



Effect of Methods of Heat Treatment of Shea Kernels on Minerals, Phytates, Oxalates and Vitamins Profiles of Shea Butter

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ABSTRACT

Shea butter is a vegetable fat of nutritional importance. This research work investigated on some minerals, vitamins, phytate and oxalate profiles of shea butters from fried, toasted, boiled and parboiled shea kernels. Minerals, vitamins and phytate and oxalate profiles of the shea butters were determined using standard methods. The method of heat treatment significantly influenced their distribution. Shea butters are minor sources of calcium (2.2×10^{-3} to 9.5×10^{-3} mg/kg), magnesium (0.8×10^{-3} to 7.9×10^{-3} mg/kg), sodium (0.1×10^{-3} to 2.4×10^{-3} mg/kg) and potassium (0.9×10^{-3} to 3.3×10^{-3} mg/kg). The heat treatment methods did not destroy phytates and oxalates of shea butter. The shea butters have good arrays of vitamins.

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Introduction

Vegetable fats and oils for domestic and industrial uses are increasingly becoming globally important in nutrition and commerce as sources of dietary energy, antioxidants, fat soluble vitamins, biofuels and raw materials for the manufacture of industrial products [1, 12 and 14]. They are useful in food, pharmaceutical, chemical and cosmetics industries. Palm fruit and its kernels, groundnut, cotton seed and soybeans are conventional oil seeds in Nigeria. Their pooled vegetable oils are not enough for the booming population and without importation which mounts heavy strain on the country's foreign exchange; Nigeria cannot meet her domestic demand [2].

Shea kernels from shea tree, (*Vitellaria paradoxa*) is an under-utilized economic oil crop with great potentials for the Nigerian economy. [3] reported that it is a potential asset for national economic development and adequate exploitation of it could make significant contribution to Nigeria's Gross Domestic Production. The shea butter plant is deciduous, perennial, tropical oil-yielding tree belonging to the family Sapotaceae. [3] reported that shea butter tree is the second most important oil-yielding tree in Africa after oil palm and it grows naturally throughout the Guinea Savannah region.

Shea butter is a complex fat lipid product obtained from dried kernels of shea tree fruits. In its pure and unrefined state it is an all-natural product that has been around for centuries [4]. According to [5 and 34] shea butter is rich in many unsaponifiable components and contains oleic acid (40-60%), stearic acid (20-50%), palmitic acid (2-9%), linolenic acids (<1%) and arachidic acid (<1%) and phytosterols. Shea butter is sold in the local and international markets for different purposes [6, 7]. Its processing is widely done in places where the tree grows from West Africa to East Africa. Processing methods differ from place to place. The nuts could be fried, toasted or roasted, boiled or parboiled before oil extraction which could be manual, mechanical or by the use of chemical solvents [7, 8, 9, 10 and 34].

Shea butter is rich in saponifiables, unsaponifiable matter, antioxidants, fat soluble vitamins, minerals, carotenes, cinnamic acid, has healing properties and it is a promising multi-functional fat in the industries [4, 12, 13]. In Europe, shea butter compares favourably with cocoa butter in the chocolate and confectionery industries because they have similar melting point of 32 - 45°C [14]. However, in most producing areas in Nigeria it has low acceptability as an edible fat by most people due to poor processing and presentation [2, 15]. The colours of manually extracted natural shea butter vary from cream-like (whipped butter) to grayish-yellow with a nutty aroma. Most of the published works on shea butter centre on solvent extracted shea butter which is an expensive technology for adoption especially in developing countries. The product may also be health hazardous. The physico-chemical properties of solvent extracted shea butter from raw shea nuts have been widely reported by several researchers [14, 9, 16, 17]. [18] reported on the physico-chemical properties of manually extracted and screw pressed shea butter from roasted shea kernels while [9] reported on the physical and chemical characteristics of shea butter from parboiled shea kernels in Southern Chad.

There is however, paucity of information on the vitamins, minerals and antinutrients profiles of manually extracted shea butters from fried, toasted, boiled and parboiled shea kernels. To increase the knowledge base and awareness of the nutritional benefits of shea butter, there is the need to investigate on these. This is the purpose of this work. The information from this study will be useful to other researchers, producers and consumers of shea butter.

Methodology

Source of Materials

Shea kernels used for this work were obtained from the Federal College of Freshwater Fisheries Technology New Bussa and a nearby village, Monnai both in (Kainji lake area) Borgu L.G.A of Niger State, Nigeria. The traditionally processed shea butter was purchased from Monnai village and the commercial

vegetable oil from Okpalagu Supermarket, New Bussa, Niger state Nigeria.

The study area

New Bussa, the head quarter of Borgu local government area (Kainji lake area) of Niger state, Nigeria is situated between latitude $9^{\circ} 50'$ to $10^{\circ} 57'$ N and longitude $40^{\circ} 25' - 40^{\circ} 45'$ E with a surface area of $1,270\text{km}^2$. It lies at the border of sub-Sudan and Guinea Savanna. The typical vegetation of the area is characterized by tall grasses and land with tall trees forming canopies. The climate is under the control of two main winds the Sudan-west monsoon winds from the Atlantic Ocean and the East trade winds from the South regions thereby giving two distinct seasons [19].

The cool and rainy season is between May and October and the hot dry is between October and May. Average annual rainfall is between 900mm – 1000mm for seven months. Local microclimate may alter this from Yelwa to Mokwa on the influence of the Lake Kainji. Immediately before the rainy season, diurnal temperature rises up to about 38°C in March due to greenhouse effect. The average duration of sunshine is four to five hours mostly shaded by the rain clouds of April to October. Relative humidity is lowest in January (30%) and highest in August (98%). Evaporation is highest in March and April and lowest in July to September [19]. This climate favours the establishment and yield of shea butter and other economic and non-economic trees.

Preparation of samples for processing

The samples were prepared according to the method of [34]. Ripe fresh shea fruits were handpicked, left to ferment for 3 days at ambient temperature, washed, parboiled for 10 minutes, sundried, cracked, winnowed and further dried to approximately 10 - 11% moisture content. The dried kernels were stored in sacks and kept in well ventilated shade at ambient temperature ($26\pm 2^{\circ}\text{C}$) till required for processing. Before use, the stored, dried, shea kernels were washed and sun dried for 4 to 5 hours.

Heat Treatment Methods

Frying method

Six kilograms of clean, dried shea kernels were fried with approximately 530 ml of previous shea butter oil (from the local processors) for about 30 minutes in a metallic pot. The initial frying temperature of 180°C was reduced to $85\pm 5^{\circ}\text{C}$ after 5 minutes to avoid burning and decrease in yield [20]. The fried shea kernels were cracked and sizes 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 five (5) kilogram of shea paste.

Toasting method

Six kilograms of cleaned shea kernels were toasted at 180°C for 5 minutes and continued at $85\pm 5^{\circ}\text{C}$ for 25 minutes (modified from [10] village method) in a metallic pot without oil. The toasted shea kernels were cracked using hammer mill and the size further reduced with mortar and pestle before grinding and extraction of shea butter from 5kg shea paste.

Boiling method

A modified method of [8] was used. Six kilograms of cleaned shea kernels were boiled at 100°C 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.

Parboiling method

Six kilograms of stored parboiled shea kernels adopted from Monnai village after a survey and [9] were washed and sun dried for four hours before size reduction, grinding and oil extraction

from 5kg shea paste. This served as the control. All the shea kernels were parboiled before further treatment.

Manual extraction method

Five kilograms of the 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 hand-churned till a brownish white shea fat separated from the brownish water solution. The shea fat was 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. The flow charts are as shown in Figures 1 and 2.

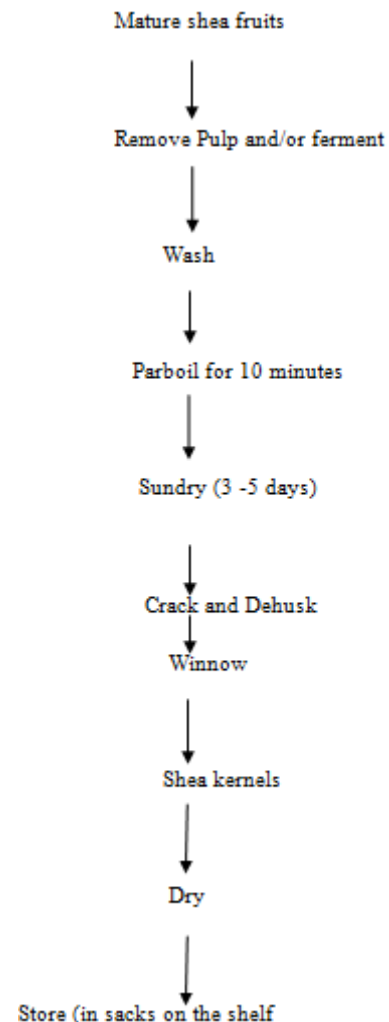


Figure 1. Preparation of shea fruits before shea butter extraction

Analysis

Minerals: After ashing and digestion, Standard of Calcium, Magnesium, Potassium and Sodium solutions of 0.2, 0.4, 0.6, 0.8 and 1.0mg/l were made from each of the heavy metals solution of 1000mg/l stock solutions of the analytes. The set of standard solutions and filtrate of the digested samples were analyzed by AAS. The detection limit of the metals in the sample was 0.0001mg/l by means of the UNICAM 929 London, Atomic Absorption Spectrophotometer powered by the SOLAAR software. Calcium, Magnesium, Potassium and sodium cathode lamps were used for the analysis of the respective

minerals in the standards and the filtrate of the samples according to 942.05, [21]. Gas mixtures were used in the generation of the flame.

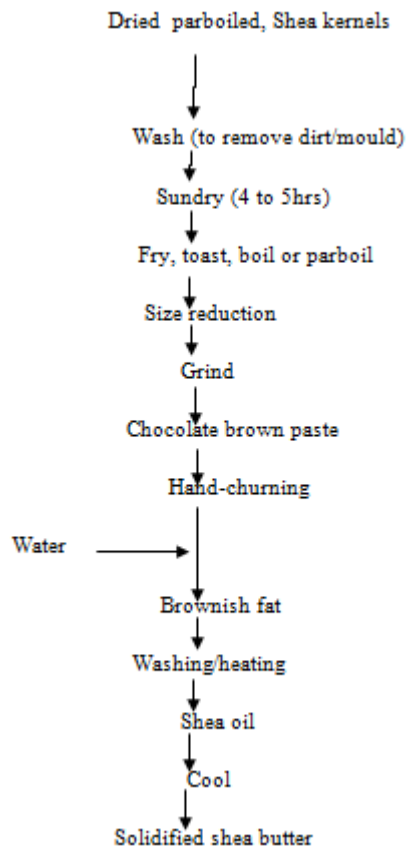


Figure 2. Manual processing of shea butter from (fried, toasted, boiled or parboiled shea kernels)

Determination of Phytate: Phytate content was determined following the modified method of [22]. Four grams of the melted fats were soaked in 100ml of 2% HCl for 3 hours and then filtered off. 0.5g of the filtered sample was placed in a 125ml of Erlenmeyer flask and extracted with 25ml of 3% trichloro acetic acid for 45 min in a shaker of moderate speed at room temperature. 3ml of the 1% $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ was added to the mixture and centrifuged for 10 minutes at $20,000 \times g$ and later incubated at room temperature. The precipitate was washed twice with 0.5N HCl allowing a 10 min incubation period between each wash. 3ml of 1.5N NaOH and 7ml of distilled water were added to the precipitated ferric phytate and heated in a boiling water bath for 15 min. It was cooled and centrifuged. The Supernatant was used for the phytate value determination according to [3].

Determination of oxalate

Oxalate content of samples was determined using the modified method of [23]. The sample was soaked in the deionized water. The mixture was sieved through a 0.20 mm sieve. The solid residue was further worked on and the procedure was repeated for the removal of the liquid until the sample was free of the fluid. The combined fluid was poured into the 1 liter glass jar for the calcium oxalate crystals. The crystallization continued until the supernatant was removed by draining off.

Vitamins: These were determined using Hewlett Packard 6890 gas chromatography powered with HP chem. Station Rev. AO9.01 (1206) software according to 92.03, 92.04 and 992.26 modified methods of [21]). Nitrogen was used as the carrier gas at a flow of 1.0ml/min, split ratio of 20:1 and inlet temperature of 250°C . The column type was HP5 and the dimension was $30\text{m} \times$

$0.25\mu\text{m}$. The oven program was set initially at 50°C for 2 minutes, first Ramp at 100°C for 20 minutes and maintained for 40 minutes. The second Ramp at $15^\circ\text{C}/\text{min}$ for 4 minutes, constant for 2 minutes. PFPD detector was used in detecting each analyte with these features: Detection temperature 320°C , hydrogen 20psi and compressed air of 30psi.

Statistical Analysis

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

Results and Discussions

Minerals and some anti-nutrients of shea butter

Effects of different heat treatment methods of shea kernels on some minerals and antinutrients (mg/100g) of manually extracted shea butter are as shown on Table 1. The shea butter samples are poor sources of calcium, magnesium, sodium and potassium. The calcium content of native shea butter ($9.5 \times 10^{-3} \pm 0.3 \times 10^{-3}$) significantly differed ($p \leq 0.05$) from others. This could be due to the prolonged frying of the shea kernels and oil at high temperatures. The method of heat treatment of the shea kernels affected the mineral content of shea butter. [9] reported higher average values of 4.21 ± 0.34 , 1.11 ± 0.12 and $21.72 \pm 1.83\text{mg/kg}$ of calcium, magnesium and potassium for the dried fruit pulp while [24] reported higher concentration in mg/100g of sodium (38.4), potassium (1825), magnesium (96.6) and (103) in shea kernels seed. Most of these minerals in shea kernels are not extracted into the shea butter during processing. [25] reported that shea butter leaves have high magnesium content (19.16mg/kg) and low potassium (0.61mg/kg). Potassium is vital in maintaining the body fluid/osmotic equilibrium and regulate blood pressure [26]. The authors reported that calcium, magnesium, sodium and potassium as micronutrients are needed by human for formation of strong bones, growth, maintenance, neuromuscular contraction and effective metabolic processes. Since these minerals are low in shea regular consumers of shea butter will require more dietary intake of food rich in these minerals.

The phytate contents (mg/100g) of manually extracted shea butter from toasted, fried, boiled and parboiled shea kernels are also shown on Table 1. The phytate content of hand-churned shea butter from fried shea kernels was the highest $5.08\text{ mg}/100\text{g}$ while the phytate content of boiled shea kernels shea butter was the least. From the results obtained from this work, boiling of shea kernels had a more destructive effect on phytate than frying. This might be due to the mode and mechanism of heat penetration into the cells of the shea kernels. [24] reported a phytate concentration of $145\text{mg}/100\text{g}$ in defatted shea kernels. [25] reported that shea butter leaves have a mean phytic content of $0.19 \pm 0.05\text{mg}/100\text{g}$ which is lower than those obtained from this work. The differences might be due to the fact that phytates migrate to the shea kernels and its butter as they are produced. The phytate values obtained in this work are lower than those of [27] and this could be due to the variety of the shea kernels, geographical locations, methods of processing and analysis.

Phytate (myo-inositol hexaphosphate) is the saturated cyclic salt or ester form of phytic acid and it is the principal storage form of phosphorus in plant tissues of legumes, nuts, seeds and cereals that are high in fiber such as soybeans, oatmeal, corn and peanuts. The mineral phosphorous is needed for many of the chemical reactions in the body. Phytates though anti-nutrients and like other anti-nutrients could bind to certain dietary minerals such as iron, zinc, manganese and calcium, they help to regulate the release of energy that fuel the body [26]. [28] reported that there are no scientific data suggesting that

eating whole soy foods which is rich in phytate leads to mineral deficiencies in human. The authors noted that the presence of phytate in foods is not a problem as some people believe it to be as phytates help to normalize cell growth, proper bone formation, stops the spread of cancer cells, lowers foods glycemic load and prevent cardiovascular diseases. In a study on phytate and risk factor for osteoporosis, [29] reported that bone mineral density increased with increased phytate consumption. The authors concluded that phytate consumption had a protective effect against osteoporosis and suggested that low phytate consumption is a risk factor in osteoporosis. [30] recently reported on the protective effect of phytate (myo-inositol hexaphosphate) on bone mass loss in post menopausal women. Oxalate content of manually extracted shea butter samples of boiled and parboiled shea kernels butters, ranged from $0.24 \pm 0.06 \times 10^{-3}$ to $0.27 \pm 1.5 \text{ mg} \times 10^{-3}/100\text{g}$ (Table 1). The value is higher than that of the commercial vegetable oil ($0.09 \text{ mg}/100\text{g}$) and lower than that of the native shea butter. Oxalate is dianion salt or esters of oxalic acid with the chemical formula of $\text{C}_2\text{O}_4^{2-}$. As reported by [31], oxalate can combine with some ionic metals to form kidney stones. Oxalates occurs in many plants where it is synthesised via the incomplete oxidation of carbohydrates. Oxalate rich plants include sorrel, carrot, parsley, spinach, cocoa, chocolates, beans, tea, sweet potatoes and beer. The occurrence of oxalate in shea butter should therefore not pose a problem to shea butter consumption as it is biodegradable as demonstrated by [31] and present in little quantity.

Legend

- A. Shea butter from toasted shea kernels
- B. Shea butter from fried shea kernels
- C. Shea butter from boiled shea kernels
- D. Shea butter from parboiled shea kernels

E. Native Shea butter

F. Commercial vegetable oil

±: Standard deviation

Values are mean and standard deviation of triplicate analysis.

Values with similar letter are not significantly different ($p \leq 0.05$)

Vitamins in shea butter

The vitamin profile of manually extracted shea butter samples are shown in Tables 2. There are significant differences in vitamin profiles of shea butter samples. The vitamin B3 content of the native shea butter is higher and differed ($p \leq 0.05$) from other shea butter samples. The vitamin B4 and B6 content of parboiled shea kernels shea butter are higher and differed ($p \leq 0.05$) from the other samples. Fried shea kernels butter had the least score of vitamin B6. According to [26] vitamin B6 also called pyridoxine ensures that biological processes including fat and protein metabolism take place in the body and it is also important in brain function by helping to create neurotransmitters.

B-complex vitamins are a group of substances which are considered essential because they must be obtained from diets. [32] reported that these vitamins serve as co-factors for numerous enzymatic pathways in the body and are not stored by the body as excesses are excreted in urine. Vitamin B1 of the shea butter samples ranged from 1.24 ± 0.17 to $1.64 \pm 0.04 \text{ mg}/100\text{g}$. B1 is a co-factor to the enzyme thiamine pyrophosphate (TPP) which participates in carbohydrate and protein metabolism and the synthesis of nucleic acid. Medically, vitamin B1 influences the neural impulse conduction in the synapse. Shea butter from toasted shea kernels has the highest vitamin B2 content and boiled shea butter the least. According to [32], B2 vitamins are co-factors to more than 100 flavoprotein

enzymes which catalyses oxidation-reduction reaction in cells and improves lipid, carbohydrates and amino acid metabolism. The authors further noted that physiologically, it participates in iron and porphyrin exchange, in haemoglobin synthesis and tissue respiration while Vitamin B6 phosphorylates to its active form pyridoxal phosphate (PLP) and it is involved in amino acid, histamine and free fatty acid metabolism.

Vitamin C content of shea butter samples ranged from 4.06 ± 0.03 to $4.32 \pm 0.08 \text{ mg}/100\text{g}$ (Table 2). The heat treatment method used during processing did not completely destroy the Vitamin C as expected. [33] reported vitamin C content of 102.1 ± 0.02 and $220.00 \pm 0.00 \text{ (mg}/100\text{g})$ for cooked pumpkin and treadsoftly (*Cnidioscolus acnoitifolicus*) leaves showing that heat does not completely destroy vitamin C. According to [32], vitamin C also called ascorbic acid is required for tissue growth and repair, proper adrenal gland function and healthy gums and it is known to protect against infection, aids the production of anti-stress hormones and enhances immunity. Vitamin C as an antioxidant preserves the shea butter as well as mops free radicals to prevent cancer. According to [26] Vitamin C may prevent or delay cataract formation, has antihistamine benefits and inhibits replication of HIV.

Vitamin E values of manually extracted shea butter from the toasted, fried, boiled and parboiled shea kernels are shown on Table 2 and ranged from 12.14 ± 0.02 to 14.40 ± 0.00 . [14] reported alpha tocopherol values of 26.3 to $44.403 \text{ mg}/100\text{g}$ in the shea oil samples from different districts of Uganda. Vitamin E is a known antioxidant that provide stability to fats and oils [4]. Vitamin E promotes normal blood clotting and healing, reduces blood pressure, relaxes leg cramps, increases fertility, prevents cancer and cardiovascular diseases [26, 32]. As an antioxidant, vitamin E prevents cell damage by inhibiting the oxidation of lipids (fats) and the formation of free radicals and protects the fat soluble vitamins from destruction by oxygen. [26] reported that there are eight different forms of vitamin E with d-alpha-tocopherol as the most potent. Vitamin E which is found naturally in shea butter is the most important fat soluble antioxidant in the lipid rich areas of the cells such as cell membrane and fat depots in human tissue. According to [32] low level of vitamin E in the body have been linked to bowel and breast cancer and deficiency may result in the damage of red blood cells and destruction of nerves. Shea butter, dark green vegetables, brown rice, wheatgerm and soyabeans are natural sources of vitamin E.

Vitamin D profile of the different shea butter differed significantly from each other and ranged from 7.20 ± 0.10 to $9.82 \pm 0.16 \text{ mg}/100$. The native shea butter and the commercial vegetable oil had lower Vit D content. [26] reported that vitamin D is responsible for getting the important bone builders calcium and phosphorus to the place in the body where they need to help bone to grow in children and remineralisation in adults. According to [26] deficiency of vitamin D leads to rickets in children and osteomalacia in adults, insufficient vitamin D in the body worsens osteoporosis a bone weakening disease that leads to fractures and tooth loss especially in the elderly. Other sources of vitamin D apart from the sun are fish, eggs, fortified milk and cereals.

Vitamin A in shea butters from this work are shown in Table 1. They are all below $1.50 \text{ (mg}/100)$. Adequate intake of food rich in vitamin A helps to prevent night blindness, skin disorders such as pimples and it is important in bones and teeth formation, aids in fat storage and protects against cold and kidney infections [26].

Table 1. Effect of method of heat treatment of shea kernel on some minerals, phytate and oxalate profiles of manually-extracted shea butter

Sample	Calcium (mg/kg)	Magnesium (mg/kg)	Sodium (mg/kg)	Potassium (mg/kg)	Phytate (mg/100g)	Oxalate (mg/100g)
A	$2.2 \times 10^{-3} \pm 1.5 \times 10^{-3b}$	$7.9 \times 10^{-3} \pm 0.1 \times 10^{-3a}$	$2.4 \times 10^{-3} \pm 0.1 \times 10^{-3a}$	$3.3 \times 10^{-3} \pm 0.2 \times 10^{-3a}$	$4.64 \pm 6.6 \times 10^{-3d}$	$0.25 \pm 1.0 \times 10^{-3c}$
B	$2.3 \times 10^{-3} \pm 0.1 \times 10^{-3b}$	$0.8 \times 10^{-3} \pm 0.1 \times 10^{-3c}$	$0.9 \times 10^{-3} \pm 0.0001^d$	$2.4 \times 10^{-3} \pm 0.1 \times 10^{-3b}$	$5.08 \pm 5.1 \times 10^{-3f}$	$0.24 \pm 2.0 \times 10^{-3b}$
C	$3.1 \times 10^{-3} \pm 0.1 \times 10^{-3b}$	$1.2 \times 10^{-3} \pm 0.1 \times 10^{-3b}$	$1.3 \times 10^{-3} \pm 0.0001^c$	$1.3 \times 10^{-3} \pm 0.1 \times 10^{-3d}$	$3.96 \pm 5.3 \times 10^{-3b}$	$0.27 \pm 1.5 \times 10^{-3e}$
D	$3.8 \times 10^{-3} \pm 0.2 \times 10^{-3b}$	$1.2 \times 10^{-3} \pm 0.1 \times 10^{-3b}$	$1.3 \times 10^{-3} \pm 0.0001^b$	$1.5 \times 10^{-3} \pm 0.2 \times 10^{-3c}$	$4.47 \pm 3.1 \times 10^{-3c}$	$0.24 \pm 2.0 \times 10^{-3b}$
E	$9.5 \times 10^{-3} \pm 0.3 \times 10^{-3a}$	$1.2 \times 10^{-3} \pm 0.1 \times 10^{-3b}$	$0.1 \times 10^{-3} \pm 0.0 \times 10^{-3c}$	$0.9 \times 10^{-3} \pm 0.1 \times 10^{-3e}$	$4.96 \pm 4.0 \times 10^{-3e}$	$0.26 \pm 0.6 \times 10^{-3d}$
F	$3.4 \times 10^{-3} \pm 4.8 \times 10^{-3b}$	$3.4 \times 10^{-3} \pm 4.8 \times 10^{-3b}$	$0.1 \times 10^{-3} \pm 0.1 \times 10^{-3e}$	$0.1 \times 10^{-3} \pm 0.0 \times 10^{-3f}$	$2.16 \pm 2.0 \times 10^{-3a}$	$0.09 \pm 2.5 \times 10^{-3a}$

Table 2. Effect of heat treatment method on the vitamin profile of manually extracted shea butter

Sample	Vitamin B3 (mg/100)	Vitamin B4 (mg/100)	Vitamin B6 (mg/100)	Vitamin C (mg/100)	Vitamin A (mg/100)	Vitamin B1 (mg/100)	Vitamin B2 (mg/100)	Vitamin D (mg/100)	Vitamin B9 (mg/100)	Vitamin E	Vitamin K
A	2.42 ± 0.22^b	1.10 ± 0.0^d	3.69 ± 0.07^d	3.69 ± 0.06^c	1.08 ± 0.03^b	1.60 ± 0.04^a	1.45 ± 0.29^a	9.34 ± 0.04^b	1.03 ± 0.00^e	12.68 ± 0.0^e	7.18 ± 0.02^d
B	2.47 ± 0.02^b	1.16 ± 0.02^d	1.05 ± 0.01^d	4.13 ± 0.02^a	1.10 ± 0.04^b	1.64 ± 0.04^a	1.33 ± 0.02^b	9.82 ± 0.16^a	9.36 ± 0.27^b	13.73 ± 0.04^c	9.14 ± 0.06^a
C	1.94 ± 0.01^d	9.00 ± 0.04^b	8.29 ± 0.07^c	3.61 ± 0.03^d	1.19 ± 0.14^b	1.24 ± 0.17^c	1.08 ± 0.01^c	7.20 ± 0.10^d	7.99 ± 0.07^d	12.14 ± 0.02^f	7.60 ± 0.05^c
D	1.86 ± 0.02^e	9.53 ± 0.40^a	9.30 ± 0.27^b	3.63 ± 0.03^c	1.09 ± 0.00^b	1.47 ± 0.02^{bc}	1.15 ± 0.02^b	8.64 ± 0.08^c	8.22 ± 0.04^c	12.78 ± 0.03^d	8.13 ± 0.06^e
E	3.91 ± 0.28^a	2.13 ± 0.02^c	9.21 ± 0.03^b	4.06 ± 0.04^a	1.25 ± 0.0^a	1.51 ± 0.00^b	1.33 ± 0.02^a	1.17 ± 0.02^e	9.70 ± 0.10^a	14.40 ± 0.06^b	1.25 ± 0.02^e
F	2.21 ± 0.05^c	1.04 ± 0.01^d	9.84 ± 0.10^a	3.97 ± 0.05^b	1.16 ± 0.03^b	1.45 ± 0.01^b	1.13 ± 0.02^{bc}	1.05 ± 0.02^d	8.11 ± 0.02^{cd}	15.13 ± 0.02^a	1.05 ± 0.01^f

Vitamin A as a good antioxidant also prevents oxidative rancidity of fats and oils, helps to mop free radicals which can cause cancer and other disease as well as slows the aging process [32]. Other natural sources of vitamin A include carrot, sweet potatoes and mangoes.

Vitamin K values of manually-extracted shea butter from fried, toasted, boiled, and parboiled shea kernels are shown in Tables 2. The fried shea kernels shea butter had the highest values of vit A (9.14 /100mg/100g) when manual extraction method was used. From the results, frying and boiling of shea kernels tend to favour the extraction of vitamin K than toasting and parboiling. Though required in minute quantity, [32] reported that vitamin K is needed in the body in the production of prothrombin which is useful in blood clotting, bone formation, repair and in the synthesis of osteocalcin, a protein in the bone tissue on which calcium crystalizes thus could prevent osteoporosis. Shea butters have higher values of vitamin K than the commercial vegetable oil used as control.

Minerals and vitamins are essential in nutrition of children and pregnant women as well as for the care of hairs, nails and skin of humans. Like water, carbohydrates, proteins, fat/oils, vitamins and minerals are essential to life. They are referred to as micronutrients because they are needed in relatively small quantities for proper body functions. Due to the importance of minerals and vitamins, there are recommended minimum amount needed to prevent deficiency diseases.

Legend: A. Shea butter from toasted shea kernels

B. Shea butter from fried shea kernels

C. Shea butter from boiled shea kernels

D. Shea butter from parboiled shea kernels

E. Native shea butter

F. Commercial vegetable oil

±: Standard Deviation (SD)

Values are mean and standard deviation of triplicate analysis.

Values with same letter in a column are not significantly different ($p \geq 0.05$).

Conclusion

The shea butters are minor sources of minerals and oxalates and good sources of phytates and vitamins. The method of heat treatment of shea kernels affected the minerals, phytate, oxalate and vitamin distribution (profiles) of shea butter. This should be taken into cognizance by processors, consumers and when setting standard for shea butter. Oxalates and phytates though anti nutrients have nutritional importance in diet and health.

Conflict of interest: "The authors declare that there is no conflict of interests regarding the publication of this paper."

References

- Oresanya, M.O, Ebuehi O.A.T, Aitezemuller K and Koleosho O.A. 2000.Extraction of guna melon (*Citrulluscolocynthis*) seed oil. *Nigerian Journal of Natural products and Medicine*4: 74 - 76
- Garba, I.D, Nwawe, C. N. And Oisakede, I. L. 2011. The potentials of shea kernels tree to the Nigeria Economics. *International journal of Agricultural Economics and rural Development* 4. 1: 62-77
- Poulsen, G. 1990. Important forest product in African other than woody – A preliminary study (project report RAF/78 /025). FAO Rome
- Alander, J. 2004 Shea butter – a multifunctional ingredient for Food and Cosmetics.*Lipid technology*16.9: 202-205
- Dovrieux, F., Llaal, F. Piombo G., Kelly, B., Okullo J B., Thaim M., Diallo, O.B and Bouvet J.M 2010.Near Infrared Spectroscopy for high- throughput characterization of shea tree

Vitellariaparadoxa) nut fat profiles. *Journal of Agriculture and Food Chemistry* 58: 7811-7819

6.Booth, F.E.M. and Wickens, G.E. 1980. Non-timber uses of selected arid Zone tree and slumps in African. F.A.O. *Conservation guide*. 19: 1 -176.

7.Carr, M., Chen, M., Tate, J. 2000. Globalization and home based workers. *FeministEconomics* 6 .3.23 -142.

8.Fobil, J. N. 2002. Research and Development of shea tree and its products. University of Ghana [http: 11 www. Solution site.org/catll. Sol.1](http://11www.Solution site.org/catll.Sol.1) retrieved 3/10/2009

9.Mbaigninam, M., Mbayhoudel K and DjekofaC., 2007. Physical and chemical characteristics of fruits, Pulps, Kernel and Butter of shea*Butyrospermumparkii* (Sapotaceae) from Mandol, Southern Chad. *Asain Journal of Biochemistry* 2. 2: 101-110

10. Coulibaly, Y, Ouedraogo S and Niculescu .N, 2010. Experimental study of shea butter extraction efficiency using a centrifugal process *ARPN Journal of Engineering and Applied Sciences* 4. 6: 14-19

11. Addaquay.J. 2004. The Shea butter value Chain. *Refining in West Africa*.West Africa Trade Hub (WATH) Technical Report No 3 United State Agencies for International Development

12. Alander, J and Anderson. A 2004. The Shea butter family – the complete emollient range for Skin care formulations. *Cosmetics and Toiletries Manufacture Worldwide* 2002: 28 – 32

13. Nikiema, A.E andUmali, B. E., 2007. *Vitellariaparadoxa* C.F Gaertn. In Van der Vossen H.M. A and Mkamilo, G. S. (Editors). *PROTA 14: Vegetable oil/ Oleagineur*. (CD-ROM). PROTA, Wageningen. Netherlands.

14. Okullo JBL, Omujal F. Agea JG, Vuzi pc, Namutebi A, Okelle JBA, Nyamzy S.A 2010 Physical – chemical characteristics of shea butter (*Vitellaria paradoxa* C.F. Gartner) oil from the shea districts or Uganda. *African Journal of Food Agriculture, Nutrition and development*. 10.1: 2070 -2084

15. Ibanga, U.I. 2007.Utilization and Commercial Acceptability of Shea butter from *Vitelaria paradoxa* in Kainji Lake Area, Nigeria. *International Journal of Food and Research Agricultural Development Universal Consortia* 4: 241 – 246.

16. Chukwu, O and Adgidzi P. P. 2008 Evaluation of some physic – chemical properties of shea butter related to its value for food and industrial utilization. *International Journal of Post-harvest Technology and Innovation* 1. 3: 320-326.

17. Asuquo, J.E, Anusiem A.C and Etim E.E 2010. Extraction and characterization of shea butter. *World Journal of Applied Science and Technology* 2.2: 282-288

18. Akingbala, J.O., Falade, K.O, Adebisi, E. Baccus-Taylor G and Lambert, I. 2006. Effect of Processing on the yield, physico-chemical properties of Shea butter. *West Indian Journal of Engineering* 29: 73-80

19. Olorok, J.O. 1995. "Climate of Kainji LAKE Basin: 1925-1994". A report prepared for the Nigerian-German (GTZ) Kainji Lake Fisheries Promotion Project New Bussa, July, 1995, 99-108.

20. Olaniyan, A. M and Oje K, 2007Quality characteristics of shea butter recovered from shea kernel through dry extraction process. *J. Food Science and Technology* 4.44: 404 – 407

21. Association of Official Analytical Chemist (AOAC), 2006 13th edition.

22. Chitravadivu, C. Manian, S. Kalachelvi . K. 2009. Qualitative analysis *Research* .3. 4: 144-146.

23. Day, R. A and Underwood, A. L 1986. Quantitative analysis 5th edition. Prentice – Hall p 70.

24. Elemo, B.O., Elemo G.N., Oladimeji O. and Komolafe O. 2002. Studies on the composition of some nutrients and anti-

nutrients of shea kernels (*Butyrospermum parkii*) Nig. *Food Journal* 20: 69 -73

25. Abidemi, T.A, Adebayo O.J, Idowu. O and Agbotoba M.2009. Nutrient content and antinutritional factors in shea butter leaves. *African journal of Biotechnology* 8.21:5888 -5890

26. Feinsteinin .A, Craig S.N, Haigh J, Kaufman .B Maleskey .G and Michard .E 1996 Prevention's Healing with vitamins. Rodale Press, INC., Emmaus

27. Weil, A. 2010Phytate (Myo-inositol hexaphosphate and risk factor for osteoporosis. *Bioscience* 2: 1093-1998

28. Lopez – Gonzalez, A.A, Grases. F, Roca. P, Vicente – Herrero and Bauza A. C.2008. Phytate (myo-inositol hexaphosphate) and risk factors for osteoporosis. *Journal of Medicinal food*. 11.4: 747 – 752

29. Angel A, Lopez – Gonzales, Grase F, Monroy N, Teofila B. M, Vicente – Herrero, Tut .F and Prelo J., 2013 Protective Effect of Myo-inositol hexaphosphate (phytate) on bone mass

loss in Post-menopausal women. *European Journal of Nutrition*.52. 2: 717-726

30. Bette, T, and Fretadorff .B. 2005. Biodegradation of oxalic acid from spinach using cereals radicles. *J. Agric Food chemistry* 53.25: 9751 – 9758

31. Balch J. F and Balch P.A 2000 *Prescription for Nutritional Healing*. Penguin Publishing Group New York, USA. 352.

32. Onyeka, E.U, Agha J. C and Nwango A.C 2010. Phytochemical nutrient and nutrient content of *Cnidoscolusaconitifolicus*, a lesser known green leafy vegetable. *Nigerian Food Journal*, 2. 2: 14-20

34 Ibanga U.I, Adegoke G.O, Akinoso R. and Liman A 2015 Effect of Frying, Toasting, Boiling and Parboiling of Shea kernels on Fatty acids and phytosterol Profiles of manually extracted Shea butter.*Elixir Food Science* 81: 31525-31531

35 Pearson, D, 1999. *The Chemical Analysis of foods*.7thEdn, Church- Hill Livingstone London. 7-11.