



## Effect of Frying, Toasting, Boiling and Parboiling of Sheanuts on Fatty Acids and Phytosterols, Profiles of Manually Extracted Shea Butter

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### ARTICLE INFO

#### Article history:

Received: 29 January 2015;

Received in revised form:  
15 March 2015;

Accepted: 1 April 2015;

#### Keywords

Shea butter,  
Processing,  
Fatty acids,  
Phytosterols.

### ABSTRACT

Shea butter is an under-utilized edible fat of nutritional importance in Nigeria. Research reports have not related it to the processing methods which vary from place to place. This work evaluated the effect of heat treatment methods on fatty acid and phytosterol profiles of manually extracted shea butters from fried, toasted, boiled and parboiled sheanuts pastes. Fatty acids and phytosterols profiles were determined using standard methods and they were affected by heat treatment methods. Fried sheanuts butter had highest percentage stearic acid ( $42.46 \pm 0.12$ ), parboiled sheanuts butter highest oleic acid ( $47.96 \pm 1.76$ ) and boiled sheanuts the highest sitosterol content ( $117.31 \pm 0.1 \text{ mg/100g}$ ).

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### Introduction

Most edible fats and oils are lipids from plants sources. They may be solid or liquid at room temperatures below  $26^{\circ}\text{C}$  depending on their degree of saturation They are sources of fatty acids which could be saturated, monosaturated, polysaturated and unsaturated and also sources of essential fatty acids like linoleic, linolenic acids and phytosterols [1]. Essential fatty acids are important in growth and maintenance of normal skin [2]. Fats and oils help in the transportation and absorption of fat soluble vitamins A, D, E and K and provide satiety; improve the flavor and palatability of food.

There is a global surge in the demand for vegetable fats and oils for domestic and industrial uses. They are increasingly becoming important in nutrition and commerce because they are sources of dietary energy, antioxidants, biofuels and raw materials for the manufacture of industrial products and are useful in the food, pharmaceutical, chemical and cosmetics industries [3]. Convectional vegetable oils are from oil seed plants such as groundnut, soyabeans, melon, cotton seeds, sesame, palm and olive and they account for 80% of the world natural edible fat and oil supply [4, 5]. Oil is obtained from oil seeds by manual, solvent or mechanical extraction. Vegetable oils are locally used in cooking, production of soap and as body cream. Processing improves the quality and acceptability of vegetable oils [4].

Palm fruit and its kernels, groundnut, cotton seed and soya beans are conventional oil seeds in Nigeria. Their pooled vegetable oils are not enough for the booming population and without importation of vegetable oils Nigeria cannot meet her domestic demand [6]. Importation puts a heavy strain on the country's foreign exchange position. Sheanuts from the shea tree, (*Vitellaria paradoxa*) is an under - utilized economic oil crop with great potentials for the Nigerian economy and adequate exploitation could make a significant contribution to Nigeria's Gross Domestic Production [6].

The shea butter plant is a perennial tropical oil - yielding tree belonging to the family Sapotaceae. 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

[7]. Sheanuts contain up to 50% shea butter oil, a complex lipid of plant origin which has saturated, unsaturated and essential fatty acids [8, 9]. In Nigeria, shea butter is consumed only by local people in producing areas [10]. The contribution of shea butter to the worlds' edible oil supply is minimal. It however has great potentials to complement and compete with other vegetable fats and oils. In places of production, it is a cooking fat/oil, useful in soap production, cosmetics, pharmaceuticals and medicine [5, 11 and 6].

Most of the published works on the fatty acids and phytosterols of shea butter centre on solvent extracted shea butter which is an expensive technology for adoption [12, 5]. The product may also be health hazardous. Shea butter is manually extracted from fried, toasted, boiled and parboiled sheanuts in various parts of West Africa. There is paucity of information on the fatty acids and phytosterols profiles of these manually extracted shea butters. To increase the knowledge base and awareness of the nutritional benefits of shea butter, there is the need to investigate on these. The information from this study will be useful to the producers and consumers of shea butter.

### Materials and methods

#### Source of Materials

Sheanuts used for the work were bought at New Bussa in Borgu Local Government Area of Niger State Nigeria. The native shea butter was purchased from a nearby village, Monnai and the commercial vegetable oil from Okpalagu Supermarket, New Bussa and Nigeria.

#### The study area

New Bussa, the head quarter of Borgu local government area of Niger state, Nigeria is situated between latitude  $9^{\circ} 50' 100 57' \text{ N}$  and longitude  $40^{\circ} 25 - 40 45' \text{ E}$  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 [13].

The climate favours the growth of shea butter and other economic and non economic trees.

#### Preparation of samples for processing

Ripe fresh shea fruits were handpicked, left to ferment for 3 days at ambient temperature ( $26 \pm 2^{\circ}\text{C}$ ) washed, parboiled, sundried, weighed, cracked, winnowed and further dried to approximately 10 % moisture content. The dried kernels' were stored in sacks at ambient temperature till required for processing. Five kilograms sheanuts pastes were used to produce shea butter from four heating treatment methods (frying, toasting, boiling and parboiling) using manual hand churning method. Before use, the stored, dried, dehusked sheanuts were washed and sun dried for 4 to 5 hours.

#### Heat Treatment Methods

##### Frying method

Six kilograms of clean, dehusked dried sheanuts were fried with approximately 530 ml of previous shea butter oil (from the natives) for about 30 minutes in a metallic pot. The initial frying temperature of  $180^{\circ}\text{C}$  was gradually reduced to  $85 \pm 5^{\circ}\text{C}$  after 5 minutes to avoid burning [14]. The sizes of the fried sheanuts 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 extraction.

##### Toasting method

The clean sheanuts were toasted at  $180^{\circ}\text{C}$  for 5 minutes and continued at  $85 \pm 5^{\circ}\text{C}$  for 25 minutes (modified from [15] village method) in a metallic pot without oil. The toasted sheanuts were cracked using hammer mill and the size further reduced with mortar and pestle before grinding and extraction

##### Boiling method

A modified method of [16] was used. The clean sheanuts were boiled at  $100^{\circ}\text{C}$  for 30 minutes and sun dried for four hours before size reduction using cracking machine, mortar and pestle before grinding and shea butter extraction.

##### Parboiling method

The stored parboiled sheanuts were washed and sun dried for four hours before size reduction, grinding and oil extraction (adopted from Monnai village, New Bussa and [17]. This served as the control. All the sheanuts were parboiled before further treatment. All the extractions were carried out in triplicates.

#### Manual extraction method

##### Hand - churning

Five kilograms of each 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 processing flow chart is shown in Figures 1 and 2

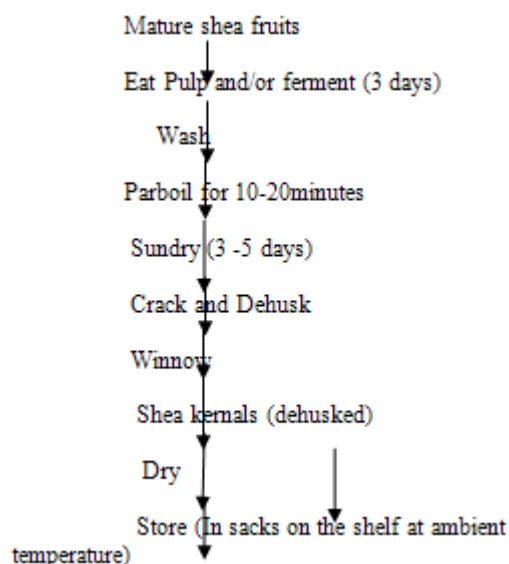


Figure 1. Preparation of shea fruits before shea butter extraction

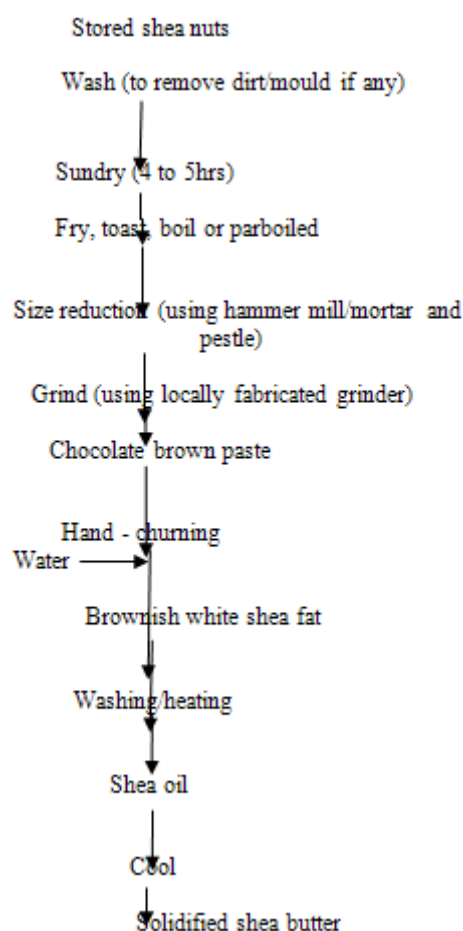


Figure 2. Manual processing of shea butter from (fried, toasted, boiled and parboiled) sheanuts

#### Analysis

**Fatty Acids:** Fatty acid profiles of shea butters were determined after methylation using Hewlet Packard 6890 gas chromatography powered with HP chem. Station Rev. AO9.01 (1206) software, 920.39 methods of [18].

**Sterols:** Sterol analysis was carried out by following the modified AOAC 994.10 and AOAC 970.51 [18] method using Hewlet Packard 6890 gas chromatography powered with HP chem. Station Rev. AO9.01 (1206) software.

## Results and discussions

### Fatty Acid Profile of Shea butter

Tables 1 shows effect of different heat treatment methods on fatty acid profiles of shea butter. The fatty acid profiles of shea butter from fried, toasted, boiled, parboiled sheanuts and native shea butter consist of an array of palmitic (hexadecanoic), palmitoleic (hexadecenoic acid), stearic (octadecanoic acid), oleic (octadecenoic acid), linoleic (octadecadienoic acid), linolenic (octadecatrienoic acid) and arachidonic (eicosatetraenoic acid) fatty acids. The heat treatment method of sheanuts affected the percentage fatty acids significantly ( $p \leq 0.05$ ) in most of the samples. The percentage stearic acid of manually extracted shea butter from boiled, fried, toasted, parboiled sheanuts and the native shea butter were  $42.35 \pm 0.28$ ,  $42.60 \pm 0.12$ ,  $41.05 \pm 0.66$ ,  $42.46 \pm 0.36$  and  $41.94 \pm 0.19$  respectively. The commercial vegetable oil had the least stearic acid. These values are within the 36- 50% stearic acid reported for shea butter in Ougadagu [19]. They are higher than the 30.7% average stearic acid content of Ugandan shea butter reported by [5] and the 31.15% average by [17].

Oleic acids content differed significantly from each other and ranged from  $44.40 \pm 0.01$  to  $47.96 \pm 0.19$ mg/100g) for toasted and parboiled sheanut shea butter. The fried sheanuts shea butter has the least oleic acid value. Oleic acid content of East African shea oil has been reported by [5] to be higher than those of West Africa. On the average, Ugandan shea oil has 57 % oleic and 30% stearic while the West African has 45% oleic and 34% stearic acids according to [20] and [21]. Variability in fatty acids profiles of shea oils across Africa was reported by [22]. They reported oleic acid content of 59, 47 and 39 percents for shea oils from Uganda, Nigeria and Burkina Faso respectively while [17] reported 53.5% for that of Mandoul, southern Chad. From analysis of 150 shea butter samples across four countries in Africa [23] confirmed the higher oleic acid content of East African shea butter and predominance of stearic acid in that of West Africa. This study shows that depending on the heat treatment method of sheanuts mean stearic acid /oleic ratio of shea butter from Kainji area is approximately (42 to 48%). The higher oleic content of East African shea butter accounts for its free flowing nature (liquid) at room temperature unlike the West African shea butter which is semi- solid. [5] noted that the differences in fatty acid composition could be due to variation in the harvesting season, geographical locations, methods of laboratory analysis and genetic variability.

Oleic acid (octadec- 9 – enoic acid) is a monosaturated fatty acid found in many plants and animal products. It is the most common monosaturated fatty acid in the human body and it is often incorporated into the cell membrane and it is useful as an emulsifier in the food industries. Though technically not an essential fatty acid, it is essential to the human body. It has been reported to lower the risk of heart diseases [24].

The palmitic acid of manually extracted shea butter from boiled sheanuts ( $7.66 \pm 0.12$ ) was higher and differed significantly at  $p \leq 0.05$  from those of fried and toasted sheanuts ( $5.53 \pm 0.31$   $5.53 \pm 0.16$ ). Palmitic acids of parboiled and native sheabutter ( $4.45 \pm 0.19$  and  $4.63 \pm 0.03$ ) were the lowest and did not differ from each other at  $p \geq 0.05$ . They were higher than the the 4% palmitic acid of [25]. The low palmitic acid of the native shea butter could probably be due to the long frying time of nuts at high temperature of about 190°C by the natives.

The percentage palmitoleic acid of manually extracted shea butter from fried, toasted, boiled and parboiled sheanuts were low. It ranged from ( $0.02 \pm 0.01$  to  $0.43 \pm 0.29$  % ). From this

work, shea butter is not rich in palmitoleic acid. This may be why there is a paucity of information of its presence in shea butter. The percentage arachidonic acid (ARA) of shea butter samples are low ranging from 0.00 to 0.12 and did not differ significantly ( $p \geq 0.05$ ). Arachidonic acid ( $C_{20}H_{32}O_2$ ) is a type of polyunsaturated omega-6- Pro fatty acid that is naturally found in some food and are known to play a role in inflammation.

Linoleic acids content of shea butters from Table 1 ranged from 6.19 to 7.67. Linoleic acids content of fried, toasted sheanuts and native butters did not differ from each other ( $p \geq 0.05$ ) but differed from those of parboiled and boiled sheanuts butters which did not differ from each other. These values are close to 6 to 8% linoleic acid content of the solvent extracted shea butter reported by [5] but much lower than the values of 74% and 53% reported by [26] for sunflower and soya bean oil respectively. The values are however within and above the 1 to 3% recommended minimum essential linoleic acid dietary calorie requirement [27]. Linoleic acid can be used to synthesis arachidonic acid and other important biological compounds in man and other mammals. The % linolenic acid of shea butter from this study ranged from 0.03 to 0.09. This is lower than the U. S recommended % dietary calorie for linolenic acid is 0.5%.

The examined shea butter samples are rich in unsaturated and saturated fatty acids. The percentage fatty acid composition of most of these shea butters differed significantly even though they were from the same sheanuts. This shows that heat treatment methods affect the fatty acid profile of shea butter. The presence of high percentage of unsaturated fatty acid in shea butter makes it a good source of poly and monounsaturated fatty acids. Monounsaturated fatty acids like oleic acid is believed to reduce the blood levels of low density lipoprotein (LDL) cholesterol called the bad cholesterol without affecting the high density cholesterol, the good cholesterol [28]. This lowers the risk of coronary heart diseases. Oleic acid also is a good energy reserve. Ingestion of large amount of oleic acid and erucic acid prevented the build up of harmful long chain ( $C_{24}-26$ ) which causes the deadly disease called adrenoleukodystrophy (ALD) in young boys [29].

Stearic acid is saturated, oleic has two fewer hydrogen and is unsaturated, linoleic has four less hydrogen and is polyunsaturated. The presence of stearic acid in shea butter accounts for its solidification at ambient temperature. [30] reported that stearic acid is not a 'bad fat' and that it has a different metabolic effect than other specific fatty acid such as trans- fatty acids and other saturated fatty acids(SFA). In their recent review of the effect of particular fatty acids on blood cholesterol and lipoprotein level, it was concluded that stearic acid is not a cholesterol raising fat. In a plasma cholesterol predictive equation [31] demonstrated that stearic acids are neutral as monounsaturated fatty acids like oleic acid and are hypocholesterolemic. According to [31], intake of vegetable fat/oil high in stearic acid favourably affects blood lipids and factor vii coagulant activity in young men and a fat high in stearic acid affects Lp(a) in a different way than fat high in palmitic and myristic/ lauric as Lp(a) concentrations and are not associated with changes in tissue – plasminogen activator activity, factor VII coagulant activity or plasma LDL cholesterol. The high percentage of stearic acid, a saturated fatty acid in shea butter therefore need not to be considered a problem as most people think.

### Legend

- A. Commercial vegetable oil
- B. Shea butter from boiled sheanuts
- C. Shea butter from fried sheanuts

- D. Shea butter from toasted sheanuts  
 E. Native shea butter  
 F. Shea butter from Parboiled sheanuts

±: standard deviation

Values are mean and standard deviation of triplicate analysis.

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

#### Phytosterols of shea butter

Table 2 shows the effect of heat treatment methods on the phytosterol profile (mg/100g) of the manually (hand churned) extracted shea butter. Shea butter and commercial vegetable oils are good sources of phytosterols. Phytosterols are plant sterols and stanols which occur naturally as minor components of vegetable oils [28]. Phytosterol profiles of shea butter from this work include cholesterol, cholestanol, ergosterol, campesterol, stigmasterol, avenasterol and sitosterol. Shea butter has several phytosterols including campesterol, beta-sitosterol, alpha-spinosterol and stigmasterol which are anti-inflammatory and anti-stiffness as reported by [33]. [34] remarked that shea butter contains phytosterols, fatty acids and vitamins that stimulate the natural cellular regeneration process and the suppleness of the dermis.

The cholesterol content of the manually extracted shea butter from boiled, fried, toasted and parboiled sheanuts are less than 2mg/100g. Apart from the native shea butter, others did not differ significantly from each other and the commercial vegetable oil at  $p \geq 0.05$ . The heat treatment did not significantly affect the cholesterol content of shea butter. Cholesterol is a steroid alcohol sterol with a chemical formula of  $C_{27}H_{45}OH$ . It is found in animals and plants as a constituent of bile acid and some hormones. It facilitates the transport and absorption of fatty acid in nutrition. Though cholesterol is very useful, it could be injurious to health if in excess. The cholesterol of shea butter is very low compared to 500mg/100g in eggs which most people cherish [35].

The cholestanol content (mg/100g) of manually extracted shea butter from fried, toasted, boiled and parboiled sheanuts are  $(1.90 \pm 0.01, 1.83 \pm 0.00, 1.89 \pm 0.01$  and  $1.83 \pm 0.01$ (mg/100g)) respectively. There are no significant differences among the shea butter samples and the commercial vegetable oil. They differed from the native shea butter which has a higher value of  $2.64 \pm 1.36$ mg/100g. The heating methods of sheanuts did not significantly affect the cholestanol content of shea butter. Cholestanol is a monohydroxyl alcohol ( $C_{27}H_{47}OH$ ) that differ from cholesterol in the absence of the double bond [36]. The ergosterol profile of manually extracted shea butter from fried, toasted, boiled and parboiled sheanuts were within the range of  $1.83 \pm 0.00$  to  $1.83 \pm 0.01$ (mg/100g). Apart from the native shea butter, others did not significantly differ from each other at  $p \geq 0.05$ . The method of heat treatment thus do not affect the ergosterol content of shea butter. Ergosterol (ergosta-5,7,22-trien-3-ol) is a natural steroid alcohol with the chemical formulae of  $C_{28}H_{44}O$ . It is mainly found in yeast and fungi and has been reported to be a useful target for anti fungal drugs. Ergosterol has been shown to have anti tumor properties [37, 38].

The campesterol profile of manually extracted shea butter from fried, toasted, boiled, and parboiled sheanuts were  $13.47 \pm 0.48, 14.35 \pm 0.45, 15.81 \pm 0.16$  and  $14.36 \pm 0.32$ (mg/100g). The campesterol content of boiled and toasted sheanuts shea butter did not significantly differ from each other ( $p \geq 0.05$ ) but differed from the fried and parboiled sheanuts shea butter. The commercial vegetable oil has higher campesterol of  $18.18 \pm 5.04$  and significantly differed from those of shea butter. Shea butter

from fried, toasted, boiled and parboiled sheanuts have higher campesterol content than the native shea butter which had the least score of  $10.87 \pm 0.41$ . The prolonged heating (frying) at high temperature of above  $180^{\circ}C$  of the native shea butter could cause the destruction of some of the campesterol and thus the reduction.

Campesterol is a phytochemical phytosterol that is structurally similar to cholesterol produced by plant [39, 40]. It helps to balance the body cholesterol by decreasing the overall LDL cholesterol levels. Campesterol molecules competes with cholesterol and thus reduces the absorption of cholesterol in the human intestine [41]. It is also sometimes used to treat some prostrate conditions especially those from saw palmeto [42]. Natural sources of campesterols include banana, pepper, grape fruits, cucumber oats, onions, potato and lemon grass. They contain 1-7mg/100g [43]. [41] also reported that campesterol has anti-inflammatory and inhibits pro-inflammatory and matrix degradation as in osteoarthritis.

The stigmasterol content of the manually extracted shea butter from fried, toasted, boiled and parboiled sheanuts were  $25.52 \pm 0.54, 27.35 \pm 0.13, 27.27 \pm 0.80$  and  $26.29 \pm 0.18$ (mg/100g) respectively. The stigmasterol content of boiled and toasted sheanuts shea butter are higher and did not differ significantly from each other but differed from that of fried and parboiled sheanuts shea butter which did not differ ( $p \geq 0.05$ ) from each other. They all differed from the commercial vegetable oil which has a higher stigmasterol content of  $31.79 \pm 0.12$ . [45] reported that stigmasterol has potential anti-osteoarthritis properties and it is known as Wulzen anti-stiffness factor phytosterol and is an unsaturated plant sterol found in fats and oils of soybeans, calabar beans, rape seeds, vegetables, legumes, nuts, seeds and the chinese herb ophiopogon japonicar. Research has indicated that stigmasterol may prevent cancer such as ovarian, prostrate, breast and colon cancers and possess potent antioxidant, hypoglycemic and thyroid inhibiting properties [46]. In the pharmaceutical industries, it is used in the manufacture of semi synthetic progesterone, a valuable human hormone, cortisone and as precursor of vitamin D3. [47,48 and 49].

The avenasterol content of the manually extracted shea butter from fried, toasted, boiled and parboiled sheanuts ranged from  $7.68 \pm 0.05$  to  $7.71 \pm 0.01$  (mg/100g). The avenasterol content of the commercial vegetable oil, native shea butter, toasted and parboiled sheanuts shea butter did not differ significantly from each other ( $p \geq 0.05$ ). They have higher content of avenasterol and differed from those of boiled and fried sheanuts which did not differ from each other. Avenasterol is a natural non-cholesterol sterol with a chemical formula of  $C_{29}H_{48}O$  that is relevant in pharmaceutical and production of therapeutic steroids. C

The sitosterol content (mg/100g) of manually extracted shea butter from parboiled, boiled, fried, and toasted sheanuts butter were  $100.35 \pm 0.35, 117.31, 112.50 \pm 0.40$  and  $111.45 \pm 0.45$ (mg/100g) They have lower value and differed significantly from the sitosterol of commercial vegetable oil ( $124.16 \pm 0.03$ (mg/100g)). The parboiled sheanuts shea butter has the least value. The temperature of parboiling may not have extracted most or all of the sitosterols of the nuts. Further boiling at a higher temperature as in the boiled sheanuts increased the sitosterol from  $100.35 \pm 0.35$ mg/100g to  $117.31 \pm 0.11$ mg/100g. In a work carried out on the analysis of 20 oilseeds including shea butter. [50] reported that  $\beta$ -sitosterol was the most predominant component of the unsaponifiables of the seed oils.

**Table 1. Effect of heat treatment method of sheanuts on fatty acid profile of manually extracted shea butter**

| Samples | Palmitic acid %<br>C = 16:0 | Palmitoleic acid %<br>C = 16:1 | Stearic acid %<br>C= 18:0 | Oleic acid %<br>C= 18:1   | Linoleic acid<br>%C= 18:2 | Linolenic acid %<br>C= 18:3 | Arachidonic acid %<br>C = 20:4 |
|---------|-----------------------------|--------------------------------|---------------------------|---------------------------|---------------------------|-----------------------------|--------------------------------|
| A       | 6.03± 0.05 <sup>b</sup>     | 0.08 ± 0.01 <sup>a</sup>       | 34.43± 0.18 <sup>d</sup>  | 50.01± 0.08 <sup>a</sup>  | 8.76 ± 0.03 <sup>a</sup>  | 0.94 ± 0.01 <sup>a</sup>    | 0.59 ± 0.01 <sup>a</sup>       |
| B       | 7.66 ± 0.12 <sup>a</sup>    | 0.05 ± 0.01 <sup>b</sup>       | 42.35±0.28 <sup>ab</sup>  | 46.58± 0.12 <sup>c</sup>  | 6.19 ± 0.05 <sup>c</sup>  | 0.06 ± 0.01 <sup>c</sup>    | 0.00 ± 0.00 <sup>b</sup>       |
| C       | 5.53 ± 0.31 <sup>b</sup>    | 0.05 ± 0.01 <sup>b</sup>       | 42.60± 0.12 <sup>a</sup>  | 44.40±0.01 <sup>d</sup>   | 7.67 ± 0.14 <sup>b</sup>  | 0.09 ± 0.03 <sup>b</sup>    | 0.00 ± 0.00 <sup>b</sup>       |
| D       | 5.53 ± 0.16 <sup>b</sup>    | 0.02 ± 0.01 <sup>c</sup>       | 41.05± 0.66 <sup>c</sup>  | 46.39± 0.41 <sup>c</sup>  | 6.98 ± 0.55 <sup>b</sup>  | 0.03 ± 0.00 <sup>d</sup>    | 0.00 ± 0.00 <sup>b</sup>       |
| E       | 4.4 5± 0.19 <sup>c</sup>    | 0.02 ± 0.00 <sup>c</sup>       | 42.46±0.36 <sup>ab</sup>  | 46.71±0.08 <sup>ab</sup>  | 7.32 ± 0.05 <sup>b</sup>  | 0.03 ± 0.01 <sup>d</sup>    | 0.13 ± 0.10 <sup>b</sup>       |
| F       | 4.63 ± 0.03 <sup>c</sup>    | 0.03 ± 0.01 <sup>c</sup>       | 41.94± 0.19 <sup>b</sup>  | 47.96 ± 1.76 <sup>b</sup> | 6.19 ± 0.26 <sup>c</sup>  | 0.03 ± 0.01 <sup>d</sup>    | 0.12 ± 0.10 <sup>b</sup>       |

**Table 2. Effect of method of heat treatment of sheanuts on phytosterols of manually extracted shea butter**

| Samples | Cholesterol(mg/100g)   | Cholestanol (mg/100g)  | Ergosterol (mg/100g)   | Campesterol (mg/100g)    | Stigmasterol (mg/100g)  | Avenasterol (mg/100g)  | Sitosterol (mg/100g)       |
|---------|------------------------|------------------------|------------------------|--------------------------|-------------------------|------------------------|----------------------------|
| A       | 1.83±0.00 <sup>b</sup> | 1.89±0.01 <sup>a</sup> | 1.83±0.01 <sup>b</sup> | 18.18±5.04 <sup>a</sup>  | 31.79±0.12 <sup>a</sup> | 7.71±0.00 <sup>a</sup> | 124.16± 0.30               |
| B       | 1.86±0.02 <sup>b</sup> | 1.90±0.01 <sup>a</sup> | 1.83±0.00 <sup>b</sup> | 15.81±0.16 <sup>b</sup>  | 27.27±0.80 <sup>b</sup> | 7.68±0.01 <sup>b</sup> | 117.31±0.110 <sup>b</sup>  |
| C       | 1.83±0.01 <sup>b</sup> | 1.83±0.01 <sup>a</sup> | 1.83±0.01 <sup>b</sup> | 13.47±0.48 <sup>cd</sup> | 25.52±0.54 <sup>c</sup> | 7.69±0.01 <sup>b</sup> | 112.50 ± 1.40 <sup>c</sup> |
| D       | 1.83±0.01 <sup>b</sup> | 1.83±0.01 <sup>a</sup> | 1.83±0.00 <sup>b</sup> | 14.35±0.45 <sup>b</sup>  | 27.34±0.13 <sup>b</sup> | 7.70±0.01 <sup>a</sup> | 111.46 ± 0.45 <sup>c</sup> |
| E.      | 2.50±0.78 <sup>a</sup> | 2.64±1.36 <sup>b</sup> | 2.83±1.03 <sup>a</sup> | 10.87±0.41 <sup>d</sup>  | 26.30±0.18 <sup>c</sup> | 7.71±0.01 <sup>a</sup> | 107.52 ± 1.05 <sup>d</sup> |
| F.      | 1.83±0.00 <sup>b</sup> | 1.85±0.02 <sup>a</sup> | 1.83±0.00 <sup>b</sup> | 14.36±0.32 <sup>bc</sup> | 26.29±0.18 <sup>c</sup> | 7.68±0.01 <sup>a</sup> | 100.35 ± 0.35 <sup>e</sup> |

All the seeds have seven phytosterols including campesterol, stigmasterol, avenasterol, traces of cholesterol and [51] also brassicasterol. observed that  $\beta$ - sitosterol (1326.74 $\mu$ g/g) was the most abundant phytosterol in *Sterculia africana* especially from Manketti area in Botswana. Vegetable oils, nuts and seeds are prominent sources of phytosterols and unsaturated fatty acids. In a study to determine the relationship between phytosterol and fatty acid concentrations in experimental diets, [52] reported that the predominant phytosterols were  $\beta$ -sitosterol, campesterol and stigmasterol. These agree with the result of this work for shea butter for all the heat treatment methods.

Phytosterols are endogenous to all plants and structurally analogous to cholesterol. Phytosterol have been shown to substantially reduce intestinal cholesterol absorption by 30-40% and have protective effect against chemically induced colon tumors in rats [53]. Animal fats are devoid of phytosterols and contain primarily saturated fatty acids. Published data indicate that plant sources of saturated fatty acids have far lower phytosterol content than most commonly used unsaturated vegetable oils. [52] also reported an inverse relationship between saturated fat (SFA) and total phytosterols, a positive relationship between polyunsaturated fat (PUFA) and no association between total phytosterol and monosaturated fat (MUFA). The total phytosterol thus increases with decreasing (SFA) and is elevated by increasing (PUFA). [53] reported that hydrogenation and refining increases the saturated fatty acids of vegetable oils while decreasing the phytosterol content by up to 50%.

Phytosterols have been reported to be effective in lowering plasma total and low density lipoprotein ((LDL) cholesterol [54]. Sitosterol and other plant phytosterols have been reported to have anti-cancer properties [55, 56, 57, and 58]. [30] noted that 1g/day of phytosterol is needed to achieve a cholesterol lowering benefits while [60] reported that approximately 2g/daily plant- derived sterols lowers blood cholesterol level by decreasing LDL. [59] reported the positive role of dietary phytosterols in colon tumors in rats.

Phytosterol have also been reported to have protective effect against chemically induced colon tumor and colon carcinogenesis in man [44]. [61] observed a synergistic and complimentary effect of phytosterols and n-3 polyunsaturated fatty acids in lipid-lowering in hyperlipidemic men and women.

All these point to the health prospect of shea butter as an edible oil. Phytosterol like unsaturated fatty acids are prone to oxidation and decreases especially when subjected to pronged heat treatment and long term storage.

#### Legend

A - Commercial vegetable oil (Kings).

B - Boiled sheanuts shea butter

C - Fried sheanuts shea butter

D - Toasted sheanuts shea butter

E - Native shea butter

F - Parboiled Sheanuts Shea butter

±: standard deviation

Values are mean and standard deviation of triplicate analysis.

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

#### Conclusion

Like most vegetable oils, shea butters from fried, toasted, boiled and parboiled sheanuts have good array of fatty acids and phytosterols. These should encourage consumers to accept and utilize them as edible oil/ fat. The quality of these shea butters are affected by the heat treatment method. This should be considered during manufacturing and in setting standards on shea butter.

#### Conflict of interest

There is no conflict of interest.

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