Chemical, Microbial and Sensory Properties ofImproved Shea Butter during Ambient Storage

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ABSTRACT--- ***Manually extractedimproved shea butters are vegetable fat from parboiled, fried, toasted and boiled sheakernel streated by clarification and deodorization with citric acid solution and coconut essence. They were packaged in transparent plastic containers and stored on the laboratoryshelf at 28±2^{o}C for four months. Sensory changes were monitored biweekly and peroxide and microbial changes were monitored weekly using standard methods. Unlike the traditionally processed shea butter which was not treated with citric acid and had an optimal sensory acceptability of two weeks,sensory attributesof improved shea butter samplesimproved during storage. There were neither noticeable microbial growths nor rancidity.Treatment with citric acid solution and coconut flavour thus preserved the sensory attributes and keeping quality of improved shea butter at ambient storage.***

Keywords--- Improved shea butter, Sensoryattributes Keeping quality, Rancidity and Microbial growth

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1. INTRODUCTION

Shea butter is a vegetable fat extracted from the kernelsof fruits of the shea butter tree *Vitellariaparadoxa* [Gartner C.F] which is a large oleiferous tree that grows in Sahelian zones of Africa (Mbah*et al.*, 2005). Shea butter like other fats and oils are often not completely consumed after processing and are stored usually at ambient temperatures. Fats and oils often undergo flavour changes which reduce their market value (Ayobella, 2000).. Shea butter is rich in monounsaturated and polyunsaturated fatty acidsand these are susceptible to lipid peroxidation (Fernandez *et al*., 1997; Okullo*et al.*, 2010, Ibanga *et al*., 2015a).The quality of shea butter may be reduced by degenerative chemical processes during storage.Peroxidation of fats and oils leads to production of by-products that negatively affect their palatability and health benefits. Some fats and oils develop off-flavour faster than others making them undesirable as edible products. Lipid oxidation in fats and oils during storage, involves a complete set of reactions, which may differ depending on the condition under which the lipid is stored and they are prone to rancidity, a phenomenon which negatively alters the physical, chemical and organoleptic properties of fats and oils (Meyer,2004). According to the author, rancidity is the unpleasant taste and smell occurring after an incubation period in fats, oils and fatty foods that have undergone decomposition, liberating butyric acid and other volatile lipids. Oxidative rancidity starts by a slow up take of oxygen by oils and fats during the incubation period, followed by the rapid propagation period which is often extended and during this period, hydroperoxides, peroxides, aldehydes, ketones and many unpleasant compounds are formed. Rancidity could be oxidative, hydrolytic or enzymatic (Meyer,2004).

Oxidative rancidity occurs as a result of absorption of oxygen from the atmosphere by unsaturated fatty acids while hydrolytic rancidity occurs in the presence of moisture and enzymatic rancidity is catalyzed by enzymes (Potter and Hotchkiss, 1995). The factors that favour rancidity include, light, temperature, moisture, air, metals, absence of antioxidants or presence of prooxidants (Meyer, 2004). Prooxidants such as metals promote the onset of rancidity by acting as catalysts. Like other fats and oils with unsaturated fatty acids, shea butter is prone to oxidative degradation due to improper processing or storage which leads to inconsistent quality and limited shelf life(Lovett, 2004; Masters *et al*., 2004; Moharram*et al.*, 2006).

Natural antioxidants such as rosmarinic acid, gallic acid, ascorbic acid, vitamin A and tocopherol as well as synthetic antioxidants likebutylated hydroxyl anisole (BHA) butylated hydroxyl toluene (BHT) and propyl gallate are often added singly or in synergy to fat/oil and the food containing them to delay the onset or slow down the development of rancidity due to oxidation(Nahm*et al.*, 2012). Judde*et al.* (2003) reported on the antioxidant property of soy lecithin on vegetable oil stability while Meyer, (2004) noted that many oils and fat undergo a change in flavour before rancidity called reversion. Rancidity differs from reversion because researches have shown that some oils and fats like corn oil are susceptible to rancidity but reversion–resistant. The flavour changes during reversion vary with different oils and fat but in rancidity the final flavour is the same for all oils and fats (Meyer, 2004).

Predictive tests and oxidation indicator assays are two main categories of methods used to test lipid oxidation.According to Nilson (2008) predictive tests are assays that are used to determine the amount of oxidation that could potentially occur in a sample and the two commonly used predictive tests are oxidative stability index and the iodine value assay. Oxidative indicator tests are used to determine the amount of oxidation that has already occurred and they can be used to determine the quality of oil or fat (Lukaszewicz*et al*., 2004). Thiobarbituric acid reactive substances assay, the peroxide value assay and the anisidine value are the three commonly used oxidation indicator tests (Nilson, 2008).

Akingbala*et al.*,(2007) reported an optimal shelf life of two weeks for unrefinedfreshly extracted shea butter.Apart from the indigenes of places of shea butter production, many people dislike shea butter because of its unpleasant aroma which is mistaken for rancidity. In a work carried out byIbanga *et al.,* (2015c), citric acid solution and coconut flavour were used to improve the sensory quality of manually extracted shea butter from parboiled, fried, boiled and toasted shea kernels. Literature is sparse on the effect of processing on the shelf lifeof traditional and these improved shea butters. This works investigated on thesensory, microbial and peroxide changes of traditional and improved shea butter during ambient storage.

2. MATERIALS AND METHODS

2.1 Source of Materials

Shea nuts used for the work were obtained from the Federal College of Freshwater Fisheries Technology New Bussa and Monnai village both in Borgu Local Government Area of Niger State. The traditional shea butter was purchased from Monnai village and the commercial vegetable oil from Okpalagu Supermarket, New Bussa.

2.2 Preparation of samples for processing

Ripe fresh shea fruits were handpicked, left to ferment for 3 days at ambient temperature(26 ± 2^oC) washed, parboiled for 10 minutes, sundried, weighed, cracked, winnowed and further dried to approximately 10 - 11% moisture content. The dried kernels were stored in sacks at ambient temperature (26 ± 2^oC) till required for processing. Five kilograms shea kernelspasteeach was used to produce shea butter from four heat treatment methods (frying, toasting, boiling and parboiling) using hand churning manual method. Before use, the stored, dried, shea kernels were washed and sun dried for 4 to 5 hours.

2.3 Heat Treatment Methods

2.3.1 Frying method

Six kilograms of clean, dried kernels were fried with approximately 530 ml of previous shea butter oil (from the traditional processors) for about 30 minutes in a metallic pot. The initial frying temperature of 180^oC was reduced to 85 ± 5^oC after 5 minutes to avoid burning (Olaniyan and Oje, 2007). The sizes of the fried shea kernels were cracked and reduced using cracking machine, mortar and pestle. The semi pounded shea paste was ground to a chocolate brown paste using a locally fabricated electric motor grinder before oil extraction from 5kg shea paste.

2.3.2 Toasting method

Six kilograms of cleaned shea kernelswere toasted at 180^oC for 5 minutes and continued at 85 ± 5^oC for 25minutes (modified from Coulibaly *et al.*, 2010 village method) in a metallic pot without oil. The toasted shea kernels were cracked usingcracking machine and the size further reduced with mortar and pestle before grinding and extraction from 5kg shea paste.

2.3.3 Boiling method

A modified method of (Fobil, 2002) was used. Six kilograms cleaned shea kernels were boiled at 100^oC for 30 minutes and sundried for four hours before size reduction using cracking machine, mortar and pestle before grinding and shea butter extraction from 5kg of shea powder.

2.4 Manual extraction method

Hand–churning: Five kilograms of shea pastes were placed in a strong Fulani calabash and was slowly hand - mixed and churned with gradual addition of warm water and later vigorously churned till a brownish white shea fat separated from the brownish water solution. The shea fats were scooped out and washed several times using potable water to remove the brownish colour. The fat was heated to melt and water dried off. The shea oil in the pot was allowed to cool and settle overnight before filtration through muslin cloth, measured and packaged into clean plastic sample bottles and one liter plastic containers before solidification. The packaged solidified shea butter samples were stored in the freezer till required. The little brownish residue was discarded.

Mature/Ripe Shea fruits

Ferment (2 – 3days)

Wash

Parboil

Sundry

Crack/Dehusk

Winnow

Fry, Toast or Boil

Size reduction

Grind

Chocolate brown paste

Hand mix or boil

Manual extraction(hand churning)

Brownish white shea fat

Wash shea fat

Heat whitish shea fat

cool

Filter

Shea oil

Addition of citric acid solution

Stir/heat/ cool 4-5hours or overnight

Filter

Clarified shea oil

Stir/heat

Addition of coconut flavour (or any good food flavour)

Stir/heat

Cool

Improved shea butter

Package

Use/sale/storage

Fig.1 Processing of Improved Shea butter

2.5 Improvement treatments

2.5.1 Preparation of Improved shea butter: The method of Ibanga *et al*., **(**2015c) was used. Improved shea butter samples were processed thus**:** Shea butter samples were manually extracted from boiled, toasted and fried shea kernels that were previously parboiled, dried and dehusked. Citric acid solution (2.5g in 100ml of distilled water) was poured into 500ml of shea butter samples and heated for five minutes at 60^oC. The mixture was stirred and left overnight at ambient temperature to cool and settle. The oils at the top were decanted and filtered through muslin cloth and sieve size 200µ. Into 500ml of the sieved shea oil, one ml (1ml) of food grade coconut flavour (Conflaco Aromatic Ltd England) was added and heated for 5 minutes with proper stirring at 60^oC before cooling and usage. The flow chart is as shown in Figure 1.

2.6 Shelf life studies of improved shea butter

Improved shea butter samples were stored in transparent plastic containers in subdued light on the shelf for four months at ambient temperature of 26 ± 2^0C. (A transparent package is known to be the least protective of the packaging materials against light, a prooxidant).The choice of transparent plastic container with cover was to minimize the effect of packaging material on the storability of improved shea butters and to provide a food package that consumers could see through.

2.7 Organoleptic changes during storage of shea butter

The organoleptic changes of shea butter were monitored bi-weekly by 20 panelists on a nine point hedonic scale as in (3.7.1).

2.8 Microbial changes during storage of shea butter

The microbial load was evaluated from the first day of the improved shea butter and at weekly intervals for twelve weeks using nutrient agar (NA) for bacteria and potato dextrose agar (PDA) to monitor mould and some bacterial growth. Culture media were prepared according to manufacturer's instructions: 28g of nutrient agar was weighed and dissolved in one litre of distilled water and 42g of potato dextrose agar likewise. They were left for 10 minutes, mixed and sterilized at a temperature of 121^oC for 15 minutes in an autoclave. They were allowed to cool to 47^oC, poured into their respective petri dishes and allowed to solidify.

The inoculating wire loop was flamed, allowed to cool in the air. A loopful of each sample was taken to make a smear from which perpendicular lines were drawn (striking) on the solidified agar respectively. Zigzag lines were drawn to terminate the striking. They were incubated at 35^oC for 24 hours and 48 hours respectively before observation for growth.

2.9 Peroxide value analysis

Peroxide values were determined according to Pearson (1999) as follows: 1g of shea oil was weighed and poured into dry clean flask and 1g of powdered potassium iodide and 20 mls of solvent mixture (2 vol. of glacial acetic acid + 1 vol. of chloroform) added. The solution was heated and allowed to boil vigorously for 30 seconds. It was later poured into another flask containing 20ml of 5% potassium iodide solution. The flask was washed with 20ml of distilled water and titrated with 0.02N sodium thiosulphate using starch and production of black colour as a positive indicator. The same procedure was repeated for the blank.

Calculation:

$$\text{Peroxide value} = \frac{T - B \times 2}{Ws} \qquad (3.1)$$

T = Titre of the sample B = Titre of the blank Ws = Weight of sample

2.10 Statistical Analysis

Data analyses were done with SPSS 16.0 software. Significant means were separated using Duncan multiple range test at 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Effect of storage on sensory attributes of shea butter:

Table 1 shows the sensory scores of traditional shea butter, improved shea butter samples and a commercial vegetable oil packaged in transparent plastic containers and stored at room temperature on the laboratory shelf for four months. From the first day of storage, traditional shea butter had the least scores in all sensory parameters and differed significantly ($p \leq 0.05$) from the improved shea butter samples and the commercial kings vegetable oil which ranked fourth. The least acceptability of the traditional shea butter in all evaluated sensory attributes is in agreement with the findings of Megnanou *et al.* (2007) who reported that traditional shea butter is reputed for its poor quality and sometimes with high content of free fatty acid which leads to rancidity. Ibanga (2007) also reported that elites and students look down on traditional shea butter because of its poor sensory quality.The improvement in the sensory qualities of improved shea butters is attributable to the effect of the citric acid treatment and the flavouring of the shea butters. Improved shea butter from boiled shea kernels (E) though not significantly different from other improved shea butter samples was preferred in all the sensory attributes as shown in Table 1.

On the 14th day of storage (Table 2), the improved shea butter from the boiled shea kernels retained its preference in all sensory parameters but did not differ significantly ($p \leq 0.05$) from other improved samples and commercial vegetable oil. It was observed that the sensory scores of traditional shea butter on the 14^{th} day of ambient storage was better than its scores on the 1^{st} day implying that its organoleptic qualities improved during storage. Subsequent evaluation of the traditional shea butter showed that the 14^{th} day was its peak for optimal sensory qualities. This agrees with the observation of Akingbala *et al*. (2007). The preservative and antioxidant properties of citric acid could be responsible for the high sensory scores of the improved shea butters. Deffence (2002) reported on the preservative and antioxidant effect of citric acid on vegetable oils and that addition of citric acid in refining plants oil inhibits oxidation as it chelates transition metals ions, imparts oil flavour and influences the shelf life of vegetable oils.

On the 28^{th} and 42^{nd} day of storage, the sensory scores of traditional shea butter and commercial vegetable oil were unacceptable to most of the panelists (Tables 3 and 4). It was also observed that while the sensory scores of traditional shea butter and the commercial vegetable oil decreased during ambient storage after the 14^{th} day those of the improved shea butter improved. The decrease in organoleptic quality of the traditional shea butter and the commercial vegetable oil could be due to flavour reversion which occurs in some fats and oil before the onset of rancidity as noted by Meyer (2004). This is further confirmed by the low peroxide values of the fat and oil as shown in Table 11. Avoidance of contamination with trace elements such as iron, copper, zinc and chromium is necessary during processing of oils/fats that are prone to reversion. Industrially, metal scavengers such as ethylenediaminetetracetic acid (EDTA) is used to remove such trace elements and inhibits reversion (Meyer, 2004). It could also be that the commercialvegetable oilhad exceeded its best before date of optimal quality though it had not expired. The shea butter from the boiled shea kernels though not significantly different ($p \leq 0.05$) from other improved samples had the highest sensory scores.

On the 56^{th} and 70^{th} day of storage, the traditional shea butter and the commercial vegetable oils had very low scores (Table 5 and 6) and differed significantly from the improved shea butters which had acceptable scores ranging from 7.00±1.78 to 8.05± 1.36 but did not differ ($p \leq 0.05$) from each other. Improved shea butter from fried, toasted and boiled sheanuts did not differ significantly ($p \leq 0.05$) from each other in all attributes.Flavoured boiled shea kernels shea butter had the highest over all acceptability of 8.05± 1.3. Since citric acid has a preservative effect on the sensory qualities of improved shea butter samples, the deteriorative organoleptic changes of commercial vegetable oil and traditional shea butter indicated that they were devoid of citric acid.

The sensory qualities of traditional shea butter improved on the 84^{th} day but differed ($p \leq 0.05$) from the improved shea butters in all sensory attributes Table 7. The synergistic effect of low moisture content, the natural antioxidant effects of vitamins A, C and E in shea butter, the preservative and antioxidant property of citric acid could have influenced and preserved the sensory attributes of improved shea butters at ambient storage. Carell*et al*. (1997) reported that the keeping qualities of rasp seed and sunflower oils were improved by the use of citric acid.

The mean sensory scores of improved shea butter from fried, toasted and boiled shea butter, traditional shea butter and commercial vegetable oil on the 98^{th} day of storage under ambient condition are presented on Table 8. Apart from the colour, the traditional shea butter had least scores of all evaluated sensory indices and did not differ significantly ($p \geq 0.05$) from the commercial vegetable oil on the 98^{th} day of ambient storage. The duo differed significantly ($p \leq 0.05$) from the improved shea butter samples which had better sensory and keeping qualities. Improved shea butter samples had higher acceptable scores in overall acceptability and did not differ significantly from each other in colour, mouthfeel, taste and overall acceptability.

On the 112^{th} day of storage (Table 9), traditional shea butter had least scores in colour, mouthfeel, taste,aroma and overall acceptability. It differed significantly ($p \leq 0.05$) from the commercial vegetable oil except in aroma and the other samples in aroma, colour, mouthfeel, taste and overall acceptability. The improved shea butter from boiled shea kernels had the highest sensory scores throughout the four months of storage though its yield during extraction was lower than those of fried and toasted shea kernels shea butter.

The decrease in sensory scores of traditional shea butter is an indication of some deteriorative changes in the oil and these changes could be enzymatic, oxidative, hydrolytic or by the activities of micro-organisms during storage (Meyer,2004). This is because the traditional shea butter was not treated with citric acid which has preservative and antioxidant effect like the improved shea butter samples which had higher scores and greater acceptance in sensory attributes and overall acceptance. Storage under ambient condition of improved shea butter samples from fried, toasted and boiled sheanuts for sixteen weeks did not significantly alter their sensory acceptability as edible fat/oil.Low moisture content and presence of natural antioxidants such as tocopherol, phytosterols, vitamins C, E and A and citric acid in improved shea butter postivelyinfluence the keeping qualities.

Many people mistake the natural aroma of shea butter as spoilage, some believe that shea butter goes rancid easily while the villagers in Kainji lake area of Nigeria from a survey conducted by Ibanga *et al*. (2015e) claimed that shea butter does not spoil. Akingbala *et al*. (2006) reported a shelf life of two weeks for a manually extracted bleached shea butter from shea kernels roasted at temperature of 160^0C and stored at 63^0C. The authors also reported that the induction period before the increase in peroxide value of stored shea butter was 14 days and attributed the short shelf life to the removal of the tocopherol group and other natural antioxidants in the fat by heat. Shea butters that were not improved by treatment with citric acid, steaming or addition of flavour may have two weeks as the shelf life of optimal quality. As was observed in this study, the traditional shea butter had its peak sensory quality on the 14^{th} day of ambient storage. The 16 weeks storage of shea butter in this study at ambient condition was to ascertain its keeping quality for at least a quarter of the year. The improved shea butter samples may store for a longer period as there were no sign of deterioration after four months storage. This should remove biasness and boost consumers acceptance of shea butter as an edibe product.

Table 1. Sensory scores of improved shea butter at ambient storage (1^{st} day)

Sample	Flavour	Mouth feel	Colour	Taste	Overall Acceptability
A	5.40± 1.23^{c}	5.55^{c} ± 1.43^{c}	5:75 ± 1.41^{b}	5.15 ± 0.99^{b}	5.55± 1.19^{b}
B	7.20 ± 1.43^{b}	7.05^{b} ± 1.57^{b}	7.85± 1.23^{a}	7.20 ± 1.54^{a}	7.10 ± 1.48^{a}
C	7.85 ± 1.31^{ab}	7.40± 0.99^{ab}	7.20± 1.11^{a}	7.35± 1.14^{a}	7.50± 1.05^{a}
D	7.90 ± 1.37^{ab}	7.30± 108^{ab}	7.25± 1.07^{a}	7.20 ± 1.4^{a}	7.55 ± 0.94^{a}
E	8.35± 1.09^{ab}	8.00± 0.97^{a}	7.50 ± 1.44^{a}	7.85± 1.22^{a}	7.85 0.97^{a}

Legend
A. Traditional Shea butter.
B. Commercial vegetable oil.
C. Improved Shea butter from fried Shea kernels
D. Improved Shea butter from toas in most ted Shea kernels
E. Improved Shea butter from boiled Shea kernels
±: Standard Deviation
Values are mean sensory scores and standard deviation of triplicate analysis.
Values with same letter on a column are not significantly different ($p \geq 0.05$).

Table 2. Sensory scores of selected improved shea butter at ambient storage (14^{th} day)

Samples	**Colour**	**Mouth Feel**	**Taste**	**Aroma**	**Overall Acceptability**
A.	6.150± 1.04^{b}	6.00 ± 1.45^{b}	5.90 ± 1.77^{b}	5.80 ± 1.73^{b}	5.86 ± 1.90^{b}
B.	7.20 ± 1.24^{a}	7.06 ± 1.23^{a}	7.15 ± 1.34^{a}	7.25 ± 1.12^{a}	7.40 ± 1.10^{a}
C.	7.20 ± 1.36^{a}	7.55 ± 1.28^{a}	7.50 ± 1.06^{a}	7.45 ± 1.06^{a}	7.60 ± 1.23^{a}
D.	7.25 ± 0.85^{a}	6.80 ± 1.10^{a}	7.10 ± 091^{a}	7.05 ± 1.10^{a}	7.15 ± 0.88^{a}
E.	7.45 ± 1.19^{a}	7.40 ± 0.99^{a}	7.30 ± 0.99^{a}	7.25 1.11^{a}	7.35 ± 1.09^{a}

Legend

A. TA. Traditional shea butter.
B.Commercial vegetable oil.
C. Improved shea butter from fried shea kernels
D.Improved shea butter from toasted shea kernels
E.Improved shea butter from boiled shea kernels
±: Standard Deviation
Values are mean sensory scores and standard deviation of triplicate analysis.
Values with same letter on a column are not significantly different ($p \geq 0.05$)..

Table 3 : Sensory scores of improved shea butter at ambient Storage (28th day)

Sample	Colour	Mouth Feel	Taste	Aroma	Overall Acceptability
A.	5.15 ± 2.46^{b}	4.85± 2.43^{b}	5.70 ± 2.61^{a}	3.4 ± 1.23^{c}	4.06 ± 0.83^{b}
B.	5.7. ± 1.89^{b}	5.50± 2.13^{b}	5.60 ± 2.70^{a}	4.151.27^{b}	3.80 ± 1.20^{b}
C.	7.25 ± 1.29^{a}	7.30 ± 1.13^{a}	6.80 ± 1.73^{a}	7.85 ± 1.00^{a}	8.10 ± 0.72^{a}
D	7.25 ±1.02^{a}	6.95 ± 1.00^{a}	6.90 ± 1.51^{a}	7.75 ± 079^{a}	7.90 ±0.91^{a}
E.	7.30 ± 1.22^{a}	7.00 ±1.12^{a}	6.96 ± 1.63^{a}	8.15 ± 093^{a}	8.25 ± 0.86^{a}

Legend
A. Traditional Shea butter.
B. Commercial vegetable Oil.
C. Improved Shea butter from fried Shea kernels
D. Improved Shea butter from toasted Shea kernels
E. Improved Shea butter from boiled Shea kernels
±: Standard Deviation
Values with same letter on a column are not significantly different ($p \geq 0.05$)
Values with same letter on a column are not significantly different ($p \geq 0.05$).

Table 4. Sensory scores of improved shea butter at ambient Storage (42nd day)

Samples	Colour	Mouth Feel	Taste	Aroma	Overall Acceptability
A.	3.45 ± 1.19^{b}	3.10 ± 0.91^{b}	3.75 ± 0.97^{b}	3.35 ± 1.14^{c}	4.15 ± 081^{b}
B.	3.60 ± 0.75^{b}	3.50 ± 0.1.^{a}^{b}	3.50 ±1.37^{b}	4.06 ± 1.10^{b}	4.00 ± 1.13^{b}
C.	7.75 ± 1.12^{a}	7.75 ± 0.97^{a}	7.96 ± 1.15^{a}	7.90 ± 0.97^{a}	8.00 ± 1.03^{a}
D.	7.76 ± 0.72^{a}	7.60 ± 1.14^{a}	7.65 ± 1.04^{a}	7.80 ± 77^{a}	7.90 ± 0.91^{a}
E.	7.90 ± 1.02^{a}	8.20 ± 1.07^{a}	7.80 ± 1.04^{a}	8.10 ± 0.97^{a}	8.36 ± 0.67^{a}

Legend
A. Traditional Shea butter.
B. Commercial vegetable oil.
C. Improved Shea butter from fried Shea kernels
D. Improved Shea butter from toasted Shea nut
E. Improved Shea butter from boiled Shea kernels
±: Standard Deviation
Values are mean sensory scores and standard deviation of triplicate analysis.
Values with same letter on a column are not significantly different ($p \geq 0.05$).

Table 5. Sensory scores of selected improved shea butter at ambient storage (56th day)

Samples	Colour	Mouth feel	Taste	Aroma	Overall Acceptability
A.	3.40± 0.88[d]	2.45± 1.10[b]	2.40 ± 1.05[c]	2.30± 1.23[b]	2.56 ± 1.15[b]
B.	2.25± 0.91[c]	2.55± 1.06[b]	2.45 ± 1.15[c]	2.75± 1.12[b]	2.70 ± 0.86[b]
C.	8.05± 1.23[a]	7.50± 1.73[a]	8.15 ± 1.23[a]	8.20± 1.11[a]	8.20 ± 1.36[a]
D.	7.90± 1.40[a]	7.54± 1.39[a]	7.56± 1.12[a][b]	7.75± 1.45[a]	7.95 ± 1.45[a]
E	7.80 ±1.32[b]	7.10± 1.29[a]	7.10 ± 1.11[b]	7.85± 1.09[a]	7.96 ± 1.36[a]
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Legend
A. Traditional Shea butter.
B. Commercial vegetable oil.
C. Improved Shea butter from fried Shea kernels
D. Improved Shea butter from toasted Shea kernels
E. Improved Shea butter from boiled Shea kernels.
±: Standard Deviation
Values with same letter on a column are not significantly different ($p \geq 0.05$).

Table 6. Sensory Scores of Improved Shea butter at Ambient Storage (70th Day)

Samples	Colour	Mouth Feel	Taste	Aroma	Overall Acceptability
A.	2.80±1.20[b]	2.60 ± 0.99[b]	2.45±0.83[b]	2.40± 1.31[b]	2.30 ± 1.17[b]
B.	2.60±1.23[b]	2.30 ± 0.92[b]	2.90±1.12[b]	2.35± 1.09[b]	2.30 ± 1.13[b]
C.	7.10 ± 10[a]	7.30 ± 1.69[a]	7.80±1.32[a]	7.70 ±1.49[a]	7.85 ± 1.90[a]
D.	7.00± 1.78[a]	7.65 ± 1.57[a]	7.60±1.39[a]	7.90± 1.59[a]	7.55 ± 1.43[a]
E.	7.50± 1.57[a]	7.60 ± 1.43[a]	7.90±1.21[a]	7.45± 1.60[a]	8.05 ± 1.36[a]

Legend
A. Traditional Shea butter.
B. Commercial vgetable oil.
C. Improved Shea butter from fried Shea kernels
D. Improved Shea butter from toasted Shea kernels
E. Improved Shea butter from boiled Shea kernels

±: Standard Deviation
Values are mean sensory scores and standard deviation of triplicate analysis.
Values with same letter on a column are not significantly different ($p \geq 0.05$).

Table 7. Sensory scores of improved shea butter under ambient storage (84th day)

Samples	Colour	Mouth Feel	Taste	Aroma	Overall Accept
A.	5.15 ± 1.19b	3.10 ± 0.91b	3.75 ± 0.97b	3.35 ± 1.14c	4.15 ± 0.81b
B.	3.60 ± 0.75b	3.50 ± 0.10b	3.50 ±1.34b	4.06 ± 1.0b	4.00 ± 1.13b
C.	7.75 ± 1.12a	7.75 ± 0.97a	7.96 ± 1.15a	7.90 ± 0.97a	8.00 ± 1.03a
D.	7.76 ± 0.72a	7.60 ± 1.14a	7.65 ± 1.04a	7.80 ±0.77a	7.90 ±0.91a
E.	7.90 ± 1.02a	8.20 ± 1.07a	7.80 ± 1.01a	8.10 ± 0.97a	8.36 ± 0.67a

Legend

A. Traditional shea butter.
B. Commercial vegetable oil.
C. Improved shea butter from fried shea kernels
D. Improved shea butter from toasted shea kernels
E. Improved shea butter from boiled shea kernels
±: Standard Deviation
Values are mean sensory scores and standard deviation of triplicate analysis.
Values with same letter on a column are not significantly different ($p \geq 0.05$)

Table 8. Sensory scores of improved shea butter at ambient storage (98thday)

Samples	Colour	Mouth feel	Taste	Aroma	Overall Acceptability
A.	5.81 ±2.65c	2.95 ± 1.85b	3.35 ±1.60b	2.60 ± 1.67c	3.65 ± 2.16b
B.	4.05 ± 1.85b	3.40 ± 1.70b	3.65 ±1.66b	4.00 1.69b	3.70 ±2.20b
C.	7.25 ± 1.33a	7.30 ± 1.89a	6.80 ± 1.67a	7.55 ± 1.23a	7.20 ± 1.44a
D.	7.25 ± 1.68a	7.20 ± 164a	7.25 ± 1.37a	7.10 ± 1.41a	7.30 ± 1.42a
E.	8.05 ± 1.05a	7.75 ± 1.33a	7.35 ± 1.81a	7.90 ± 1.12a	8.10 ± 1.17a

Legend

A. Traditional shea butter.
B. Commercial vegetable Oil.
C. Improved shea butter from fried shea kernels
D. Improved shea butter from toasted shea kernels
E Improved shea butter from boiled shea kernels.
±: Standard Deviation
Values are mean sensory scores and standard deviation of triplicate analysis.
Values with same letter on a column are not significantly different ($p \geq 0.05$).

Table 9. Sensory Scores of Improved Sheabutter at Ambient Storage(112th day)

Samples	Colour	Mouth feel	Taste	Aroma	Overall Acceptability
A.	3.15±1.34c	2.45± 1.10c	2.40±0.10c	2.95±1.05b	2.75 ± 1.25c
B.	4.00± 1.30b	3.20±1.54b	3.55±1.67b	3.45± 1.57b	3.65 ± 1.42b
C.	7.65± 1.23a	7.40± 1.05a	7.45±1.23a	7.30± 1.45a	7.80 ± 1.11a
D.	7.80± 1.01a	7.75± 0.85a	7.10±1.55a	7.25± 1.37a	7.85 ± 0.88a
E	7.35± 1.04a	7.60±0.99a	7.85±0.99a	7.45± 1.32a	7.90 ± 1.02a

Legend

A. Traditional Shea butter.
B. Commercial vegetableoil.

C. Improved Shea butter from fried shea kernels
D. Improved Shea butter from toasted shea kernels
E. Improved Shea butter from boiled shea kernels
±: Standard Deviation
Values are mean sensory scores and standard deviation of triplicate analysis.
Values with same letter on a column are not significantly different ($p \geq 0.05$).

3.2 Microbial changes of improved shea butter during storage

The microbial changes in improved shea butter samples under ambient storage are shown on Table 10. There were no noticeable microbial growth on the media (nutrient and potato dextrose agar) throughout the weeks of storage and this could be due to the preservative effect of the citric acid treatment on improved shea butter and the aseptic condition during processing and storage.Shea butter had been reported to be antimicrobial (Soladoye *et al.*, 1989). However, Megnanou *et al*. (2007) reported high contamination of shea butter samples with microorganisms such as aerobic mesophilic bacteria, coliforms yeasts, moulds and Salmonella spp in collected from local markets in Cote d'Ivoire. Proper handling and aseptic packaging of shea butter during and after processing operations will prevent microbial contamination of shea butter

Table 10. Microbial changes of selected improved shea butter at ambient storage

Samples	1	2	3	4	5	6	7	8	9	10	11	12	Weeks
A	-	-	-	-	-	-	-	-	-	-	-	-	-
B	-	-	-	-	-	-	-	-	-	-	-	-	-
C	-	-	-	-	-	-	-	-	-	-	-	-	-
D	-	-	-	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-	-	-	-	-	-	-

Legend
-No microbial growth observed.
A.Traditional Shea butter.
B. Commercialil.
C. Improved Shea butter from fried Shea kernels
D. Improved Shea butter from toasted Shea nut.
E. Improved Shea butter from boiled Shea kernels
±: Standard Deviation
Values are mean sensory scores and standard deviation of triplicate analysis.
Values with same letter on a column are not significantly different ($p \geq 0.05$).

3.3 Peroxide value changes of improved shea butter during storage

Table 11shows the peroxide value changes in shea butter during 12weeks storage under ambient storage in transparent plastic containers. The peroxide values of improved shea butter ranged from 2.00 to3.40, 2.20 to 3.70 and 2.35 to 3.50 (meq/kg^{-1}) for toasted, boiled and fried shea from the 1st day to the12th week of storage respectively. Peroxide value (PV) is an indication of the extent of oxidation by the oil at the early stage of rancidation. It is the number that expresses in milli- equivalents of active oxygen the quantity of peroxide in 1000g of the oil sample. Though peroxide value is possibly not directly responsible for the taste and odour of rancid fats, their concentration as represented by the PV is useful in assessing the extent of oxidative rancidity. Pearson (1999) reported that high peroxide value (>10meqkg^{-1}) is associated with the development of rancidity in fats and oils and limits their use in the food industries. Sheabutterlike other fats and oils are susceptible to deteriorative changes which can lead to rancidity. In this study, throughout the storage period, the PV of not more than 10meqkg^{-1}was obtained for all the fats and oils examined. This indicates their good quality and non-rancidity. Similar low peroxide values were obtained for non-rancid peanuts, palm oil, canola oil and soya bean oil by Gan *et al.* (2005). The low peroxide values of improved shea butters suggest that they can be stored for a longer period without deterioration except reversion sets in. Fats and oils become rancid when the PV ranges from

20.00 to 40.00meqkg^{-1}(Pearson, 1999).The presence of antioxidants such as phytosterols, tocopherols, vitamin A and C as well as the effect of citric acid prevented the rancidity of the improved shea butter samples during storage.

Some crude shea butter extracted by traditional method has high peroxide value (Akingbala *et al*., 2007). This might be due to lipoxygenase catalyzed lipid oxidation and non-treatment of fat with an antioxidant like citric acid. Akingbala *et al*. (2007) also noted that bleaching and storage at higher temperature of 63^{0}C increase the tendency of shea butter to rancidity. Improved shea butter samples in this work were not bleached and were stored at room temperatureof not more than 28^{o}C. The irregular slight increment in the peroxide values of some of the shea butter samples might have been due to the presence of water in the samples as Gilliard (1999) reported that the presence of water could cause rapid oxidation of unesterified poly unsaturated fatty acids. Murthi*et al*. (1987) noted that PV changes of edible oils stored at ambient temperature were not regular. Storage in transparent plastic could increase the PV as light accelerate auto and photo – oxidation. This study was however carried out in a laboratory under subdued light.

Peroxide value of traditional shea butter and commercialvegetable oil increased faster than those of citric acid solution treated shea butter. During traditional and other processing methods of shea butter, the shea oil is usually boiled very well. This helps to ensure low moisture content and destroys spoilage microorganisms which could lead to spoilage during storage. This treatment, the presence of natural anti-oxidants as well as the anti-oxidative effect of citric acid could have contributed to the good keeping quality of improved shea butter samples. Honfo *et al.(*2011) reported that storage conditions and packaging are key constraints for quality assurance of shea butter during storage in Sudan Savannah Africa. Since method of storage of traditional shea butter vary across and among the processors, traders and consumers, quality and the marketability of shea butter are affected. Improvement of shea butter quality, acceptability and keeping quality by citric acid and flavour adds value to shea butter. The Peroxide values of the shea butter samples examined in this work are within the specified standard of 10 Meq/kg for fresh edible oil (Regional Technology Committee Comment on Draft African regional standards for unrefined shea butter, 2006).

Table 11. Peroxide value (meq kg $^{-1}$) changes of improved shea butter at ambient storage

Samples	1	2	3	4	5	6	7	8	9	10	11	12weeks
A	3.90	3.40	3.00	4.50	4.80	4.60	5.00	5.70	6.00	6.40	8.00	8.20
B	3.80	3.00	2.80	5.20	6.00	5.60	7.00	7.80	6.40	9.00	8.70	10.00
C	2.35	2.70	1.80	2.50	2.56	2.60	2.45	2.75	1.90	2.90	2.30	3.50
D	2.20	2.60	2.00	2.40	2.60	2.80	2.30	3.50	2.60	3.10	3.20	3.70
E	2.00	2.70	2.60	2.40	2.20	2.10	2.20	2.10	1.90	2.4	3.20	3.80

Legend

A.Traditional Shea butter.
B.Commercial vegetable oil
C.Improved Shea butter from fried Shea kernels
D.Improved Shea butter from toasted Shea kernels
E.Improved Shea butter from boiled Shea kernels
Values are means of duplicate analysis

4. CONCLUSION

This study show a wide difference in the sensory attributes oflocally processed (traditional) shea butter and the citric acid treated improved shea butter samples during storage. The sensory scores of improved shea butter samples were higher and differed significantly from the traditional shea butter and the commercial vegetable during storage. The peak or optimal sensory quality of the traditionally processed shea butter was the fourteenth day while sensory scores of the improved shea butter improved and were acceptable after four months and may store for a longer time if kept. The samples were also not rancid as indicated by the peroxide values nor were microbial growth seen. Citric acid and coconut flavour therefore have positive effects on the sensory and keeping quality of shea butter during ambient storage.

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