Journal of Food Research; Vol. 2, No. 5; 2013
ISSN 1927-0887 E-ISSN 1927-0895
Published by Canadian Center of Science and Education

Effect of Nut Treatments on Shea Butter Physicochemical Criteria and Wrapper Hygienic Quality Influence on Microbiological Properties

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Received: April 7, 2013 Accepted: August 15, 2013 Online Published: August 22, 2013

doi:10.5539/jfr.v2n5p66 URL: http://dx.doi.org/10.5539/jfr.v2n5p66

Abstract

The increasing importance of traditional shea butter led to standards criteria establishment. Nevertheless, criteria are difficultly achieved because traditional processes are generally uncontrolled. In this study, optimal processing conditions in order to get shea butter in conformity with standard were determined. Hence, the drying duration and mode, the kernel quality and roasting time were varied. The wrapper hygienic quality effect was also considered. Resulting shea butters of each variation was analyzed and the ANOVA test performed on characteristics to evaluate variations effects. The peroxide index increased continuously (2.79 ± 0.05 to 10.30 ± 0.05 mEg O_2/kg) from the first week to the fourth sun drying week, while unsapnifiable matter decreased (17.60 ± 0.05 to 1.55 ± 0.05%). Both peroxide and acid index were higher after five minutes of roasting than they were before; and shea butter conserved in sterile wrapper was germs free, compared to other wrappers. Moreover, the process taking into account all these optimal conditions conduced to shea butter with moisture (0.15%), acid (11.94 mg KOH/g), peroxide (2.79 ± 0.05 mEg O_2/kg), saponifiable (196.10 ± 0.15 mg KOH/g), refractive (1.465 ± 0.005) index and melting point (35.0 ± 0.1 °C) conforming to international standard. Moreover, it was heavy metal and germs free, and its unsapnifiable content (17.61 ± 0.25%) was high.

Keywords: shea butter, processing, optimal, physicochemical, microbiological, standards, criteria

1. Introduction

Shea tree is a typical African important oil bearing tree. It is commonly found in the savannah zone, where rainfall is not excessive (Hall et al., 1996). The extracted fat called shea butter is widely exploited either locally or industrially. Locally, shea butter is used as a cooking fat, illuminant, medicinal ointment, body cream, hairdressing cream, and as raw material in the manufacture of soap and traditional candle (Hall et al., 1996; Carette, Malotaux, Van Leeuwen, & Tolkamp, 2009). Industrially, shea butter is commonly used in cosmetics and in the production of cocoa butter equivalents or improvers (up to 5% content by weight is allowed under European Union (EU) regulations on chocolate), other confectionaries and margarines (Leakey, 1999; United States Agency International development [USAID], 2004). These utilizations are linked to shea butter interesting properties (Warra, 2011). Indeed, cosmetic/pharmaceutic industry for instance, exploit shea butter for its unsapnifiable compounds (kariten, terpenic alcohols, phytosterols, etc.) which would protect from UV rays, soften and confer youngness to the skin (Hall et al., 1996). Food industry as for it, base its interest in shea butter relatively high melting point (for chocolate), composition in fat acids (cooking fat) and its latex (pastry) according to the same authors.

Consequently, if sensorial characteristics such as color, odor, texture are sufficient for ordinary consumers, (Carette et al., 2009; Megnanou & Niamké, 2013), industrials are more exigent about physicochemical criteria (Hall et al., 1996; USAID, 2004). Indeed, according to USAID (2004), certification of shea kernel and butter has become increasingly important for a number of reasons, generally linked to shea butter wide range of properties. Hence, a number of cosmetic companies and other buyers are asking for certified shea butter (USAID, 2004; Programme des Nations Unies pour le Développement [PNUD], 2010; Aarhus Karlshamn [AAK Global], 2012).

These physicochemical characteristics (criteria) are various and depend mainly on the process (Hall et al., 1996; Kiyayila, 2002; Omujal, 2009; Aculey Lowor, Winifred, & Assuah, 2012), but also on the origin of nuts and on the conditioning of the butter. It is worth noting here, that shea butter conditioning can be considered as an essential element in preserving (saving) shea better quality post-preparation. In fact, either air oxygen, sun rays

or any other heat source could induce oxidation and hydrolysis reactions (Hall et al., 1996; Kiyayila, 2002)

About process influences, if Hall et al. (1996) underline the diversity of the traditional (artisanal) processes, it is worth noting the wide variability in shea butter quality this situation induces. However, this kind of shea butter called bio-shea butter present an increasing interest for cosmetic and pharmaceutical industrials more than hexan-extracted shea butter does. At regard to industrials exigencies about the quality and considering how artisanal shea butter production could improve the producer (women) socio-economical conditions, the artisanal process might be improve through a rigorous control of the processes factors.

Concerning the processes factors, Semmelroch and Grosch (1996) and Sanz, Ansorena, Bello, and Cid (2001) demonstrated the roasting effect on sensorial characteristics of coffee and cocoa butters. Hall et al. (1996) and Kapseu et al. (2005), as for them reported some results about shea nuts pre-treatment effects on shea butter quality. Many other studies underlined the impact of raw material treatment on resulting products quality. Nevertheless, suitable artisanal conditions ranging from fresh nut pre-treatment to shea oil wrapping had not been defined.

Furthermore, several seminars and other meetings were carried out, and led to the harmonization and the establishment of standards for artisanal unrefined shea butter (Union Economique et Monétaire Ouest Africaine [UEMOA], 2011). These standards are subdivided into quality (moisture, acid and peroxide index), distinctive or typical (melting point, sapnifiable, iodine and refraction index, etc.) and mineral (absence of heavy metal, mainly) criteria Hence, the present study aimed to identify the optimal conditions of each processing step (nuts drying duration and mode, kernel quality, roasting duration and wrapper hygienic quality) in order to produce shea butter with characteristics in conformity with international standards. For this purpose, fresh nuts drying duration and mode, kernel quality, roasting duration and the wrapper hygienic quality, were varied. Then, the physicochemical, mineral and microbiological characteristics of each resulting shea butter were determined. The best result of each step was revealed through statistical analyses.

2. Material and Methods

2.1 Material

Different samples of shea butter were prepared in laboratory following the aqueous process. Shea fruits used for experimentations at the laboratory were purchased on Dabakala (Department in Northern Côte d'Ivoire) market and at the train station of Adjamé (District of Abidjan, Côte d'Ivoire). As for dried nuts, they were bought with a regular producer of shea butter of Foungolo (a village of Dabakala).

2.2 Methods

2.2.1 Shea Butter Preparation

The aqueous traditional process used here, is currently employed in Dabakala to prepare marketed shea butters because it is the least hard and takes less time compared with the churning process. It consists in boiling shea kernel paste in two equivalent volumes (or more) of water and removing the floating oil which is then dehydrated in another recipient by heating. Factors which vary in this process are drying duration and mode, kernel quality and roasting time.

2.2.2 Variation of Nut Drying Time

Fresh seeds resulting from shea fruits de-pulping were dipped in two equivalent volumes of boiling water for 20 min (bleaching) and then put on plates for sun drying. Each week, during four weeks, 2 Kg of nuts was de-hilled; the kernels were chopped finely with a kitchen chopper and then roasted at 120 to 150 °C for 5 min (by part of 500 g). Then, the roasted kernels were ground with a kitchen electric grinder (*Moulinex La Moulinette DP 700 GB1, capacity: 1.5*) and the paste was boiled for 1 hour in 2 equivalent volumes of distilled water. The floating oil of the boiling solution was collected and dehydrated by heating it for 5 min. Each shea butter was stored at home temperature, in a sterile box.

2.2.3 Variation of Drying Mode

Two batches of 2.5 Kg of fresh nuts were constituted and after bleaching for 20 minutes. One was sundried and the other oven-dried at 50 °C, for one week (both of them). The two batches were then transformed into shea butter following the previous process.

2.2.4 Variation of Kernel Quality

The hills of dried shea nuts (purchased dried nuts) were removed and the kernels were classified (sorted) according to their aspect (sound, moldy and rotten). Each quality of kernel was transformed into shea butter

following the aqueous process previously described. The three resulting shea butter (sound, moldy and rotten kernels butters) were stored separately in sterile box.

2.2.5 Variation of Roasting Time

Ten (10) kilograms of sound kernels were shopped and separated into seven parts. Each part was roasted at 120 to 150 °C, for a specific time ranging from zero (0), two (2), four (4), five (5), six (6), ten (10) and fifteen (15) minutes, and then transformed into seven different shea butters, according to the aqueous process. The choice of the present heating time was based on an anterior experience about roasting realized in our laboratory (no published) which revealed that for a portion of 500 g after 5 minutes shopped kernels became deeply dark and smoky. Hence, the time of 5 minutes was suggestive (indicative) for the present experience; the others times were considered in order to get more precision.

2.2.6 Preparation of Shea Butters of Optimal Processing Conditions

Optimized shea butters were manufactured following the optimal conditions of the different steps. Fresh nuts were blanched and then put on plates for sun drying for one (1) week. Sound kernels were then chopped and roasted at 120 to 150 °C for 5 min (by part of 500 g). The reminding steps were not different from the usual aqueous process. At the end, the optimized shea butters were stored at 4 °C, in a sterile pot.

2.2.7 Determination of Physicochemical Characteristics of Shea Butters

Iodine, peroxide and saponification values were determined by using the European pharmacopoeia norms described in 2002. The acid value was obtained by Cooks and Van Rede method as described by Ocho (1999). The unsapnifiable content was evaluated by the French norm numbered NF T60205 (2001). Thus, the unsapnifiable fraction was carried out by extracting 5 g of shea butter in hexane, after saponification with 25 ml of potassium hydroxide 2 N in alcoholic solution. The moisture content was determined by the Association of Officiel Analytical Chemists [AOAC] (1980) method by dehydration of 5 g of shea butter and drying in an electric oven (100 °C) up to a constant weight. The method of Hamilton and Rossel (1986) was used to obtain the melting point value of the shea butter. Melted shea butter (2 g) was poured into a Pasteur's pipette and frozen overnight. The pipette containing shea butter was then put in an icy bain-marie (0 °C) which was heated until the frozen shea butter starts melting. The temperature of the bain-marie was then read on a thermometer first kept in the bain-marie. The refractometric value (index) was read at 40 °C with a digital refractometer Atago RX-5000 (Cat. Ner 3251).

The mineral content of the shea butter ash was determined following the AOAC (1980) method by spectroscopy atomic absorption with a spectrophotometer *SpectrAA-5*. For the ash, one gram (1 g) of shea butter was mineralized in a mineralizing oven (J.P. Selecta, s.a. Ner 0346540) at 550 °C, for 24 h, as described by Biego, Oga, Agbo, Kouadio, and Hartemann (2004). The mineralization temperature increased progressively (50 °C by 30 min) from 50 to 550 °C, and then stopped the process 24 h later.

2.2.8 Determination of Microbiological Characteristics of Shea Butters

The microbiological analysis concerned the presence of *Salmonella* and counting microbial organisms such as aerobic mesophile bacteria (on Plate Count Agar [PCA] for 72 h), total coliforms (on Violet Red Bile Lactose agar [VRBL] at 30 °C for 24 h), thermotolerent coliforms (on VRBL at 44 °C for 24 h), yeast and moulds (on YGC at 25 °C for 72 h). The different methods used for these analyses are described by the French standards numbered NF V 08-052 (1997), NF V 08-051 (1999), NF V 08-050 (1999), NF V 08-060 (1996) and NF V 08-059 (2002), respectively. For the principal suspensions, 10 g of melted shea butter were added to 90 ml of buffered peptone water.

Concerning Salmonella detection (presence), 10 g of shea butter were pre-enriched in a non-selective buffer (buffered peptone water) by incubation at 37 °C for 24 h. Aliquots of the previous solution were inoculated into selective brothes (Rappaport Vasiliadis Soy (RVS) and Salmonella-Shighella) and incubated respectively at 42 °C and 37 °C for 24 h, before being struck into Salmonella-Shighella and Hektoen Enteric agar. Both agars were incubated at 37 °C for 24 h. Several tests of confirmation were performed on typical Salmonella colonies (transparent with a black center and blue-green, respectively). Hence, after culture on Kligler-Hajna agar, urea-tryptophan and glycerol, at 37 °C for 24 h, salmonella colonies gave negative results for lactose, urease, glycerol and indole, but positive result for glucose, gaz and sulfite.

2.2.9 Statistical Analysis

Analyses for each parameter were preformed in triplicate.

Data were treated using XLSTAT (2007) Software. Comparison between the different samples was realized by

the analysis of variance (ANOVA) with a mean of 95%. Each significant ANOVA test, completed with the test of Fischer (LSD) led to homogeny groups.

3. Results

3.1 Process Effect on Shea Butter "Quality Criteria"

All the shea butter samples of the whole experience unregistered very weak moisture contents which ranged from 0.15± 0.01 obtained with oven and sun dried kernel shea butter to 0.60% which represented the moisture of shea butter extracted from kernels roasted for 5 minutes.

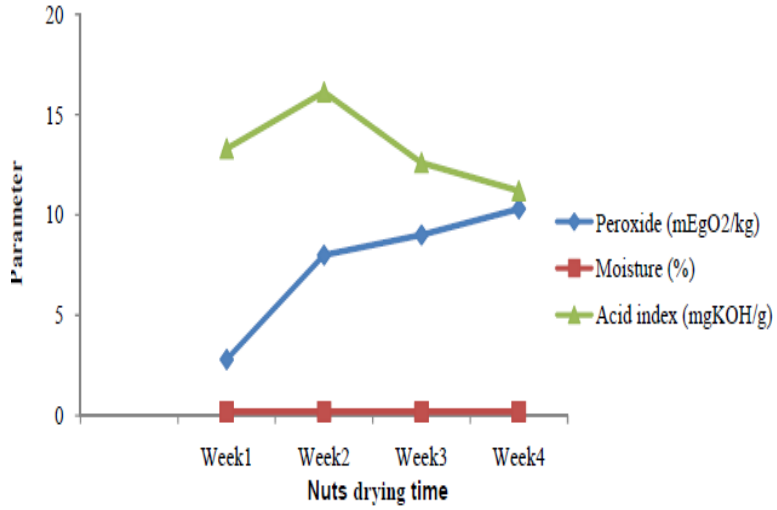

Figure 1. Variation of shea butter moisture, acid and peroxide index during sun drying from one to four weeks

Moreover, according to Duncan test of the ANOVA, samples moisture contents were affected neither by sun drying duration, drying mode, kernels quality nor by kernels roasting duration. Contrary to moisture contents, acid and peroxide index were significantly affected by all the previous process factors (drying duration, kernel quality, etc.). Indeed, during four week experimentation, moisture remained constant at 0.2%, while peroxide index rose continuously, from 2.79 ± 0.05 the first week to 10.30 ± 0.05 mEg O_2/kg, the fourth one. Acid index as for it, increased (13.30 ± 0.05 to 16.13 ± 0.05 mg KOH/g) the first week to the second, and then decreased continuously till the fourth week (16.13 ± 0.05, 12.60 ± 0.05 and 11.20 ± 0.05, successively) (Figure 1). Concerning the drying mode (Figure 2), shea butter extracted from sundried nuts presented weaker peroxide index (2.79 ± 0.05 mEg O_2/kg) than oven dried nuts (5.77 ± 0.05 mEg O_2/kg). Inversly sun dried nuts gave higher acid index 17.61 ± 0.05 mg KOH/g than oven-dried nuts (6.65 ± 0.05 mg KOH/g) did.

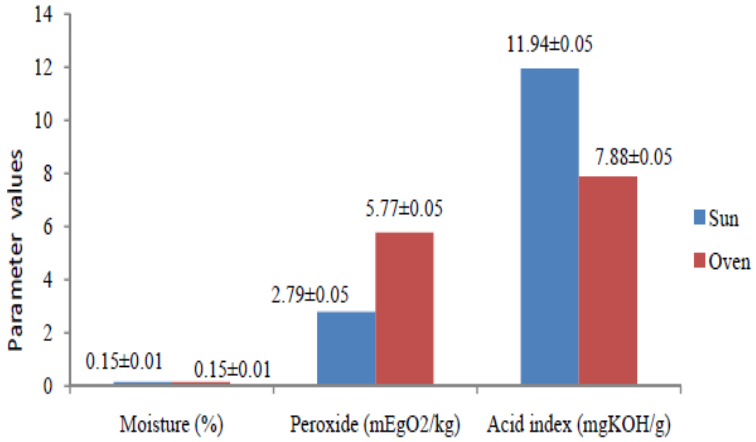

Figure 2. Variation of shea butter moisture, acid and peroxide index following nuts drying mode

About kernels quality (Figure 3), rotten and moldy kernels produced shea butter with weaker acid index (12.25 ± 0.00 and 20.83 ± 0.00 mg KOH/g, repsectively) than sound kernels (43.40 ± 0.05 mg KOH/g) did. In opposition, their peroxide indexes (10.00 ± 0.05 and 12.86 ± 0.05 mEgO2/kg) were higher than those of the sound ones (7.75 ± 0.05 mEg O_2/kg).

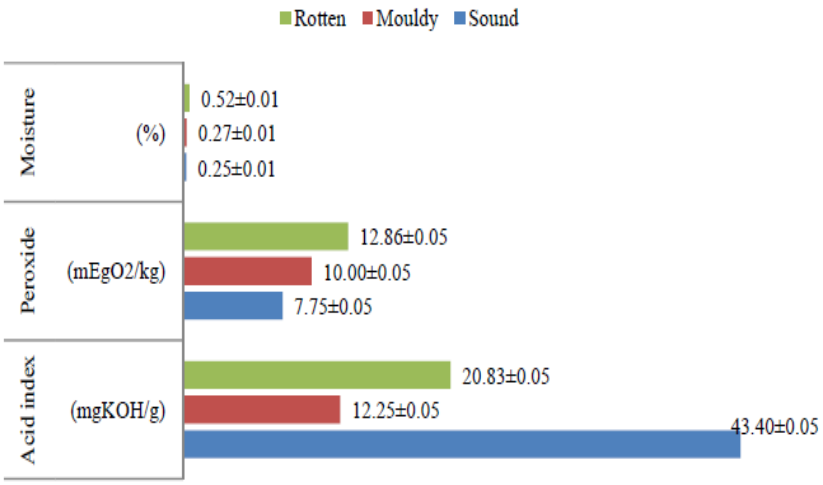

Figure 3. Shea butter moisture, acid and peroxide index as function to kernel quality

Concerning kernel roasting duration (Figure 4), the peroxide index increased progressively from zero (0) minute (3.43 ± 0.05 mEg O_2/kg) to fifteen (15) minutes (16.35 ± 0.05 mEg O_2/kg). Acid index also rose continuously (15.40 ± 0.05 to 54.60 ± 0.05 mg KOH/g), excepted for 0 to 2 min (15.40 ± 0.05 to 14.00 ± 0.05 mg KOH/g). That rising were very rapid (15.40 ± 0.05 to 54.60 ± 0.05 mg KOH/g) from six (6) to 15 minutes (Figure 4).

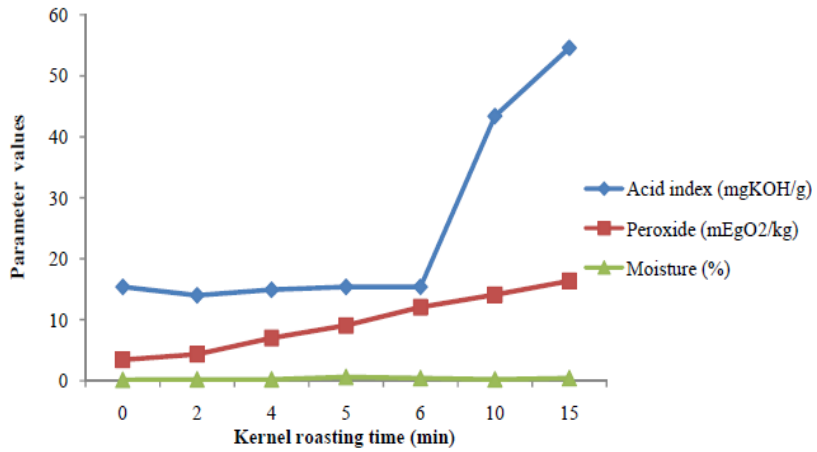

Figure 4. Variation of shea butter moisture, acid and peroxide index as function to the kernel roasting time

At the whole, moisture contents and peroxide index obtained were in conformity with UEMOA (2006) standards (2.00% and 50.00 mEgO_2/kg, respectively) about unrefined sea butter. As for sea butter prepared in optimal processing conditions, its moisture content (0.15%) acid (11.94± 0.05 mgKOH/g) and peroxide (2.79±0,05 mEgO_2/kg) index, were the weakest of the whole experiences.

3.2 Process Effect on Shea Butter "Distinctive Criteria (Characteristics)"

Distinctive criteria behavior fluctuated from a factor to another. Indeed, they did not vary under sun drying excepted for unsapnifiable content which decreased continuously from 17.60± 0.05% the first week, to 1.55± 0.05% the fourth (Table 1).

Table 1. Kernels mointure and shea butter distinctive characteristics as function to the drying time

Sun drying time (week)	Kernels moisture (%)	Saponification index (mg KOH/g)	Iodine index ($mgI_2/100g$)	unsapnifiable (%)	Réfraction Index	Melting point (°C)
Week1	19.0±0.01a	171.40 ± 0.50a	24.61±0.20a	17.60 ±0.05a	1.462 ± 0.010a	34.60 ± 0.50a
Week2	10.0±0.01b	175.17 ± 0.50a	28.33±0.20a	6.70 ± 0.05b	1.465 ± 0.010a	34.40 ± 0.50a
Week3	7.25±0.01c	179.23 ± 0.50a	27.50±0.20a	1.88 ± 0.05c	1.465 ± 0.010a	33,8 ± 0,5a
Week4	5.75±0.01d	181.52 ± 0.50a	26.90±0.20a	1.55 ± 0.05c	1.465 ± 0.010a	33.70 ± 0.50a

Legend: values given represent means ± the standard deviation. Values with different letters a, b and c underlined significant difference between samples.

As for the drying mode, it affected significantly the unsapnifiable and the saponifiable index (Figure 5). In fact, unsapnifiable amount (17.61 ± 0.05%) was higher for shea butter extracted from sun dried nut, compared with shea butter from oven dried nuts (6.65 ± 0.05%). Inversly, saponifiable index of the previous sample (206.10 ± 0.50 mg KOH/g) were more important than that of the sun dried shea butter (196.10 ± 0.50 mg KOH/g).

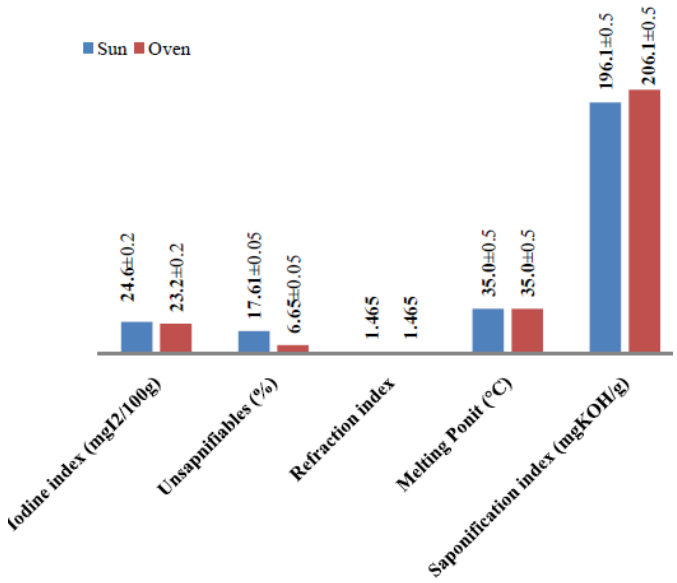

Figure 5. Distinctive characteristics of shea butter as function to nuts drying mode

Considering kernels quality, it influenced significantly shea butter melting point, unsapnifiable, iodine and saponifiable indexes (Figure 6). Moldy kernels produced butter with higher saponifiable (172.90 ± 0.50 mg KOH/g) and iodine indexes (41.05 ± 0.20 mg I_2/100g), while rotten and sound kernels conduced to the highest unsapnifiable (1.87 ± 0.05%) and melting point (35.6 ±0.5 °C), respectively.

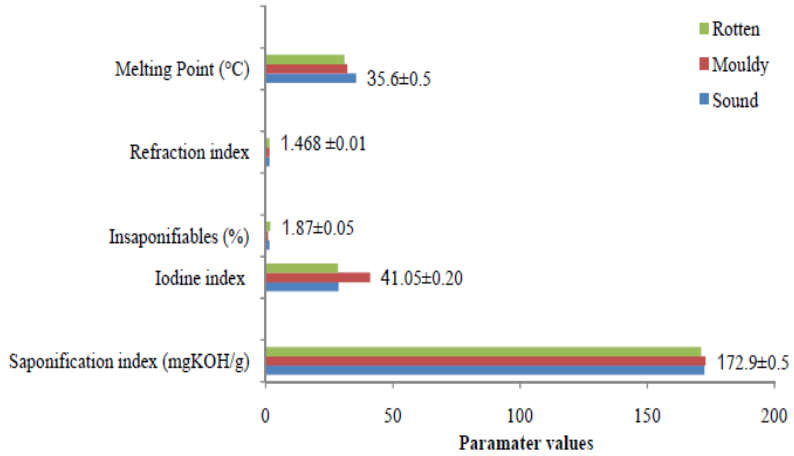

Figure 6. Distinctive characteristics of shea butter as function to kernel quality

About kernels roasting, its effects were very fluctuant on melting point, iodine and saponifiable index, when refraction index and unsaponifible content presented no significant variation (Table 2).

At the whole, refractive index did not varied significantly, and it ranged from 1.462 to 1.465 for all the experiences, excepted for sample extracted from moldy (1.467) and rotten (1.468) kernels.

3.3 Heavy Metal Content and Wrapper Effects on Shea Butter Microbiological Quality

About heavy metal in shea kernels and butters, no plumb was noticed (Table 3). Nickel was present only in shea butter resulting from commercial dried nuts (kernels quality and roasting duration experimentation). As for copper and iron, they were not unregistered during kernel roasting experimentation, but in kernels (3.30 ± 0.01 and 30.65 ± 0.01 mg/Kg, respectively). Copper was detected in other samples, but the most important amounts were in sound and moldy kernels (3.02 ± 0.00 and 0.95± 0.00, respectively). Iron, as for it was highly present in shea butter of oven dried nuts (3.99 ± 0.00 mG/Kg), as shown on Table 3.

Concerning shea butter microbiological quality, it was affected by the wrapper hygiene. However, neither Salmonella (except for recycled recipient) nor thermo tolerant Colliforms were detected.

Table 2. Shea butter distinctive characteristics as function to kernels roasting duration

Kernel roasting time (min)	Saponification index (mg KOH/g)	Iodine index (mg I_2/100g)	Unsapnifiables (%)	Refraction index	Melting Point (°C)
M0	181.44±0.50 ab	39.20±0.20a	0.89 ± 0.05a	1.464±0.010a	35.2±0.5ab
M2	171.70 ± 0.50 c	35.44±0.20a	0.89 ± 0.05a	1.463±0.010a	36.2±0.5a
M4	181.75 ± 0.50a	29.40±0.20b	1.44 ± 0.05a	1.465±0.010a	33.9± 0.5b
M5	157.61 ± 0.50e	28.60±0.20b	1.52 ± 0.05a	1.464±0.010a	34.4±0.5ab
M6	157.61 ± 0.50de	29.00±0.20bc	1.87 ± 0.05a	1.465±0.010a	34.4±0.5ab
M10	172.11 ± 0.50bc	24.51±0.20cd	1.88 ± 0.05a	1.464 ± 0.010a	35.2±0.5ab
M15	167.40±0.50cd	20.97±0.20d	1.89± 0.05a	1.465±0.010a	34.1±0.5ab

Legend: M0, M2, etc. correspond to roasting duration 0 minute, 2 minutes, etc.

Values given in the table represent means ± the standard deviation. Values with different letters a, b and c underlined significant difference between samples.

Table 3. Heavy metal in shea butter samples as function to process factors

Factor	Variation	Copper	Iron	Plumb	Nickel
SDD	Week1	0.95	0.00	0.00	0.00
	Week2	3.02	1.85	0.00	0.00
	Week3	0.00	0.00	0.00	0.00
	Week4	0.00	0.00	0.00	0.00
DM	Sun	0.95	0.00	0.00	0.00
	Oven	0.00	3.99	0.00	0.00
KQ	Sound	3.02	1.85	0.00	1.20
	Moldy	0.95	0.00	0.00	0.72
	Rotten	0.00	0.00	0.00	0.38
KRD	Minute 0	0.00	0.00	0.00	0.00
	Minute 2	0.00	0.00	0.00	3.61
	Minutes 4	0.00	0.00	0.00	11.23
	Minute5	0.00	0.00	0.00	13.60
	Minute6	0.00	0.00	0.00	13.60
	Minute 10	0.00	0.00	0.00	22.90
	Minute 15	0.00	0.00	0.00	29.21
Shea kernel	-	3.30± 0.01	30.65±0.01	0.00	0.00

Legend: SDD: Sun drying duration, DM: Drying mode, KQ: Kernel quality, KRD: Kernel roasting duration.

At the whole, germs were less numerous in cleaner wrappers (Table 4). Hence, shea butter conserved in sterile recipient contained no germs, contrary to those of the new commercial plastic bag which presented fewer germs than recycled recipient shea butter did. Concretely, samples stored in commercial plastic bag and recycled recipient counted 7×10^2 UFC and 30 against 9.6×10^4 UFC and 10 UFC, respectively for aerobic mesophile germs and mould/yeast. Moreover, recycled recipient one contained Salmonella.

About shea butter obtained from optimal processing conditions and conserved in sterile pot, it was heavy metal and germs less.

Table 4. Shea butter microbiological quality as function to wrapper hygienic quality

Number of germs (UFC/g)	Microbiological standard	3×Microbiological standard	Sterile recipient	Recyclided recipient	Commercial plastic bag
Aerobic Mesophiles Bacteria/g	1×10^4	3×10^4	0	9.6×10^4	7×10^2
Total Coliforms /g	25	75	0	15	0
Coliformes Thermotolerent	0	0	0	0	0
Yeast andMoulds/g	10	30	0	30	10
Salmonella	Absence	Absence	Absence	Présence	Absence

4. Discussion

Shea butter quality depends on both its conditioning and its processing (Hall et al., 1996; Kiyayila, 2002; Megnanou, Niamke, & Diopoh, 2007), but mostly on its processing (Elias & Carney, 2004; Kapseu et al., 2005). It is worth precising that according to Elias and Carney (2004) traditional shea butter (bio product) would be preferentially chosen by industrials (cosmetics). Nevertheless, the process presents a wide variability which would

be linked to uncontrolled processing factors (Hall et al., 1996). Indeed, the previous authors noticed that the color and the smell of the shea butter are as pronounced as kernel roasting duration is long. The results of the present study demonstrated that shea butter physicochemical characteristics are also influenced by the roasting time because the acid, peroxide, iodine index and unsapnifiable content varied considerably with the roasting time. These variations would be due to the high roasting temperature (120-150 °C). In fact, high temperature and residual water in kernels would not only induce hydrolysis reactions of glycerides, but also the oxidation of unsaturated fatty acid (Kajimoto et al., 1986; Dieffenbacher, Buxtorf, Derungs, Friedli, & Zürcher, 2000). Hence, the present results could be considered as a complement to those of Kapseu et al. (2005) because they concern the effect of kernel roasting time not only on shea butter "quality" criteria (acid and peroxide indexes) but also on its "distinctive" criteria (iodine, saponifiable, refraction indexes, unsaponiable, and other). Moreover, the present results precise the conditions for getting shea butter with specific physicochemical characteristics.

About kernels quality, moldy and rotted kernels produced shea butters with higher peroxide index compared to those of sound kernels. This situation confirms Cruz, Troude, Griffon, and Hebert (1988) and Dieffenbacher et al. (2000) approach about fat in general and oleaginous plant in particular. As for the highest iodine index recorded by shea butter of moldy kernels, it could be correlated to the presence of fungal pigment (yellow-orange) (Cruz et al., 1988; Pfohl-Leszkowicz & Castegnaro, 2002). This pigment would be a fungal secondary metabolite and would play the role of antioxidant. Hence, it would protect unsaturated fatty acid from oxidation during the processing (heating). Similar results were also reported by Joanny (2005) concerning the olive oil. However, Galtier, Hagler, and Hopkins (2006) and Jouany, Morgavi, and Boudra (2006), underline the potential danger which could constitute moldy foodstuffs. Hence, it would be rather ejecting both moldy and rotten shea kernel during shea butter manufacturing in order to guaranty shea butter quality (absence of rancidity) and consumers' health (absence of eventual mycotoxin).

Concerning nuts drying effects on shea butter characteristics, it is important recalling that the shea butter obtained after four week of sun drying recorded the slightest acid index and the highest peroxide index. The acid and peroxide indexes variation noticed during the nuts drying could be the combined actions of fungal hydrolases and oxidases, as well as sunbeams. Both factors would cause triglycerides hydrolysis and unsatured fatty acids oxidation (Risch & Ho, 2000; Dieffenbacher et al., 2000). However, taking into account, the development of moulds on kernels after one week drying, which returns them potentially harmful (Pfohl-Leszkowicz, 2000; Jouany et al., 2006; Galtier et al., 2006), and the increasing peroxide index from the first to the fourth week, it would be better not exceeding one week for shea nut drying. Moreover, a part from mould development and the peroxide index rising, unsaponifible decreased rapidly (17.60 to 1.55%). This decline in unsapnifiable matter might be related to the oxidation of polyunsaturated unsapnifiable (sterols, triterpen and kariten) but also to the coagulation of the kernel latex. This situation would confirm the necessity of not exceeding one week of nut drying in order to get shea butter (17.60% of unsapnifiables) which mostly interests Industrials (cosmetics and pharmaceutical).

Above all, the maximal value of 17.60% recorded about unsapnifiable, would confirm that the ivorian shea belongs to the sub-specie Mangifolia (5 to 17 % of unsapnifiable), according to Mensier (1957) classification. Whatever, the present (study) variations of unsapnifiable contents, in correlation with the drying time, kernels quality and roasting time, would underline the crucial influence of processing factors on unsapnifiable. In the same logic, moisture content of the butter during its preparation seems to be mainly linked to the process (shea oil dehydration), than to other effects. Moreover, the non-conformity between shea butter and kernels content in mineral would suggest outside contaminations. Indeed nickel for instance was detected in some shea butters but not in the kernels. This situation could be explained by the utilization of processing utensils (Casseroles) made of nickel (Guggenbühl, 2003). This situation suggests that it would be better avoiding the utilization of heavy-metallic utensils for food preparation (by heating).

In summary, the causes of the variation shea butter quality linked to the process are various and could be controlled. Post-processing effects might also be taken into account, mainly as far as contaminations are concerned. In fact, Cruz et al. (1988), Roquebert (1997) and Dieffenbacher et al. (2000) attribute contamination of foodstuffs to the water and the atmospheric air. Adegunloye, Agarry, Adebolu, and Adetuyi (2006) as for them explain the bad microbiological quality of some commercial foods by the hygienic quality of their wrapper. These different factors could justify the bad microbiological quality of shea butters conserved in non-sterile recipients. Hence it would be worth calling out the whole actors of shea sector, consumers' associations, persons in charge of the public health, on the necessity of improving the hygienic quality of shea butter conditioning. That precaution is essential though shea butter is not only consumed in households, but also used as antiseptic balm on infant wounds,

as eye drops for some eye infections (Hall et al., 1996). In these cases, the presence of pathogen germs such as Salmonella would be alarming.

5. Conclusion

Taking into account the optimal conditions of each shea butter processing steps, it was possible to achieve an optimized traditional process. The first optimal condition was the sun drying for a maximum of one week to avoid moulds development, peroxide rising and unsapnifiable decreasing. The second condition was the ejection of moldy and rotten kernels in order to preserve shea butter from rancidity and eventual mycotoxin contamination. The third condition was the kernels roasting by portion of 500 grams, at 120-150 °C for a maximum of 5 minutes, because acid and peroxide index rose rapidly after 5 minutes of roasting. The whole optimal conditions conduced to a shea butter with biochemical, physical, mineral and microbiological characteristics in conformity with both the regional and the international standards for unrefined shea butter. Indeed, if criteria such as melting point, unsapnifiable amount, refractive and saponifiable index, respected the standard, moisture content, acid and peroxide index were at fat inferior to prescribed maximal values. With such characteristics this shea butter would be apt to food industry exploitation for chocolate, margarine and over fat manufacturing. Moreover, it could interest cosmetics and pharmaceutical industries as far as its unsapnifiable matter is concerned.

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