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Impact of Different Extraction Processes on the Quality of Shea Butter (*Vitellaria paradoxa*) Produced by Women in the Northern Regions of Côte d'Ivoire

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The objective of this study is to evaluate the influence of different extraction processes on the quality of butter produced in each region.
Study Design: The production of shea butter (*Vitellaria paradoxa*) is an activity widely practiced in the North of Côte d'Ivoire using different processes, specific to each region. This leads to the great

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variability of butters on the market, calling into question the control of the quality of butter and limiting its valorization in the food and even technological fields.

Place and Duration of Study: Laboratory of Food Biochemistry and Tropical Products Technology, between June 2021 and July 2022.

Methodology: To do this, the physical and chemical properties of butter from four (4) regions of northern Côte d'Ivoire (Poro, Bagoué, Tchologo and Hambol) were studied to judge their qualities. These different butters were then subjected to an organoleptic test in order to evaluate their levels of acceptability by a panel trained for this purpose.

Results: The results obtained reflect a significant influence of all the processes on the physical and chemical properties of the butter, particularly on the quality criteria. We observe a high level of oxidation between 10.347±0.01 meq/kg (Poro) and 10.430±0.011 meq/kg (Bagoué), an accentuated acidity where the acid number varied from 10.763±0.01 mg/g (Tchologo) to 11.373±0.01 mg/g (Bagoué), leading to high free fatty acid contents of 5.986±0.02% (Bagoué), 5.891±0.01% (Poro), 5.771±0.010% (Hambol) and 5.665±0.010 (Tchologo) and an impurity phase to monitor ranging from 0.168±0.002 to 0.192±0.001. These impurity indices mostly show non-compliance for direct consumption (category I butter). However, some conformities are recorded when butters are downgraded to category II intended for the food industry with vigilance on these said conformities. Finally, the organoleptic analysis revealed a strong correlation of the general appreciation of butters with the taste but also texture and color which were influenced by the processes.

Conclusion: This study highlighted the impact of all the extraction processes on the shea butter produced in Côte d'Ivoire, particularly on the peroxide indices and free fatty acids; confirmed by sensory testing.

Keywords: Extraction processes; shea butter (Vitellaria paradoxa); quality; physicochemical properties; organoleptic test.

1. INTRODUCTION

The production of shea butter is an activity known and practised in Africa for many years [1]. This butter made from shea kernels (*Vitellaria paradoxa*) plays a very important socio-economic and dietary role for all populations in 16 countries in sub-Saharan Africa [2]. It has properties that are highly appreciated in the food (oil making, chocolate making), cosmetics (skin hydration, UV protection, etc.) and pharmaceutical (wound healing, etc.) industries [3,4,5]. All its benefits make it a popular product whose demand is growing strongly in international markets [6]. In Côte d'Ivoire, shea butter is prepared in an artisanal manner in the North and then transported to other regions for marketing [7]. Preparation processes vary from one region to another and within the same region, from one ethnic group to another. This leads to a wide variety of shea butter on the markets [8,9,10,11]. This environment varying in processes between regions leads to a questioning of the control of the quality of this butter which could not escape criticism from consumers and manufacturers according to the work of Megnanou and Diopoh [12]. This raises the question of the impact of different production processes on the quality of shea butter (*Vitellaria paradoxa*). Therefore, the general objective of this study is to evaluate the influence of different production processes on the quality of shea butter (*Vitellaria paradoxa*) produced in the north of Côte d'Ivoire. Specifically, this will involve studying the physical and chemical properties responsible for the quality of butter from four regions in the North of the country produced using different processes; before submitting them to an organoleptic test to judge their acceptability levels.

2. MATERIALS AND METHODS

2.1 Materials

The plant material used during this work is shea butter (*Vitellaria paradoxa*). The samples used come from the different study areas.

2.2 Methods

2.2.1 Sampling method

The different shea butter samples in this study were taken directly from producers in the different localities surveyed. Indeed, during the investigation phase, four (4) regions were visited at the rate of three (3) localities per region. Also, in each locality, a quantity of three (3) kilograms of shea butter was collected and put in sealed and labelled opaque containers. Then these

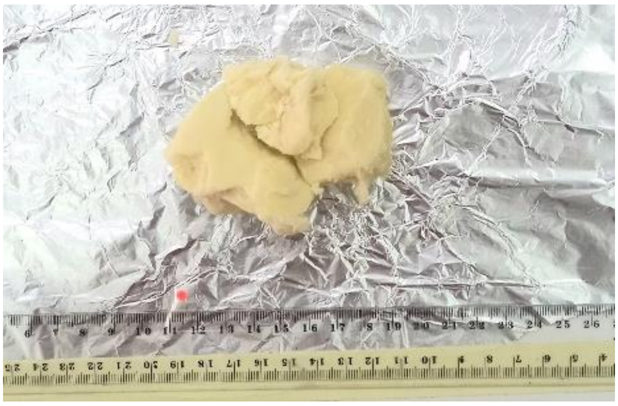

Fig. 1. Photograph of shea butter

different quantities were grouped by region in boxes and formed into batches: four (4) batches for the four regions. A total of thirty-six (36) kilograms of shea butter in batches of nine (9) kilograms were purchased and then sent to the Laboratory of Food Biochemistry and Tropical Products Technology (LBATPT) and stored at room temperature at the protected from light for subsequent analyses.

2.2.2 Analysis methods

2.2.2.1 Physical and chemical properties of shea butter (Vitellaria paradoxa)

Moisture and dry matter: The determination of humidity and dry matter was carried out according to the AOAC method [13]. Ten (10) g of each sample contained in the crucible were then placed in a BIOBASE brand oven (Shandong, China) at 105°C until constant mass.

Density: The method used to determine the density of butter was that described by IUPAC [14]. It consisted of measuring the mass, at a given temperature, of a volume of fatty substances contained in a pycnometer previously calibrated at the same temperature. After weighing the empty pycnometer with a capacity of 24.87 mL, it will be filled with distilled water. The pycnometer will then be emptied and dried in an oven. It was then filled with butter and subjected to the same operating conditions as described for distilled water.

Refractive index: The refractive index was measured using a refractometer (RFM 81, Multisecale Automatic Refractometer).

Acid index: The acid number of the shea butter samples was determined according to AOAC [15]. The method consists of titrating with a solution of alcoholic potash, the acidity of the fat initially dissolved in a mixture of solvents in equal parts. Two (2) g of shea butter (*Vitellaria paradoxa*) will be dissolved in ten (10) mL of an ethane-diethyl ether mixture in respective proportions 1:1 (v/v). The mixture was then titrated in the presence of three (3) drops of phenolphthalein with a 0.5 N alcoholic potassium hydroxide solution contained in a burette until it turned pink. A blank test was carried out under the same conditions. The tests will be carried out in triplicate for each sample of shea butter.

Acidity: Acidity, determined according to the AOAC method [15], is the percentage of free fatty acids conventionally expressed according to the nature of the fatty substance, in oleic acid of molecular weight 282, in palmitic acid of molecular weight 256 or lauric acid of molecular weight 200. The acidity was determined according to the ratio of the acid number (Ia) to the constant 1.9.

Saponification index: The saponification index was determined according to the AOAC method [15]. The method consists of treating the fat with an excess of hot alcoholic potash solution and then titrating the excess alcoholic potash with a hydrochloric acid solution.

Unsaponifiable: The determination of the content of unsaponifiable materials was carried out according to the AFNOR NF T 60-205 standard described by Lozano et al. [16]. The flasks used for the determination of the saponifiables were rinsed several times with 25 mL of hexane. The rinsing liquid has been transferred into this ampoule. The ampoule was capped, and then shaken vigorously for one minute while equalizing the pressure. After one minute, it was left to rest in order to promote the complete separation of the two phases. The hydroalcoholic soap phase was collected in a separatory funnel designated B. The extraction of the soap phase was repeated twice with 25 mL.

Iodine and peroxide index: The iodine and peroxide index of shea butter (*Vitellaria paradoxa*) were determined according to the AOAC method [15] using the WIJS reagent and chloroform respectively.

Impurity content: The content of insoluble impurities was determined by the method described by Benbada [17]. The principle consists of treating a test portion with an excess of hexane or petroleum ether then filtering the solution obtained.

2.2.2.2 Organoleptic properties

Sensory profile: This method was used in order to give a sensory identity to the different shea butter samples. The samples were prepared and tested by a jury of around fifteen people, all students from Nangui Abrogoua University, Abidjan (CI). The tasters were trained in the descriptive and quantitative analysis methods [18].

The sensory evaluation of each product took place in two phases during which the experts evaluated each product according to the organoleptic criteria previously defined on a linear interval scale between zero (low intensity) and ten (high intensity).

Hedonic test: The acceptability of shea butters was determined by hedonic tests. The tests took place in two sessions for each of the shea butter with around fifty untrained people and consumers of shea butter. The different shea butters were presented in identical containers, coded with random three-digit numbers. The acceptability of each sample was tested using a nine-point hedonic scale [19]. Numerical values were assigned to the different categories (1-9) of the scale, assigning 1 for extremely unpleasant and 9 for extremely pleasant. Five attributes were evaluated, namely: color, aroma, taste, texture and general acceptability.

2.3 Statistical Analyzes

Statistical analysis of the data was carried out using STATISTICA software (version 7.1). The results obtained were expressed as mean ± standard deviation. Significant differences were highlighted by a one-way analysis of variance (ANOVA) followed by the Duncan test. Pearson correlation for the identification of discriminating parameters was carried out. These differences were considered significant at the 5% threshold.

3. RESULTS AND DISCUSSION

3.1 Physico-chemical Properties

Moisture, melting point and density of different butters: The results for humidity, melting point and density are presented (Table 1). These results vary significantly from one region to another at $p < 0.05$. The humidity values of the Bagoué and Hambol regions are identical, i.e. 0.059±0.003%, while those of Poro and Tchologo are respectively 0.099±0.005% and 0.179±0.07%.

Water content is an important quality criterion linked to bacterial and fungal growth in butters. The water contents of our different shea butters varied between 0.059±0.003 (the minimum in Bagoué and Hambol) and 0.179±0.07% (the maximum in Tchologo). These values are consistent with the range of 0.05 to 0.2% recommended by the Codex Alimentarius standard for unbranched shea butter. However, the risk of non-compliance is very real for shea butter produced in the Tchologo region given its water content which is very close to the maximum recommended limit. The type of drying (in an artisanal oven in Bagoué) or even the double drying of the shea seeds (in Hambol) would have had the effect of significantly lowering their water content and therefore influencing the final product.

As for the melting point which is a characteristic property of solid crystalline substances. It varies slightly of the order of 0.5 with values of 33.4±0.020 in Bagoué, 33.6±0.010 in Hambol, 33.103±0.025 in Poro and 33.5±0.010 in Tchologo. The results showed slight variations in melting points reflecting the level of purity of butters produced in the north of the country. Indeed, the presence of impurities would have had the effect of varying the melting point of the substance analyzed here of the different shea butters. However, the different extraction processes had the effect of lowering the temperature of transition from the solid state to the liquid state in comparison with the recommendation of the regional Codex Alimentarius standard which recommends a

Table 1. Physical composition of shea butter (*Vitellaria paradoxa*) from different extraction processes in the northern regions of Côte d'Ivoire

	Bagoué	Hambol	Poro	Tchologo
Humidity (%)	**0.059±0.003[a]**	**0.059±0.002[a]**	**0.099±0.005[b]**	**0.179±0.07[c]**
Fusion point	33.4±0.020[b]	33.6±0.010[d]	33.103±0.025[a]	33.5±0.010[c]
Density	0.852±0.001[a]	0.925±0.001[d]	0.895±0.001[b]	0.897±0.001[c]

Trials: n = 3; the means ± standard deviations, assigned different letters on the same line, are significantly different at p < 0.05 according to the Duncan test.

melting point of between 35 and 40°C for shea butter for food use.

Concerning the densities, they are relatively high with values of 0.852±0.001; 0.925±0.001; 0.895±0.001 and 0.897±0.001 respectively in Bagoué, Hambol, Poro and Tchologo. Density is a parameter that depends on temperature. This parameter was measured at a temperature of 20°C. The relative density of shea butter is between 0.852±0.001 and 0.925±0.001. The highest density is observed in the Hambol region. It is also the only one of the four regions which is in compliance with the regional standard of the Codex Alimentarius which recorded densities in a range of 0.91 to 0.98 at 20 °C for unrefined shea butter from category II intended for the food industry.

Index: Table 2 describes the evolution of the index of the different samples of shea butter produced in the North of Côte d'Ivoire. There is a significant difference between index values across regions at $p < 0.05$.

The refractive index varies slightly (of the order of 0.31) from one region to another where they are on average 1.477±0.000 in Bagoué, 1.466±0.001 in Hambol, 1.487±0.000 in Poro and 1.456±0.001 in the Tchologo. The refractive index is an important optical property for oils. The refractive index is used as an indicator of the purity and quality of an oil. Variations in refractive indices can indicate the presence of impurities, additives or contaminants in the oil. The refractive indices of this study vary slightly with the highest value observed in the Poro region (1.487±0.000) and the lowest value (1.456±0.001) in the Tchologo region. These refractive index values are relatively high, reflecting a non-compliance with the recommendations of the regional Codex Alimentarius standard which recommends a range of 1.462 to 1.465 outside of butter from the Tchologo region.

The acid index varies from 10.763±0.01 mg/g (Tchologo) to 11.373±0.01 mg/g (Bagoué), leading to high free fatty acid (FFA) contents of 5.986±0. 02% (Bagoué), 5.891±0.01% (Poro), 5.771±0.010% (Hambol) and 5.665±0.010 (Tchologo). Acid index is often used in industry to measure the amount of free fatty acids in fats and oils. This characteristic accounts for the state of degradation of butter to the extent that free fatty acids are degradation products and more particularly the hydrolysis of triglycerides, the majority constituents of the oil [20]. It is used to assess the quality of food products or to determine the free fatty acid content of a chemical. The acid index values vary between 10.763±0.01 and 11.373±0.01 (mg/g) with the lowest value observed in Poro while the highest observed in Bagoué. The relatively high acid numbers would be due to the time and temperature of butter extraction as well as the drying of the almonds. Indeed, these two parameters according to Womeni et al. [11], are at the origin of the release of fatty acids responsible for acidity. However, the acid indices remain in the same order as those observed by Megnanou and Diopoh [12] on shea butter sold in Ivorian markets.

In addition, the direct consequence resulting from these acid indices, namely the free fatty acid contents, display high values, between 5.771±0.01 and 5.986±0.02%. These high values of free fatty acid contents in shea butter reflect the negative influence of all the extraction processes on the quality of the butters with regard to the non-compliance with the regional standard of the Codex Alimentarius which recommends a minimum limit of 1.1% to 3% for the maximum. Indeed, direct drying of shea kernels in the sun is a slow technique, subject to climatic conditions leading to high risks of pollution and oxidation. It is nevertheless favourable to the action of lipases, thus leading to an increase in free fatty acids in butter according to Kpegba *et al*. [21]. The disadvantage of free fatty acids is that they oxidize more quickly than triglycerides and also have an unpleasant taste.

The saponification indices are relatively high with values of 180.360±0.021 mg/g (Bagoué), 185.330±0.030 mg/g (Hambol), 185.441±0.018 mg/g (Poro) and 182.120±0.015 mg/g (Tchologo). The contents of unsaponifiables and insoluble impurities are relatively low and range respectively from 2.060±0.010% in Bagoué to 2.450±0.010% in Hambol and from 0.168±0.002% in Tchologo to 0.192±0.001% in Bagoué.

The saponification index, it measures the average molecular weight of the fatty acid chains present in an oil. This parameter is inversely proportional to the molecular weight of fatty acids [22]. The values of the saponification indices between 180.360±0.021 to 185.441±0.018 mgKOH/g fat obtained are lower than those obtained by Megnanou and Diopoh [12] on shea butter sold on Ivorian markets. However, they remain in the range of 160 to 195 mgKOH/g fat defined for unrefined shea butter [23]. These high saponification indices are due to the relatively low molecular weight of the fatty acids in our shea butter. Indeed, according to Kumar and Krishna [24], the saponification index is directly proportional to the number of short and medium-chain fatty acids attached to the glycerol. Such saponification indices would be of great use in the cosmetics industry where it would find use in the manufacture of soap having beneficial effects on the skin and hair.

Concerning the percentages of impurities, these oils are subjected to oxidation, the oils lose their nutritional values by the appearance of several harmful oxidation products represented by these impurities [25]. These impurity values are higher than those of unbranched shea butter intended for direct consumption, the maximum limit of which is 0.09%. However, they remain in compliance with the recommendations of the regional Codex Alimentarius standard, the minimum of which is 0.1 to 0.2%. All these parameters are the basis of these butters, products not recommended for direct consumption but recommended in the food industry.

The iodine index is between 6.180±0.001 g/100g (Poro) and 6.750±0.010 g/100g (Bagoué). The Hambol displays 6.250±0.001 g/100g and the Tchologo 6.551±0.017 g/100g. The iodine value is a measure of the amount of fatty acid unsaturation in a substance. The higher the amount of unsaturation, the higher the iodine value. The iodine index is important to the food industry because it can be used to determine the quality and stability of oils and fats. The iodine indices of butter from different regions are low (6.18±0.01 to 6.75±0.01 g/100g). This reflects a predominance of saturated fatty acids in butters and therefore a high stability of these butters. This is especially true as this butter has a long shelf life of up to two years in most cases. However, this slight difference in the index from one region to another can have a significant influence in terms of the organoleptic quality of foods prepared with Bagoué butter compared to that of Poro or even shelf life. Ultimately, these different butters with low iodine values could be easily used for cooking and frying.

The results showed small variations in peroxide indices where the minimum is 10.347±0.01 meq/kg in the Poro region and the maximum is 10.430±0.011 meq/kg in Bagoué; passing through the Tchologo with a value of 10.391±0.017 meq/kg) and the Hambol for 10.401±0.011 meq/kg. Peroxide index, it is a quality criterion which makes it possible to evaluate the oxidation state of oils and to control the first stages of oxidative alteration [26]. The peroxide indices of butter are significantly different at the 5% threshold and vary from 10.399±0.01 meq/kg (Poro) to 10.456±0.015 meq/kg (Bagoué). They comply with the recommendations of the regional standard of the Codex Alimentarius whose minimum range is 11 meq/Kg and 15 meq/Kg for the maximum for category II butter reserved for the food industry but higher than the maximum limit of 10 meq/Kg for Category I butter intended for direct consumption. These relatively high peroxide index values indicate an acceptable level of oxidation in the different butters and therefore a low influence of the different extraction processes on the quality of our butters obtained just after extraction. Indeed, the high temperatures during heating combined with the contact of the oil with air and light are the cause of extensive oxidation called peroxidation [27].

3.2 Organoleptic Properties

Descriptive test: The results of the descriptive test are shown in the radar figure (Fig. 2). The intensity levels of the different selected attributes are relatively low and are between 0.8 and 6.3 on a scale of 0 to 9. The lowest intensity is obtained with the whitish color while the maximum intensity (6 ,3) is obtained with compact texture in the Poro region. In terms of color attribute, Hambol butter displays the greatest intensity of

Table 2. Evolution of the index values of shea butter (*Vitellaria paradoxa*) from different extraction processes in the northern regions of Côte d'Ivoire

	Bagoué	Hambol	Poro	Tchologo
Refractive index	1.477±0.000c	1.466±0.001b	1.487±0.000d	1.456±0.001a
Acid index (mg/g)	11.373±0.01d	10.964±0.02b	11.193±0.01c	10.763±0.10a
Acidity (%)	5.986±0.01d	5.771±0.01b	5.891±0.010c	5.665±0.010a
Saponification index (mg/g)	180.360±0.021a	185.330±0.030c	185.441±0.018d	182.120±0.015b
Unsaponifiable (%)	2.060±0.010a	2.450±0.010c	2.095±0.001a	2.260±0.058b
Iodine index (g/100g)	6.750±0.010d	6.250±0.001b	6.180±0.001a	6.551±0.017c
Peroxide index (meq/kg)	10.430±0.011d	10.401±0.01c	10.347±0.01a	10.391±0.011b
Insoluble impurities (%)	0.192±0.001d	0.173±0.002b	0.182±0.001c	0.168±0.002a

Trials: n = 3; the means ± standard deviations, assigned different letters on the same line, are significantly different at p < 0.05 according to the Duncan test

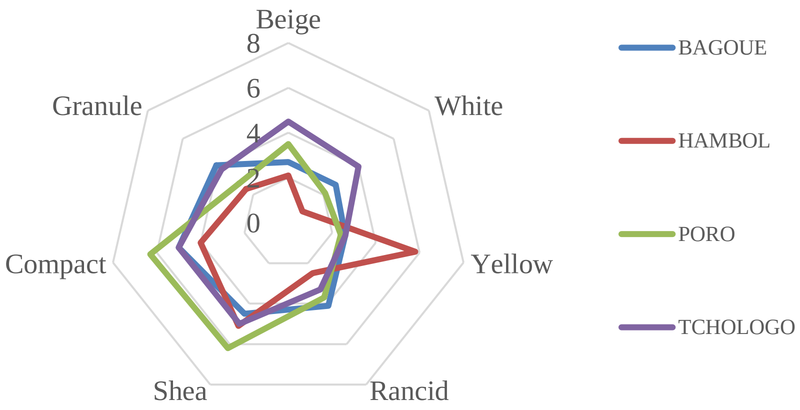

Fig. 2. Sensory profile of different shea butters

yellow color (5.8). The other regions are weakly yellow with yellow intensities close to 2.5. Tchologo shea butter is more white and beige in color with respective intensities of 4 and 4.5. That of Poro is closer to Beige (3.5) than yellow (2.5) according to the descriptive test. While the Bagoué butter was shared between the three colors: Beige and White (2.7) and Yellow (2.6). As for the texture, we note a low level of granulation to the touch with a maximum of 4.1 (Bagoué); 3.8 in the Tchologo, 2.8 in the Poro and finally the minimum rated at 2.4 in the Hambol. The butters were more compact in Poro (6.3) and much less compact in Hambol with an intensity level of 4. The regions of Bagoué and Tchologo were both rated at 5. In addition, the shea smell was most pronounced in the Poro region (6.2) followed by Hambol (5.1) then Tchologo (5) and Bagoué (4.5). Finally, the rancid smell gave 4.1 in Bagoué 3.7 in Poro 3.3 in Tchologo and Bagoué recorded the minimum with 2.5. However, there is no significant difference between the different extraction processes in terms of the values of the Belgian color attributes, odors (shea and rancid) and granulated texture according to the Duncan test at the 5% threshold.

The French standard NF ISO 5492 defines sensory analysis as the examination of the organoleptic properties of a product by the sense organs. It is therefore a question of using the human being as a measuring instrument by taking advantage of their olfactory, taste, visual, auditory and tactile capacities to characterize and evaluate products, particularly in areas where the senses provide certainly added value compared to usual physicochemical measurements. The descriptive test, which serves as a sensory identity card for our different shea butters, concerned several attributes, namely: color (Belgian, white and yellow), smell (shea and rancid), taste and texture (compact and granulated). This descriptive test revealed relatively low levels of intensities assigned to the attributes by the panelists with a few peaks, notably the yellow color, the compact texture and the characteristic shea odor of butters. This suggests that despite the differential treatments applied to butters, they have for the most part respected the main organoleptic criteria sought. Indeed, the regional Codex Alimentarius standard recommends that the color, odor and flavor must be characteristic of unrefined shea butter and free from any rancidity. Unfortunately, degrees of rancidity are to be reported although they are low and could be at the origin of the derogatory choices of certain panelists.

Hedonic test: Table 3 describes the results of the hedonic test of shea butter from the different regions studied. The attributes were ranked from extremely unpleasant (1) to extremely pleasant (9). We observe that the pleasure ratings are overall between 4.66 and 6.96 with the lowest indicators in the taste attribute (4.66 in Bagoué and 4.77 in Hambol) and the highest in the texture attribute (6.96) in the Poro region. More precisely, the color gave 5.93 in Bagoué, 6.71 in Hambol, 6.73 in Poro and 6.77 in Tchologo: i.e. degrees of pleasure of "slightly pleasant" for the first and " pleasant" for the last ones.

As for the aroma, we note indicators of 5.3; 5.9; 5.9 and 6.45 respectively in the Bagoué, Hambol, Poro and Tchologo regions; or “Slightly Pleasant” for Bagoué and “Pleasant” for the other three regions. Then the indicators of the taste attribute are low with 4.66 in Bagoué, 4.67 in Hambol, 6.1 in Poro and 5.71 in Tchologo: either “Neither Pleasant nor Unpleasant” in Bagoué and the Hambol then “Pleasant in the Poro and the Tchologo. Finally, the texture attribute presents indicators of 5.2; 6.48; 6.96 and 5.87 respectively in Bagoué, Hambol, Poro and Tchologo, corresponding to “Neither Pleasant Nor Unpleasant” for Bagoué and “Pleasant” for the other three regions. Ultimately, the general appreciation of Bagoué shea butter is less appreciated by the panelists who judged it “Neither Pleasant nor Unpleasant”. It is followed by those of Hambol and Tchologo judged “Slightly Pleasant”. While the Poro shea butter was more appreciated by the panel with the mention “Pleasant”.

Furthermore, to explore a possible relationship between the indicators resulting from the different extraction processes and the general appreciation of the different shea butters, the Pearson correlation matrix was produced (Table 4) based on the results of the hedonic panel (Table 3). The correlations are positive in all indicators and strongly correlated with taste ($r = 0.944$; $P < 0.05$). We note values of 0.783 with color; 0.641 for aroma and 0.792 for texture.

The hedonic test which focused on pleasure reflected a relatively acceptable level of appreciation of the different shea butters. In addition, the Pearson correlation carried out on the hedonic attributes showed a strong correlation between general appreciation and taste ($r = 0.944$; $P < 0.05$). In other words, the extraction processes had a strong impact on the final taste of the different shea butters studied.

Table 3. Sensory data from the hedonic analysis of shea butters from the regions studied in northern Côte d'Ivoire

	Color	Aroma	Taste	Texture	General appreciation
Bagoué	5.93a	5.3a	4.66a	5.2a	5.43a
Hambol	6.71a	5.9ab	4.67a	6.48bc	5.84ab
Poro	6.73a	5.9ab	6.1b	6.96c	6.67c
Tchologo	6.77a	6.45b	5.71b	5.87ab	6.25bc

Trials: n = 3; the means ± standard deviations, assigned different letters on the same column, are significantly different at P < 0.05 according to the Duncan test.

Table 4. Correlation matrix (Pearson)

Variables	Color	Aroma	Taste	Texture
General Appreciation	0.783B	0.641A	0.944C	0.792B

Significant correlation at the 5% threshold

4. CONCLUSION

At the end of this study, it emerged that the different extraction processes used by shea butter producers in the North of Ivory Coast had a strong impact on the physico-chemical quality criteria with a level of oxidation high, accentuated acidity and an impurity phase to be monitored, given the non-conformities observed after comparing our values to the regional Codex Alimentarius standard. This impact could be highlighted during the organoleptic evaluation which expressed the presence of rancidity in the different shea butters although low and a significant difference in taste in strong correlation with the general appreciation ($r = 0.944$; $P < 0.05$) of the panelists with the final product. If the impact was harmful for certain quality and organoleptic criteria, it is quite different for others such as humidity, refractive indices, saponification iodine and unsaponifiables. Overall, the acceptability of different shea butters remains nuanced because according to the regional standard of the Codex Alimentarius, if these butters are to be prohibited for direct consumption (category I butter), they should find a happy place in food industry (category II butter).

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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