Chemical Analysis of Shea Butter (*Vitellaria paradoxa*) Nut obtained from Benue State

Anhwange, B.A and Ese H.A

Department of Chemistry, Benue state University Makurdi

ABSTRACT

Shea butter fruits were collected and the oil extracted using Soxhlet extractor and hexane as the solvent. The oil was characterised while the residual cake was analysed for nutrients, anti-nutritional factors, and amino acids contents using standard methods. The results of the analyses indicated the percentage yield of the oil to be 15.52%. The acid value, free fatty acid, saponification value, iodine value, and ester value were found to be 12.24 mgKOH/g, 4.90 mg/g, 215.65 mgKOH/g, 53.05g/100g and 302.42 mgKOH/g respectively. The specific gravity and refractive index were found to be 0.88 and 1.48 respectively. Results of proximate composition indicate moisture, ash, crude fat, crude fibre, crude protein and carbohydrates to be 11.82%, 4.33%, 2.26%, 1.83%. 2.65 and 76.93% respectively. The anti-nutritional factors of the cake indicate oxalate (2.41%), phytate (0.21%), saponins (16.71%), alkaloids (6.34%) and tannis (071%). The cake was found to contain varying concentrations of both essential and non-essential amino acids which could be serve as amino acid supplements to animals if incorporated in feeds. The results of the study revealed shea butter oil as an oil which could be used for domestic and other industrial purposes. The proximate analysis revealed high content of carbohydrate; this qualified the shea seed cake as a source of feed for livestock. The results of the research indicate the shea butter cake to also contained varying concentrations of anti nutritional factors.

Keywords: Shea, Butter, Vitellaria, paradoxa, Nuts, Nutritional

INTRODUCTION

The increasing demand for shea butter has led to increased production of shea butter to satisfy demand, resulting in the production of a byproduct the shea cake, which constitutes an environmental pollutant (Kouakou *et al*., 2021). The shea butter oil is gotten from shea nuts of shea fruits produced by the shea butter tree which is also known as *Vitellaria paradoxa* C. F. Gaertn, which belongs to the family *Sapotaceae* and is indigenous to Africa (Ugese *et al*., 2007, Sagoremi and Akens 2021). After palm tree, it has been reported as Africa's second most abundant oil-yielding tree. Ibanga *et al*,(2015), reported that in Northern parts of Nigeria, the shea

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Correspondence:
Anhwange, B.A
Email:
banhwange@bsum.edu.ng

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butter tree replaces the oil palm tree as a source of edible oil among many ethnic groups.

The Shea butter tree is found in the guinea savannah belt and the lower Sahel region with an annual rainfall of (600-1300) mm but is absent in arid zones (Mohammed *et al*., 2021). In Nigeria, it is locally abundant in the middle-belt (Benue, Kwara and Niger States and Abuja) region, where it found as a wild tree (Azeh *et al.,* 2021). According to Saba *et al.*(2018), the tree starts bearing fruits when it is about 20 years old, and full production is attained when the tree is about 45 years old. It then produces nuts for up to 200 years.

Aliyu (2015), reported that the fat obtained from the shea kernels is known as shea butter and is the most valued product from the shea tree. Shea butter, like most vegetable oils and fats, consists of mixtures of triacylglycerols, which constitute about 95% of its constituents, and a non-triacylglycerol which contains variable amounts of phosphatides, free fatty acids, unsaponifiable matter, oxidation products and other impurities (Omodara *et al*., 2020).

Nagalakhshmi *et al.* (2016), observed that the shea-nut cake is a byproduct obtained from the extraction of shea butter. In some African countries, a huge amount of this residue is produced. For example, in Ghana and Togo, it is estimated that about 30,300 and 7,500 tons of shea cake are produced yearly. In Nigeria, there are no official statistics on the quantity of shea cake produced annually despite the presence of local processing factories. In Benue State, for instance, Ugese *et al.* (2016), reported that Oracle Farms Ltd processes shea butter for local and international markets and as such, reasonable quantities of shea cake are produced as byproducts.
Despite the extensive research on shea butter, there is a dearth of information about the tree in Benue State even though the tree is found in large quantities in the state. Also, studies have shown that not much research has been done on the shea cake. This is evident from the limited scientific reports available particularly in Nigeria (Abdul-Mumeen *et al*., 2013, Ugese *et al*., 2010). It is in the light of the above that this study considers the extraction and characterisation of the shea butter produce in Benue State very pertinent. The study also looks at the assessment of the shea cake with reference to its nutritional and anti-nutritional composition and amino acid contents. This information may help in considering the cake as a nutrient supplement, especially for animal feeds.

MATERIALS AND METHODS

Sample collection and pretreatment

Shea fruits were collected in Abaji Kpav district, Katsina-Ala Local Government Area of Benue State, Nigeria. The fruits together with the leaves of the tree were taken to the Department of Biological Sciences, Benue State University for identification and filing. The pulps were then removed by manual peeling and the nuts were dried for two weeks. Then, the shells were cracked and the kernels removed and further sun dried thereafter oven-dried to constant weight. The kernels were crushed into paste using porcelain mortar and pestle and stored in screw capped bottles for further analysis.

Extraction of the shea butter

Exactly 10.00 g of the paste was weighed into pre-weighed fat free thimble. 350cm^3 hexane was poured into a previously weighed 500 cm^3 round bottom flask containing few anti-bumping granules. The soxhlet extractor was fitted into the 500 cm^3 flask and the extraction carried out for six hours. The hexane was then distilled off using a rotary evaporator leaving the oil in the flask. This was dried in a water bath to constant weight.

Physicochemical properties of the shea butter oil.

Physicochemical properties of the shea butter (

acid value, iodine value, free fatty acids, peroxide value, saponification value, refractive index and density) were determined using methods prescribe by AOAC (2012). Refractive index was performed using the Abbe 60/DR Refractometer.

Proximate analysis

Moisture content was calculated by loss in weight on drying the sample in an oven at 105 °C for 2 h. Fat content was calculated by drying fats after extraction in a Soxhlet using hexane (AOAC, 2012). Crude protein was determined by the Kjeldahl method and the total protein content was calculated as the amount of total nitrogen multiplied by the nitrogen to a protein conversion factor of 6.25. Ash content was determined by combusting the samples at 550 °C for 4 h in a porcelain crucible placed in a muffle furnace Model: TP-1700M. Carbohydrate was determined by deference (AOAC, 1995).

Determination of Amino acids

The dried samples were hydrolyzed with 200 µL of constant boiling 6M HCl and 40 µL of phenol through vapor-phase hydrolysis. The sample was dried in an oven at 112 - 116 °C for 20 - 24 h. After completion of hydrolysis, excess HCl was cleaned off and the tubes were vacuum dried for 90 min. The plant samples were then reconstituted with 100 µL of 20 mM boiling HCl (Musadiq *et al.,* 2019). The reconstituted 20 µL samples were derivatized with AccQ-Fluor reagent kit (WAT052880- Waters Corporation, USA). AccQ-Fluor borate buffer (60 µL) was added in the sample tube with micro pipette and vortexed. Thereafter, 20 µL of AccQ-Fluor reagent was added and immediately vortexed for 30 s. and the contents were transferred to maximum recovery vials. The vials were heated for 10 min in a water bath at 55 ºC before separation of amino acids using the reverse phase-high pressure liquid chromatography (HPLC) (Buck scientific BLC10/11 USA (Musadiq *et al.,* 2019).

Determination of Anti-nutritional factors

The anti-nutrients (oxalates, alkaloid acid, phytate, saponins and tannins) were determined using standard methods described by Agbai, *et al*, (2021), Igidi and Edene (2014) and Sango *et al.,*(2016).

RESULTS AND DISCUSSION

The oil yield from the shea kernels was 15.22% (Table 1.0). This value is lower than (48%) reported by Datti *et al,*(2020), for shea nuts obtained from Hadejia in Jigawa State and the 34.50%, reported by Ibrahim *et al,*(2019).

The specific gravity of the extracted oil was found to be 0.88. This value is less that 0.92 reported as the maximum specific gravity of oil (Codex, 2005). Ichu and Nwakanma (2019) reported that, specific gravity is commonly used in conjunction with other figures in assessing the purity of oil. This is a dimensionless unit and it is the ratio of density of a substance to the density of water at a specified temperature. It is a physical quality parameter of edible oils which is used for the identification of the different types of oils.

The refractive index of the oil was found to be 1.48 (Table 1.0). Refractive index of oil is an indication of the possible chances of the oil becoming rancid. The higher the refractive index, the higher the chances of spoilage due to oxidation. Refractive index is used as a rapid control for the determination of the product endpoint of hydrogenation reactions. According to Awuchi *et al,* (2018), it is a value that relates molecular weight, fatty acid, chain length, the degree of unsaturation and degree of conjugation of oil. The value obtained in this study compared favourable with the 1.47 given by FAO as the standard value for the refractive index of vegetable oils(Codex, 2005).

Acid value of the shea butter was found to be

12.24 mgKOH/g (Table1.0). This value is lower than the minimum safe limit (15%) meant for consumption (Codex, 2005). This implies that the oil can be stored with low deteriorating rate. . The acid value of an oil is the number of milligrams of KOH required to neutralize the free fatty acids in one gram of the oil. It measures the decomposition of the oil by lipase action. The decomposition is usually accelerated by heat and light (Chibor *et al*., 2017). The value obtained in this study compared favourable with 14.26 mgKOH/g reported by Warra and Ahmed (2013) for vegetable oils.

Table 1.0: Physico-chemical properties of shea butter

Physico-chemical Properties	*Values*
Acid value(mgKOH/g)	12.24
Free fatty acid (mg/g)	4.90
Saponification value (mgKOH/g)	215.65
Iodine value (g/100g)	53.05
Ester value (mgKOH/g)	203.41
Refractive index	1.48
Specific gravity	0.88
Yield (%)	15.22

Table 2.0: Proximate Analysis of Shea Cake

Parameters	Concentration (%)
Moisture content	11.82± 0.29
Ash content	4.33± 0.70
Crude fat	2.26± 0.14
Crude fibre	1.83± 0.01
Crude protein	2.65± 0.13
Carbohydrate	76.93± 0.18

Table 3.0: Amino acid profile of shea cake

Amino acid	Concentration (g/100 g)	Estimated Amino acid requirement for and adult (g/100 g)
Histidine	2.23±0.00	0.0012
Isoleucine	2.41±0.01	0.0010
Leucine	5.75±0.01	0.0014
Lysine	3.14±0.00	0.0012
Methionine	2.27±0.01	0.0013
Phenylalanine	3.22±0.01	0.0014
Threonine	2.33±0.01	0.0007
Tryptophan	3.98±0.01	0.00035
Valine	2.34±0.01	0.0010
Arginine	3.92±0.01	4.75
Alanine	3.85±0.01	-
Aspartic acid	5.82±0.01	-
Cysteine	2.52±0.01	-
Glutamatic acid	8.77±0.01	7.21
Glycine	4.94±0.01	5.11
Proline	3.17±0.01	-
Serine	3.84±0.01	-
Tyrosine	3.45±0.01	-

Table 4.0 : Anti-nutrient analysis of shea cake

Parameters	Concentrations (%)
Oxalate	2.41
Phytate	0.21
Tannis	0.71
Saponins	16.71
Alkaloids	6.33

Free fatty acid value of the shea butter was found to be 4.90 mg/g. The free fatty acid value of oil is the measure of the amount of acid formed on exposure to air. Generally, high free fatty acid value indicates the deteriorating conditions and low edibility of the oil because of the development of objectionable flavour and odour and hence reduction in consumer acceptability the oil (Aliyu, 2015). Wara and Ahmed (2013), reported a high FFA value (7.52 and 5.04) mg/g for shea butter. The low value of the free fatty acid obtained is an indication that the shea butter found in Benue has low deterioration rate and high edibility.

Saponification value is the amount of milligrams of potassium hydroxide required to convert one gram of the oil into glycerol and soap. Ichu and Nwakanma (2019) reported that oils with high saponification values contained high proportion of lower fatty acids. A high saponification value of oil above 195 implies greater proportion of fatty acids of low molecular weight (William and Vida, 2015). The saponification value of the Shea nut oil was obtained to be 215.65 mgKOH/g. This implies that the shea butter in Benue State has enhance quality because it shows the presence of lower molecular weight fatty acid that can yield more energy on combustion.

Iodine value is an expression of the level of unsaturation of fats/oils. It determines the stability of oils to oxidation and is the number of grams of iodine compound absorbed by 100 g of fat. The higher the iodine value, the greater the unsaturation level of the oil (Ibanga *et al*., 2015). The iodine value of the shea butter was 53.05

g/100g. The result implies that shea butter oil is a non-drying oil (Misbaudeen *et al*., 2020)..

The ester value of oil is a function of the saponification value and the acid value. It is an indication of the saponifiable fatty acids excluding the free acids of the fat (Chibor *et al*.,2017).
The ester value of the extracted oil was found to be 203.41mgKOH/g. The high ester value of the extracted oil is an indication that the oil is suitable for culinary purposes (Aremu *et al*., 2015).

Proximate Composition of the Shea Cake
Moisture content has an important relationship between conservation and the physical, chemical and microbiological changes during conservation, moderate moisture content of ≤ 12 % is preferred for long storage (Oloakele *et al.,* 2018). Moisture content of the cake was found to be 11.82 % (Table 2.0). The moisture content of the cake implies that it will be resistance to micro-organism attack and thereby enhance long storage (Shaahu *et al.,* 2020).

Ash content predicts the mineral composition of a food material. The ash content of the shea cake was observed to be 4.33 % (Table 2.0). The ash content obtained is a direct measure of the total mineral content of the cake.

Fats provides good sources of energy and aids in transport of fat soluble vitamins, protects internal tissues and contributes to important cell processes (Adel *et al*., 2018). The crude fat value obtained was 2.26 % (Table 2.0). This implies that the cake is a poor source of fats.

The value for crude fibre obtained was 1.83 % (Table 2.0). Fibre diet promotes the wave-like contractions that move food through the intestine. High fibre foods expand the inside walls of the colon, easing the passage of waste by absorbing large amount of water, resulting in softer and bulkier stool. Apart from treatment of constipation, fibre diets also lowers cholesterol level in the blood, reduces the risk of various cancers, bowel diseases, improve general health and well-being. The recommended amount of fibre in an average adult is 18 32g per day (Misbaudeen *et al.,* 2020, Farid *et al*., 2017). The result of the study indicates that shea cake is not a good source of fibre, however if supplemented with more fire diets, it could be explored in formulating diets for treating indigestion, constipation and other diseases such as colon cancer, diverticulosis, coronary heart disease and obesity (Michael*, et al,* 2019).

The observed crude protein of the shea cake was found to be 2.65 % (Table 2.0). This value is less than 15% recommended by FAO for a proteineous food material (Oyewusi *et al*., 2007). The low value of crude protein is an indication that it is unsuitable to be used as protein supplement for livestock except it is complemented with some protein concentrates.

The carbohydrate content obtained was 76.93 % (Table 2.0). The high carbohydrate content suggest that the cake will be high in dietary energy hence it will be suitable for animal feed.

Amino Acids
The results of amino acid composition of the shea cake (Table 3.0) indicate glutamatic acid (8.77) g/100g and leucine (5.75) g/100g to be the most concentrated and the least was histidine (2.23) g/100g. Concentrations of both the essential and non-essential amino acids were higher that the WHO estimated Amino acid requirement for an adult. Essential amino acid like phenylalamine (3.22 g/100g), tryosine (3.98 g/100g) and threonine (2.33) g/100g were obtained in the sample. Lysine content was found to be (3.14 g/100g) indicating it is fairly a good source of lysine. Lysine insures the adequate absorption of

calcium, help the formation of collagen, in addition aiding the production of antibodies, hormones and enzymes. Lysine deficiency may result in tiredness, inability to concentrate, irritability, bloodshot eyes, retarded growth, hair loss, anemia and reproductive problems. Tryptophan content was found to be 3.97 %. It is also an essential amino acid which can be used in supplementing animal feeds. Lysine and methionine have been identified frequently as first limiting essential amino acid in feedstuffs of growing cattle and lactating cow(Pousg *et al*., 2007). In fact, methionine is clearly recognized as first limiting amino acid in poultry, high-yielding cows and third limiting amino acid in pigs (Roberto and Remo, 2015). Since young mammals have a high dietary requirement for arginine due to its role as a nitrogen carrier in tissue proteins and its primary role in gastrointestinal growth and development, arginine is important for feed industries. Some researchers consider arginine as a major essential amino acid for maximal growth of young pigs, especially for piglet plasma concentrations decline throughout a sow's lactation (Roberto and Remo, 2015). Arginine is also necessary for children growth (Matthew *et al*., 2013)

Anti-nutrient analysis

The results of anti-nutrient analysis Table (4.0) indicate pyhtate content of shea cake to be 0.20 %. Phytate decrease protein digestibility by forming complexes and also interacting with enzymes such as trypsin and pepsin. The knowledge of the phytate level in food is necessary because of its high adverse effects on the digestibility if in high concentrations. According to Ogunbode *et al,*(2021), a phytate diet of (1-6 %) over a long time decreases the bioavailability of mineral elements in monogastric animals. The result shows that shea cake is low in phytate.

The oxalate content was found to be 2.41%. The presence of oxalate in foods causes irritation in the mouth and interferes with absorption of divalent minerals particularly calcium by forming insoluble salts. This renders calcium unavailable for normal physiological and biochemical roles, such as the maintenance of strong bone, teeth, cofactor in enzymatic reaction, nerve impulse transmission and clotting factor in the blood (Euloge *et al*., 2013). In addition, high oxalate intake can result in hyperoxaluria thereby increasing the risk of kidney stones (Jeremiah *et al*., 2017). Agbai *et al*, (2021), considered foods containing >10 mg oxalate as high-oxalate foods.

The tannins content of the shea cake 0.71% (Table 3.0).The stipulated maximum limit of tannin in food is 12 mg/100 which is equal to 0.012 % (Agbai *et al.,* 2021). Based on this argument, the tannis content of shea cake is above tannin safety limits. Tannins are aromatic compounds containing phenolic groups. They interact with the salivary proteins and glycoproteins in the mouth and render the tissues astringent to taste. High amount of tannins is known to form complexes with proteins and reduce the solubility of proteins (Adeniyi *et al*., 2017).

The alkaloid content of the cake was found to be 6.33 %. The permissible limit for alkaloid content is 20 mg/100g, equivalent to 0.04 %. Cooking reduces the alkaloid content by (40-50) % (Igidi and Edene, 2014)The shea cake is high in alkaloid therefore should be boiled to reduce the percentage alkaloid before use.

The saponin content of the shea cake was found to be 16.71 %. High concentration of saponin may cause cell damage by disrupting cell membranes and consequently reduce cell growth. Saponins reduce the uptake of certain nutrients including glucose and cholesterol at the gut through intra-luminal physicochemical interaction. It is also linked with reduction of palatability and intake of nutrients. They are active as clearing agent of

defective erythrocytes from the body system. They may also be very useful as sources of prophylactic and therapeutic drugs in cardiovascular, diabetic and peptic ulcer diseases (Ameen *et al*., 2014).

CONCLUSION

The results of the study revealed that Shea butter oil has the potential to be incorporated into foods and other industrial purposes such as soap making and cosmetics. The proximate analysis showed high carbohydrate content, which qualifies the shea cake as a source of feed for livestock. Although the cake has low content of proteins however it was found to contained essential amino acids like lysine and tryptophan in varying concentrations, which could be vital to animals if incorporated into their feeds. However, the results of anti-nutrient analysis indicate the presence of oxalate, tannins and alkaloids, which were found in varying concentrations. This implies that the cake should be well treated to reduce the anti-nutrient before utilisation.

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