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Nutritional and bio-physicochemical characterization of *Vitellaria paradoxa* butter (Shea butter) prepared and sold in Kano, Nigeria

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Abstract
The ethnopharmacological uses of shea butter provides an evidence of its uses in our dishes and has been a tradition in many West African continent. This may be related due to it higher nutritional values, phytochemical content etc hence make it's a valuable material in African folk medicine. This study is aimed to evaluate the phytochemicals, proximate and physicochemical analysis of Shea Butter. The AOAC protocols were followed for the proximate and physicochemical analyses, whereas the Brain and tuner techniques were used for the qualitative phytochemical study. The qualitative phytochemical analysis reveals the presence of various phytochemicals such as Terpenoids, Alkaloids, Saponins, Flavonoids, Tannins and Cardiac glycosides, the proximate analysis shows the percentage composition of Moisture (1.233±0.033), Ash (0.090 ± 0.0), Protein (3.103 ± 0.023), Fat (92.91±0.069) and Carbohydrate (2.660 ± 0.098), whereas the Physicochemical analysis shows the Physical and Chemical parameters as; Slip point ^{0}C (68.67±0.67), Clear point ^{0}C (119.3 ± 0.66), Smoke point ^{0}C (162.0 ± 1.155), Flash point ^{0}C (198.7±0.67), Fire point ^{0}C (302.0 ± 1.155), Specific gravity (0.856±0.001) Refractive Index @25 ^{0}C (1.531 ± 0.003), Free fatty acid Value (0.533 ± 0.0067), Saponification Value (186.9 ± 0.073) Iodine Value (30.78 ± 0.012), Peroxide Value (0.9367±0.012). The findings revealed that, the Shea butter contained certain phyto-constituents and it physicochemical parameters fulfilled the FOA/WHO criteria. Similarly, shea butter contains some nutritionally significant components and has health benefits in addition to its numerous industrial applications.

Keywords: Shea Butter, phyto-chemical, proximate, physicochemical, nutrition

1. Introduction
Vegetable oil is mostly generated in Nigeria from groundnut, palm, soya bean, and cotton seeds, while indigenous plants containing oil are known differently among various populations. Increased awareness of the value of vegetable oils in food, medicinal, and cosmetic items leads to a rise in demand, necessitating a focus on new plant species to supply the rising need. The shea tree (Vitellaria paradox) is a wild tree that grows in African savanna grassland [1].

Shea butter is a fat produced from the nut of the African Shea tree fruit, and it is typically yellow in color when raw, unprocessed, but extremely refined. Shea butter is often ivory or white in hue [2].

Shea butter is a poly saturated fatty acid bonded together in groups of three to create a molecule called triglycerides [3, 4], which is considered a basic necessity for human health and well-being. When a fatty acid enters the body, it is transformed into glucose and stored as energy [5]. Shea butter is a fat-rich oil derived from the nuts of the African Shea tree. At room temperature, it is solid [6]. When raw, it is often yellowish in color, but unrefined, refined, and ultra-Shea butter are ivory or white in color [7]. Shea butter is a triglyceride (fat) composed primarily of stearic and oleic acids. Shea butter is generally edible and is used in food preparation in various African nations. Shea butter is typically harvested at the village level and sold there in neighborhood markets. While commercially it is done by pressing or solvent extraction with further refining and deodorizing of Shea butter, as opposed to the ancient method of heating water and skimming off the liberated oil [8]. However, traditional Shea butter production is preferred due to the rising popularity of products made from organic sources, hence efforts have been made to industrialize Shea butter extraction utilizing the traditional extraction method.

Some of the ingredients in the butter have a limited capacity to absorb UV radiation, and it has been used as a sunscreen lotion [8]. It is mostly utilized in skin care and hair products. Because it includes a respectable amount of unsaponifiables, it is also utilized in the manufacturing of soap in modest amounts (5-7 percent of the oils in the formula), while greater levels result in softer soaps with poorer cleansing capabilities. It has also been stated that Shea Butter is utilized as an anti-aging and anti-free radical agent, that it soothes irritated and peeling skin, and that it minimizes stretch marks during pregnancy. It soothes dry and irritated skin, includes vitamin A and E all the way to the ends of the hair, and is used to cure rheumatism and arthritis [2].

Nowadays, vegetable oil and fats are highly valued nutritionally and financially because they are good sources of dietary oil supplements that provide energy, sources of antioxidants, and are also employed in the creation of fuels and industrial goods. For example, in the cosmetic, pharmaceutical, and chemical sectors. These oils accounted for over 80% of the world's natural oil and fat supply [9].

The qualitative Phytochemicals screening, Physicochemical and proximate analysis of Shea Butter marketed in Kano state would be the focus of this research.

2. Materials and Methods

2.1 Sample collection

Shea butter was purchased from a trader on January 10, 2022 in Kurmi Market in Kano State, Nigeria.

2.2. Qualitative Phytochemical Analysis

In order to conduct the analysis, the Shea Butter was heated on an electric heater until it transformed into oil [10].

2.2.1. Test for Terpenoids (Salkowski test)

The oil (3 ml) was put along the tube's walls with 1.5 ml of concentrated H_2SO_4 and 1 ml of chloroform. The presence of terpenoids was determined to be present by the reddish brown color in the interface.

2.2.2. Test for alkaloids

The Wagner test (Kohl iodine reagent, iodine) A few drops of Wagner's reagent were added to around 2 ml of oil. The precipitate was obtained in a reddish-brown color, which denotes the presence of alkaloids.

2.2.3. Test for saponins

The oil (2 ml) and 3 ml of distilled water were briskly shaken. For saponins, froth formation is favorable. The presence of saponins is confirmed when emulsion forms after adding a few drops of olive oil to the froth.

2.2.4. Test for Flavonoids

After the oil was treated with concentrated H_2SO_4, an orange color developed, signifying that flavonoids were successfully detected.

2.2.5. Test for tannins

A few drops of a neutral ferric chloride solution at 5% were added to 5 ml of oil, and the creation of a dark green color confirm the formation of tannins.

2.2.6. Test for cardiac glycosides (Keller-Killani test)

A drop of ferric chloride solution was added to the oil (5ml), which was then combined with 2ml of glacial acetic acid. Next, 1ml of concentrated H2SO4 was added. The presence of deoxy sugars of cardenoloides is shown by a brown ring in the interface. In the acetic acid layer, a green ring was also seen just gradually approached the layer, indicating the presence of cardiac glycosides. A violet ring also occurred beneath the brown ring.

2.3 Proximate Analysis of shea butter

The proximate analysis was done following the guidelines adopted by AOAC [11].

2.3.1 Determination of Moisture content

A clean porcelain crucible was dried in a hot air oven at 110 °C, cooled in a desiccator, and weighed as (W1). The pre-tagged crucible was filled with 2 g of the sample, which was then weighed again (W2). The sample-containing crucible was heated air dried till consistent weight (W3). The following formula was used to calculate the percentage of moisture in the samples:

$$\% \text{ Moisture content} = \frac{W2-W3}{W2-W1} X100$$

2. 3.2 Determination of Ash content

To determine the amount of ash in the sweet potato samples, a porcelain crucible was dried in an oven at 100 °C for 10 minutes, cooled in a desiccator, and then weighed (W1). Two (2) grams of the powdered material were added to a preweighed ceramic crucible (W2). The crucible sample was lighted, transferred to a muffle furnace prepared to 550 °C, and permitted to burn for eight hours. The ash-containing crucible was then removed, cooled in a desiccator, and weighed (W3). The ash content as a percentage was estimated as follows:

$$\text{The percentage of ash content} = \frac{W3-W1}{W2-W1} X100$$

2.3.3 Determination of Crude protein content

The crude protein was evaluated using the Kjeldahl method. Kjeldahl machinery digested the materials, yielding a clear, green output. The digest was diluted with 100 cm3 of distilled water after cooling. To distill the digest, 50 cm3 of 2% boric acid were added to a flask containing 40 cm3 of 40% NaOH. Before being placed on the Kjeldahl distillation device, the tubes were placed in the conical flask and the Kjeldahl flask. Heat was utilized to evaporate the ammonia that was liberated by the distillate in the boric acid solution. After titrating the distillate with 0.1 M HCl, the amount of nitrogen recovered was calculated using the following equation:

$$\text{Nitrogen (\%)} = \frac{14\ X\ M\ X\ Vt\ X\ V100}{Weight\ of\ sample\ (mg)}\ X\ Va$$

The crude protein was determined from the amount of the nitrogen obtained and a factor 6.25 as:

$$\% \text{ Crude Protein} = \% N_2 \text{ (Nitrogen)} \times 6.25$$

Where
M is the molarity of Acid
V, the volume of HCl used,
Vt is the total volume of diluted digest and Va is the volume of aliquotdistilled.

2.3.4 Determination of Crude fat

Using the Soxhlet equipment and petroleum ether as the extraction solvent, the crude fat was quantified repeatedly [9].

Weighing was done on a dry round bottom flask of the Soxhlet extraction machine that contained petroleum ether and boiling chips (40 to 60 °C) (W1). The extraction apparatus was installed with the extraction thimble containing the 20 g sample. On the extraction thimble, a condenser and cooling circulator were installed. The round bottom flask containing the boiling chips and the extraction solvent was heated for six hours using the heating mantle. After recovering the solvent, crude fat was gathered in the flask with a circular bottom. Weighing the gathered fat and the flask with a round bottom (W2), the percentage of crude fat was estimated as follows:

$$\% \text{ Crude Lipid content} = \frac{W2-W1}{weight\ of\ the\ sample} X100$$

2.3.5 Determination of Carbohydrate content
The total amount of carbohydrate was determined by difference. As shown in the relationship below, the percentage of total carbohydrate was computed by deducting 100 from the total of the percentages of moisture, ash, crude fat, crude protein, and crude fiber.% Total carbohydrate = 100 - (% moisture + % Ash + % fat + % Protein + % Fiber)

2.4. Physicochemical Analysis of shea Butter
The AOAC technique was used to determine physicochemical parameters such as acid value, iodine value, free fatty acids, peroxide value, saponification value, slip point, clear point, smoke point, flash point, fire point, refractive index, and specific gravity.

2.4.1 Physical Parameters
Slip point: A capillary tube containing a little quantity of fat was heated gradually. The "slip point" is the temperature at which fat merely begins to slide downward because of its weight.

Clear point
A capillary tube was filled with a little quantity of fat, and it was gradually heated. The "clear point" is the temperature at which fat totally melts and turns transparent.

Smoke point
A metal container containing 10 ml of the melte fat was filled and heated in an oven at a regulated rate. The temperature at which a thin, steady stream of bluish smoke initially appears is known as the smoke point.

The flash point
10 ml of the melte fat was placed into a metal container and heated at a regulated pace, with a flame being passed over the surface of the sample at regular intervals. The term "flash point" refers to the temperature at which a flash may be seen everywhere on a sample's surface as a result of volatile gaseous compounds igniting.

The fire point
A regulated rate of heating was applied to 1g of fat on a metal container while a flame was periodically passed over the sample's surface. The temperature at which development of volatiles owing to the thermal degradation of the lipids progresses so swiftly that continuous combustion occurs (a fire), is called “fire point ”

The refractive index
The Hanna refractometer was used to determine the refractive index, or RI. With the use of a light comparator, the refractor was reset (water at 20oc). Sample of the Shea butter (Oil form) was spread on the prism of the instrument, the refractive index was read off.

Specific Gravity
A 50 ml Pycometer bottle was carefully cleaned with soap, water, and petroleum ether before being dried and weighed. The bottle was weighed after being filled with water. The bottle was filled with molten butter (oil) and weighed after being thoroughly dried.

Calculation
Specific gravity = Weight of Xml of oil /Weight of Xml of water

2.4.2. Chemical parameters
Determination of Acid Value or FFA
To 25 ml diethyl ether, 25 ml alcohol and 1 ml of 1% phenolphthalein were added, the mixture was neutralise with 0.1M NaOH, 5g of Shea butter was dissolved in the neutralized solvent and then titrated with 0.1M NaOH solution, shaken constantly until a pink colour was observed which persisted for 15 seconds.

Calculation:

$$Av = \frac{X \text{ mls x (fat factor)}}{W}$$

Where
X = Volume of 0.1 m NaOH used in titration
W = Weight of sample taken

Determination of Saponification Value (S.V)
The Shea butter (2g) was added to 25ml alcoholic KOH solution in as Erlenmeyer flask, a reflux condenser was attached to the flask and heated in boiling water for one hour with frequent shaking. Then 1ml of 1% phenolphthalein was added and titrate hot with standard 0.5 N HCl (an ml). End point is colourless. A blank determination was made (b mill)

Calculation:

$$SV = \frac{(b - a) \times 28.05}{\text{Wt (in g) of sample}}$$

Determination of Iodine value
Shea Butter (0.5g) was put into a glass stoppered bottle (250ml). 10ml CCL_4 was added and dissolved the butter. 20mls wij’s solution added and inserted the stopper and allowed to stand in subdued light for 30 minutes. 15ml KI solution (10%) and 100ml water were added. Titrate with 0.1M $NaS_2.\ 0_3$ using starch indicator. A blank determination was carried out commencing with 10ml of CCl_4

Calculation

$$\text{Iodine Value} = \frac{(b - a) \times 1.296}{\text{Wt (in g) of sample}}$$

Where: b = Blank titration
a = Test titration

Determination of Peroxide value
The fat (1g) was introduced into a clean dry boiling tube, to the fat 1g powered potassium and 20ml solvent mixture were added, and then placed in a boiling water bath for 60 seconds,

the content was poured into a titration flask containing 20ml potassium iodide solution, the tube was washed twice with 25ml portions of water and the washings were added to the titration flask. The contents in titration flask was titrated with 0.002M thiosulphate using starch as indicator.
Calculation.

$$\text{Peroxide value} = 2\ \text{vmEq/kg} \frac{(\text{Titre} - \text{blank}) \times (\text{molarity of thiosulphate} \times 100)}{\text{Weight of sample}}$$

2.4.3 Data Analysis
The data were statistically analyzed at P-value (p<0.05) significant was accepted and comparison between the data was performed using one-way analysis of variance (ANOVA).

3. Result and Discussion
3.1 Qualitative Phytochemical Analysis of shea Butter
Phytochemicals are substances that are not nutrients but have curative or disease-preventive effects. They are non-essential nutrients, which means that the human body does not need them to maintain life. Numerous phytochemicals that are present in leaves, fruits, beans, whole grains, nuts, seeds, or the entire plant have been identified by scientists. The presence of Terpenoids, Alkaloids, Saponins, Flavonoids, Tannins, and Cardiac Glycosides in Shea Butter was confirmed by Phytochemical analysis in this study. It is well known that plants produce these chemicals to protect themselves, but recent research has shown that they can also protect humans against diseases [10]. The phytochemicals that can cure particular illness symptoms. For instance, several of these chemicals have antioxidant properties. According to Michalak [11] as peroxidase oxidizes flavonoids and other phenylpropanoids, they begin to behave as hydrogen peroxide scavengers. Studies have shown that flavonoids not only have antioxidant properties but also have a variety of other biological impacts, including antiviral [12], antibacterial [13], and anticancer [14] properties. They can also reduce enhanced capillary permeability and fragility [15], as well as platelet aggregation and lipid peroxidation. Alkaloids have been demonstrated to possess anti-diabetic and antioxidant effects [16]. According to research, saponins have strong antioxidant potential and can be used in functional foods, nutraceuticals, and as natural food preservatives [17]. According to studies, tannins have potent antioxidant qualities [18]. Saponins, polyphenols, terpenes, and microbial byproducts are examples of natural pancreatic lipase (PL) inhibitors that have untapped potential for use in the treatment of obesity and the development of novel medications [19]. By blocking hepatic HMG-CoA reductase, flavonoids have been shown to lower lipid profiles [20].

Table 1: Qualitative Phytochemical Analysis of shea Butter

Parameter	Observations
Terpenoids	+
Alkaloids	+
Saponins	+
Flavonoid	+
Tanins	+
Cardiac glycosides	+

Key: + Present, - Absent

3.2 Proximate analysis of Shea butter
The proximate analysis revealed that Shea Butter contains a substantial quantity of moisture, carbohydrates, protein, fat, and ash. According to the proximate analysis findings, the moisture content is comparatively low (1.233 0.033%) and the ash level is substantially lower (0.090 0.0%), while the contents of carbohydrates, protein, and fats were determined to be 2.660 0.098%, 3.103 0.033%, and 92.91 0.069%, respectively (Table 2). A sample's relative water content is known as its moisture, and a high moisture level increases an organism's sensitivity to microbial growth and enzyme activity [21]. Because they are excellent providers of energy, carbohydrates play a crucial role in nutrition. Values of total carbs in the range of 40-60 percent are for edible, cultivated and wild fruits [22]. The concentration of protein in the Shea butter is small which is good for consumption as advised by W.H.O [23]. The concentration of crude fat (lipid) in Shea butter is 92.910.069 percent. Fat is important for both nutrition and health. They are antioxidants and the second-largest source of energy [24].

Table 2: Proximate analysis of Shea butter

Parameter	Mean ±SD
Moisture (%)	1.233 ± 0.033
Ash (%)	0.090 ± 0.0
Protein (%)	3.103 ± 0.023
Fat (%)	92.91 ± 0.069
CHO (%)	2.660 ± 0.098

Value are presented in triplicate as mean ±SD

3.3 Physicochemical characteristic of shea butter
3.3.1 Physical Properties of shea butter
The Physical and Chemical Properties of the Shea butter was presented in Table 3. And 4. The slip, clear, smoke, flash, and fire point were found to be 68.67±0.67, 119.3±0.66, 162.0±1.155, 198.7±0.67 and 302.0±1.155 respectively. While Specific gravity and Refractive index (RI) of the shea butter were 0.856±0.001 and 1.53±0.003 respectively. The Density, which is a measurement of specific gravity, this give an update on the solid as well fat composition at a certain temperature. Shea butter has a lower SG than crude palm oil, pumpkin seed oil, etc. Refractive index (RI) of fat rises as chain length and the number of double bonds in the oil both increase [25]. RI also influenced by the oil's degree of conjugation and unsaturation [26]. The slip melting range discovered that Shea butter is a solid fat below 36 °C, making it an excellent source of solid fat for the manufacturing of margarine and mayonnaise. The smoke, Flash and Fire points indicate the temperature limit up to which that cooking oil can be used [27]. It correlates with the amount of free fatty acid in the oil [28].

Table 3: Physical Properties of shea butter

Parameters	Mean ±SD
Slip melting point ^{0}C	68.67±0.67
Clear point ^{0}C	119.3±0.66
Smoke point ^{0}C	162.0±1.155
Flash point ^{0}C	198.7±0.67
Fire point ^{0}C	302.0±1.155
Specific gravity	0.856±0.001
Refractive Index(RI) @25 ^{0}C	1.531±0.003

Value are presented in triplicate as mean ±SD

3.3.2 Chemical Property of Shea Butter
Fatty Acids Content (FFA)
The free fatty acid content of unprocessed Shea butter was discovered to be 0.533 0.0067%. Shea butter has less FFA than cashew nut seed oil, which contains 0.71 % [20]. Shea

butter's low FFA content makes it an excellent choice for baking fat and other food product compositions. The cost and energy necessary for refining and adjustments will be significantly lower than the cost and energy required for cashew nut seed oil refining [29].

Peroxide Value (PV)

The peroxide value (PV) is the milliequivalent (mEq) of oxygen per 100g of fat and is used to quantify how much a fat has been oxidized [30]. The generation of hydroperoxides occurs during the oxidation of an unsaturated oil. The hydroperoxides, as the principal oxidation products, have no off-flavor [31]. The PV of Shea butter in this study is 0.93670.012mEqO2/kg, which is consistent with the previously reported range (0.4 – 2.57mEqO2/kg) for unprocessed Shea butter [32]. The PV of Shea butter is substantially lower than the maximum PV standard for edible fats and oils, which is 10mEqO2/kg [33].

Iodine Value (IV)

The iodine value is a simple chemical constant used to determine the degree of unsaturation in a sample of Fat/oil; it is defined as the number of grams of iodine that could be added to 100 g of oil [34]. In this study, the iodine value of Shea butter was determined to be 30.78 0.012g/100g. This is a low amount when compared to the reported IV of 83.3g/100g [35]. The allowable iodine value for shea butter is between 58 and 72g/100g [36]. The low iodine value of Shea butter shows that the oil is rich in saturated fatty acids, which maintains the stability of meals cooked with the oil against oxidation and rancidity [37].

Saponification Value (SV)

The saponification value (SV) of Shea butter was 0.530.0067mgKOH/g, which is much higher when compared to other oils recorded, and a high SV is an indication of oil suitability for industrial usage [38].

Table 4: Chemical Properties of Shea Butter

Parameter	Mean ±SD
Acid value (mgKOH/g)	0.533 ± 0.0067
Saponification value (mgKOH/g)	186.9 ± 0.073
Iodine value (g/100g)	30.78 ± 0.012
Peroxide value ($mEqO_2$/kg)	0.9367 ± 0.012

Value are presented in triplicate as mean ±SD

4. Conclusion

The study revealed that the Phytochemicals, Proximate and Physicochemical analysis of Shea Butter confirmed that the Shea butter has a great Health and nutritional importance as such it is good for consumption. Additionally, the study shows the industrial viability of shea butter as such its production should be promoted because it can be economically important for being used in Food, drugs, cosmetics, and other Chemical industries.

5. Ethical Approval

No ethical approval required.

6. Acknowledgement

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Declaration of Competing Interests

No competing interests exist between the authors of this study.

7. Author's Contribution

This work was carried out in collaboration among all authors. Authors ALB, TAM and AY designed the Study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MM, AIM, ISY, SAB and MMD managed the analyses of the study. Authors SIS, AMS SMS, and ANA managed the literature searches. All authors read and approved the final manuscript.

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