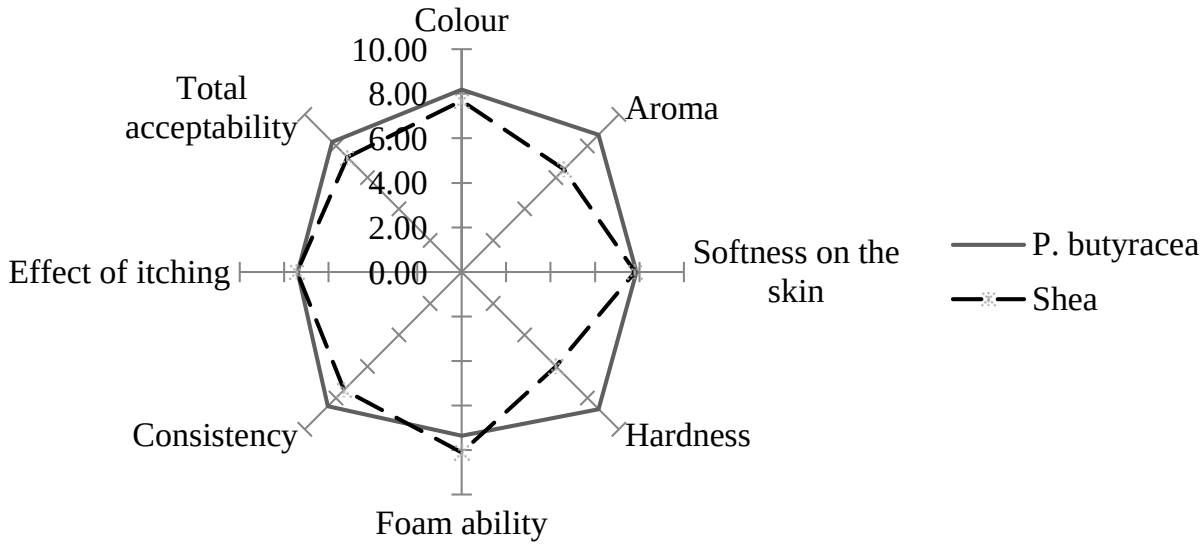

Figure 5. Hedonic score of the *P. butyracea* and shea soap.

the soap. The commercial pharmapur soap, used as control, produced higher quantity of foam compared the *P. butyracea* and *V. paradoxa* soaps. High level of unsaponifiable fraction in the *V. paradoxa* soap could be reason for this difference in the foam producing capacity of the two types of soaps studied. The soap of *P. butyracea* is distinctively yellow, certainly because of the presence of carotenoids pigments which are capable to confer a high resistance to oxidation. This could represent an advantage on the cosmetic market (Table 3).

Sensory properties of P. butyracea soap

A panel of 30 users evaluated the *P. butyracea* soap in comparison to *V. paradoxa* soap (Figure 5). The panellists found no significant difference between both soaps in terms of softness on the skin and effect of itching. Both soap samples showed good for the softness on the skin and effect of itching accordingly. Softness on the skin of both soap samples is certainly due to their relatively high oleic acid contents (Ayegnon et al., 2015; Honfo et al., 2013; Tchobo et al., 2013). Users attributed high

preference score for the colour and aroma of *Pentadesma* soap (p≤ 0.001). In addition, the soap of *P. butyracea* butter is harder than the *V. paradoxa* soap (p≤ 0.001). Panellists also clearly identified the *V. paradoxa* soap for its high foam producing capacity compared to the *P. butyracea* soap. The overall acceptability score is high for the *P. butyracea* soap.

Conclusion

The study has shown that *P. butyracea* seeds are high yielding oilseeds and serve as a commercially rich source of vegetable butter. The butter has the qualities suitable for the production of soaps, cream, confectionaries and margarine. Therefore the butter of *P. butyracea* can be successfully used in the cosmetic sector to produce various products. More importantly, such products from the butter of *P. butyracea* exhibited superior quality characteristics in comparison to products made with *V. paradoxa* butter. Products from *P. butyracea* have a yellow attractive colour and consistent texture with a pleasant aroma. Interestingly, users corroborated this quality superiority by ranking the cosmetics products from *P. butyracea* butter as higher than equivalent products from *V. paradoxa* butter. The cosmetic and soap making industries can use *P. butyracea* butter to formulate cosmetics, soaps, shampoos, creams and balsams for hair and other skin cleansing and rejuvenating products.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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