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Chemical characterization of shea butter oil soap (Butyrospermum parkii G. Don)

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Abstract

Shea butter oil was obtained from the edible nut of the fruit from Karite (Butyrospermum parkii) tree grown in Savannah Grasslands of West Africa. It is a wild growing tree that produces tiny, almond-like fruit. Shea Butter oil was extracted from the fruit by cold process and was used to prepare medical soap. Chemical analysis showed that the obtained soap has 76.0 %, 9.0 %, 3.41 minutes, 9.0, 0.0 %, 3.7% and 0.87 as its total fatty matter, moisture, foam stability, pH, free caustic alkali, unsaponified and specific gravity respectively. Due to the phytoconstituents in shea butter oil and the favourable chemical characteristics of the soap, it can be used as medical and cosmetics toilet soap. Such soap is used to alleviate problems of the skin and scalp.

Keywords: Medical Soap; Karite Tree; Butyrospermum Parkii; Shea Butter Oil; Chemical Characteristics

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1. Introduction

The meaning of the term soap is considerably restricted, being generally limited to the combinations of fatty acids and alkalis, obtained by treating various animal or vegetable fatty matters or the fatty acids with soda or potash. The reaction of fatty acids with alkalis is known as saponification (Rohman et al., 2011). Based on its chemical properties as an anionic surface active agent (surfactant), soap is used to clean and wash skin and clothing (Firempong and Mak-Mensah, 2011; Kerr-Pontes et al., 2006). The fatty acids, stearic, palmitic, myristic, lauric and oleic acids, contribute to lathering and washing properties of the soaps. Palm oil has been widely used as fatty raw material in the manufacture of soap (Oluwatoyin, 2011). The chemical characteristics of soap depend on several factors: the strength and purity of alkali, the kind of oil used, completeness of saponification and age of the soap. Such physico-chemical characteristics include moisture content, total fatty acids (TFM), pH, free alkali, percent unsaponified matter, foam stability and specific gravity (Firempong and Mak-Mensah, 2011).

Shea butter oil has been used in the manufacture of natural cosmetics, toothpaste, hair and skin care products, emulsions, liquors, ointments and medicinal cosmetics (Coulibaly et al., 2009). However, shea butter oil can be produced mechanically (hot or cold process) or chemically (solvent extraction) from the edible nut of the fruit from the Karite tree (Butyrospermum parkii) grown in Ghana, Mali, Burkina Faso and other Savannah Grasslands of West Africa.

The best quality shea butter oil with a majority of phytoconstituents intact is obtained through cold process. In cold process, the oil is light coloured with almost all its natural inherent qualities intact and has a milder odour (Shahinuzzaman et al., 2016; Warra et al., 2010). Moreover, potential residual solvents in chemical extracted oil that may pose health hazards to consumers are eliminated since solvents are not used in the cold processing techniques.

Shea butter oil contains high triglycerides and has 5% fatty acids, 8% unsaponifiables and 7% waxy esters that reduce tumors and cancers eg lymphocyticleukemia (Fokou et al., 2009; Honfo et al., 2014). The phenolic compounds present in them contain catechin which reduces inflammation, pain and swelling that occur in arthritis (Badoussi et al., 2015; Honfo et al., 2014). Shea butter oil combats vaginal infections and sexually transmitted diseases (Shahinuzzaman et al., 2016), kills lice, scabies, ringworm, athlete's foot fungus and *Phytophthora infestans* (George and Raymond, 2015). Its phytoconstituents repel mosquitoes, fleas and houseflies when applied to the skin and solves the problem of dandruff, baldness and graying of hair. Moreover, it cures leprosy, rheumatism, chronic syphilitic sores and indolent ulcer. It also clears herpes simplex; resistant strains of *E. coli, Staphylococcus aureus*, chicken pox, cholera, pneumonia, tuberculosis, peptic ulcer, diabetic foot, dry psoriasis and heals wound and other skin disorders (Israel, 2014).

Shea butter oil is rich in essential fatty acids (EFAs), triglycerides, vitamin E and calcium. Because of its EFAs and vitamin E, the oil penetrates deep within the skin to heal the minute cracks brought on by severe dryness. Fatty acids present in the oil are oleic acid (46.4%), linoleic acid (6.6%), palmitic acid (4.0%), stearic acid (41.5%) and arachidic (1.3%) (Honfo et al., 2014; Israel, 2014; Zaidul et al., 2014). Acid value of shea butter oil is < 13.4 (Zaidul et al., 2014). Shea butter oil also has many uses and may or may not be refined. In the West, shea butter is mostly used for cosmetics (Alonge and Olaniyan, 2007). Throughout Africa it is used

extensively for food, as it is edible, and medicinal purposes, and is a major source of dietary fat. It is used for massaging purposes especially if one has body pains and also for swollen injuries. Vitamin E acts as a free radical scavenger, by hindering the oxidizing processes in the skin. It promotes soft and supple skin, helps in reducing old scars and promotes healing (Firempong and Mak-Mensah, 2011; Sarasan and Rangwala, 2014).

The tree is perennial and starts bearing its first fruits after 10–15 years old; full production is attained when the tree is about 20–30 years. It then produces nuts for up to 200 years. The fruits resemble large plums and take 4–6 months to ripen. The average yield is 15–20 kilograms of fresh fruit per tree, with optimum yields up to 45 kg. Each kilogram of fruit gives approximately 400 grams of dry seeds. Exploitation of shea butter oil as a substitute for palm oil in soap production will not merely reduces competition between cosmetic industries and domestic use of palm oil for cooking, but also minimizes palm oil imports. The shea butter soap will also be antimicrobial. In addition, the shea butter soap will be acceptable to people suffering from skin diseases such as acne, psoriasis and eczema who are allergic to soaps containing Diethanolamine, Isopropyl alcohol, Butylated hydroxyl toluene and Triclosan additives (Garba et al., 2015; Israel, 2014).

Phenolic compounds are known to have antioxidant properties. A recent study characterized and quantified the most important phenolic compounds in shea butter. This study identified 10 phenolic compounds in shea butter, eight of which are catechins, a family of compounds being studied for their antioxidant properties. The phenolic profile is similar to that of green tea, and the total phenolic content of shea butter is comparable to virgin olive oil. Also, this study was performed on shea butter that had been extracted with hexane, and it was noted that alternative extraction methods — such as traditional extraction — may result in higher phenolic levels. Furthermore, it was noted that the catechin content alone of shea butter oil is higher than the total phenolic content of ripe olives (Honfo et al., 2014).

However, work on the chemical properties of soap using only shea butter is an emerging subject that needs much attention. Therefore, this work, aims at employing shea butter oil as an alternative source of fatty material in medicinal soap preparation and to determine the chemical characteristics of the produced soap which may help to impart its medicinal characteristics. We hypothesized that the overall concentration of phenols in shea butter oil is linked to the level of environmental stress that the trees endure.

2. Methodology

2.1. Shea butter

Fully matured fruits of Shea tree were collected in the morning from trees at Wa in the Upper West region of Ghana. The fruits were kept in a clean container and were transported to Cape Coast.

2.2. Extraction of shea butter

The fruits were de-pulped, boiled in water bath and sun dried at a temperature range of 40-50 ^{0}C. It was then de-husked to remove the shell and sun dried again. The kernel were pound with pestle and mortar to break

the seed into grits and roasted to facilitate extraction of the butter. The paste was knead in water to capture the fat into emulsion and the mixture boiled gently to skim off the fat. The final cooling process leads to shea Butter. The process was done manually to obtain oil with all its natural phytoconstituents intact (Ayegnon et al., 2015; Fokou et al., 2009).

2.3. Soap preparation

The method as described by Firempong and Mak-Mensah, 2011; Sarasan and Rangwala, 2014 was modified and used for shea butter soap preparation. A 100 g of shea butter oil was weighed into a 500 ml beaker and carefully heated to about 70 ^{0}C on a water bath. Saponification was initiated by adding 20 ml of 23.5 % NaOH. To the resulting solution, 60 g of $NaOH_{(s)}$ pellets dissolved in 100 ml of distilled water was added gradually while stirring until completion of saponification. Exactly 12 g of $NaCl_{(s)}$ crystal was dissolved in 30 ml of distilled water and added to the grain soap. The salt was added to separate the spent lye in the bottom, while saponified mass floated on the surface to reduce the soap viscosity and to separate the glycerol water in the bottom. The glycerol water was isolated by siphoning. Afterwards, the soap paste was washed again by 5-10 % hot water (80 °C) to reduce excess sodium hydroxide and sodium chloride and any impurities found in the soap paste. The soap obtained was washed with 10 ml of distilled water, filtered using a linen cloth, air-dried, and a small amount of water was added to soften it while heating. The soap was placed in a cast and allowed to dry.

2.4. Determination of Total Fatty Matter (TFM)

A modified method as described by Ogunsuyi and Akinnawo, 2012; Sarasan and Rangwala, 2014 was used. The total fatty matter test was carried out by reacting the soap with acid in the presence of hot water and measuring the fatty acids obtained. Exactly 10 g of finished soap was weighed and 150 ml distilled water was added and heated gently in water bath. The soap was dissolved in 20 ml of 15 % H_2SO_4 while heating until a clear solution was obtained. Fatty acids on the surface of the resulting solution was solidified by adding 7 g of bee wax and reheated. The set up was allowed to cool to form a cake. The cake was removed and blotted to dry and weighed to obtain the total fatty matter using the formula:

$$\% \, TFM = \frac{A - X}{W} \times 100$$

where A= weight of wax + oil

X= weight of wax and

W= weight of soap

2.5. Analysis of unsaponified matter

The method described by Schröder and Vetter (2012) and Tranchida et al. (2013) was used. Exactly 5 g of soap obtained was refluxed with 50 ml of 0.1 M alcoholic potassium hydroxide solution on water bath for about an

hour. When saponification was completed, the content of the flask was transferred to a separating funnel and the flask was washed with 50 ml distilled water and poured into the separating funnel. Then 50 ml petroleum ether was used to extract the water insoluble matter (unsaponified matter). This extraction was repeated several times and the petroleum ether was expelled by heating gently. The average value was calculated and this gives the total unsaponified matter present in the soap.

2.6. Determination of total alkali

The total alkali was determined by titrating excess acid contained, in the aqueous phase with standard volumetric NaOH solution. Procedure by Hasibuan and Ma'ruf (2014) and Warra et al. (2010) was modified and used. A 10g of finished soap was weighed and 100 ml of neutralized alcohol was added to it. Afterwards, 5 mL of 1

N H_2SO_4 solution was added to the mixture and heated till the soap sample dissolved. Test solution was titrated against 1 M NaOH using phenolphthalein as indicator. The total alkali was obtained by the formula:

$$\%Total\ Alkali = \frac{\mathrm{VA} - \mathrm{VB}}{W} \times 3.1$$

where VA= Volume of acid

VB= Volume of base

W= weight of soap

2.7. Determination of free caustic alkali

A modified method as described by Sarasan and Rangwala (2014) and Shahinuzzaman et al. (2016) was used. A 5 g of finished soap was weighed and dissolved in 30 mL of ethanol. Few drops of phenolphthalein indicator and 10 ml of 20 % $BaCl_2$ were added. The resulting solution was titrated against 0.05 M H_2SO_4. The volume of the free caustic alkali obtained was calculated using the formula;

$$NaOH = \frac{0.31 \times Va}{W}$$

where Va = Vol. of acid

W = weight of soap

2.8. Determination of foam stability

Exactly 4.0 g of soap produced was dissolved in 100 mL of distilled water in a 200 mL measuring cylinder. It was shaken vigorously for 4 minutes and was allowed to stand for 15 to 20 minutes. The time taken for the foam to collapse was determined using a stopwatch (Ameh et al., 2013; Ogunsuyi and Akinnawo, 2012).

2.9. Analysis of % moisture Content

Approximately 5 g of samples was accurately weighed using analytical balance (Mettler Toledo, Sensitivity 0.1mg) into dried, tarred moisture dish and dried in an oven (Memmert, Germany) for 2 hr at 101 ±1 ^{0}C and repeated until a constant weight (difference between two measurement not exceeding 0.5 mg/g of sample) was reached. The % moisture was calculated using the following formula (Badoussi et al., 2015):

$$\% \, Moisture = \frac{\mathrm{Cs} - \mathrm{Ch}}{\mathrm{Cs} - \mathrm{Cw}} \times 100\%$$

where Cw= weight of crucible

Cs= weight of crucible + sample

Ch= weight of crucible + sample after heating.

2.10. Determination of specific gravity

The specific gravity (S. G.) was determined based on the method used by Adam et al. 2015. An empty specific gravity bottle was weighed and its mass recorded as M_1. The bottle was filled with water and weighed. The weight was recorded as M_2. The bottle was then emptied, dried and filled with shea butter oil. The weight obtained was recorded as M_3. The specific gravity was then calculated based on the equation:

$$S.G = \frac{M_3 - M_1}{M_2 - M}$$

2.11. Determination of pH

Exactly 10 g of the caked soap was weighed and dissolved in distilled water in a 100 mL volumetric flask. This was made up to prepare 10 % soap solution. The pH of the 19 % soap solution was determined using a pH meter (SPER 840087). A 2 g of finished soap was dissolved in 10 mL of distilled water and stirred till sample dissolved. The pH was determined with pH meter according to Rafaela et al. 2016 method.

3. Results

Figure B shows shea butter oil extracted from the shea seed kernels through mechanical pressing. The soap prepared from this oil is shown in Figure D. However, the results of chemical analysis reflecting the characteristics of the soap are summarized in Table 1.

Figure A. Shea butter tree

Figure B. Shea nuts

Figure C. Shea butter

Figure D. Shea Butter Soap

Table 1. Chemical characteristics of the prepared shea Butter Soap, compared with a standard toilet soap values obtained from literature

Characteristics	**Shea Butter Soap**	**Standard Literature Values**
% Total fatty matter	76.0	76-77
% Moisture	9.0	10.5-12.5
Foam Stability	3.41minutes	2.23minutes
pH	9.0	9-11
% Free Caustic alkali	0.0	0.07
% Unsaponifiable matter	3.70	3-6
Specific gravity	0.87	0.86-0.873

(Values are mean ± Standard deviation, n = 3)

Total fatty matter (TFM) is the ratio of mass of fatty matter to the total mass of the soap (Oyekanmi et al., 2014). It measures the quality of soap. TFM of 76.0% (Table 1) was close to the standard literature value of 76.0-77.0 %. Other physicochemical characteristics such as moisture content in the soap was 9.0 % ; free caustic alkali content was 0.0; pH was 9.0; foam stability was 3.41minutes; unsaponifiable matter was 3.70 % and specific gravity was 0.87 (Table 1). All the results for the sample were close to the standard literature values.

4. Discussion

Shea Butter soap was prepared as a product of saponification reaction between NaOH solution and oil extracted from shea fruit seed kernel. The soap free caustic alkali value (0.0) compares well with the standard literature value. NaOH and NaCl contribute to the total alkali for shea butter soap. The free caustic alkali is the amount of alkali free to prevent soap from becoming oily (Vivian et al., 2014). Moreover, the detected free caustic alkali content of the soap (0.0%) is in harmony with the results obtained by Firempong and Mak-Mensah (2011), Ogunsuyi and Akinnawo (2012), and Vivian et al. (2014).

From Table 1 the specific gravity obtained for the shea butter oil was 0.89. This value was close to the one published by Adam et al., 2015 which was between 0.91. This property means that shea butter floats on the surface of water when dropped on it. It was based on this property that makes it easier to collect shea butter on the surface of water during shea butter extraction from the shea nut (Coulibaly et al., 2009).

The unsaponifiable matter value was found to be 3.70 % (Table 1) for shea butter oil. This value falls within the range reported in literature by Schröder and Vetter (2012) which was 3-7 %. This means that the oil can be used for saponification without refining. Phytosterol, cinnamic acid and karitene responsible for high values of unsaponified matter can be removed by boiling in water and ethanol mixture (Ogunsuyi and Akinnawo, 2012). The soap absorbs into the skin without leaving a greasy feel.

The total fatty matter (TFM) of shea butter soap was 76.0 % (Table 1) and found to be lower than the standard literature value and those obtained (76-77 %) by Firempong and Mak-Mensah, 2011; Ogunsuyi and Akinnawo, 2012; and Vivian et al., 2014 but higher than Ghana standard of 59 %. The lower TFM value is due to the presence of unreacted NaOH in the mixture. These differences in the TFM is responsible for high moisture contents and the quantities of the used fatty materials and also perhaps due to the difference in the saponification method. However, dry skin needs soap which is high in TFM of 80 %. This re-hydrates, the skin making it smooth and additionally the high oil content within the soap acts as a lubricant throughout the day (Ogunsuyi and Akinnawo, 2012). This property makes it ideal medicinal soap for people in the tropics.

The foam stability of shea butter soap was determined by measuring the time it takes for the lather formed by the soap with pure water to collapse (Ameh et al., 2013). The time it took for the lather to collapse was 3.41 minutes compared to standard literature of value 2.23 minutes (Table 1). This observation corroborates moisture loss, that is, as the moisture content reduces, the corresponding foaming strength increases (Ogunsuyi and Akinnawo, 2012).

The moisture content of the shea butter soap (9.0 %) found in this work (Table 1) was lower than those (10 %) reported by Sonwai et al. 2014 and literature value of 10.5-12.5 %. This value may be due to the difference in the soap preparing methods.

From the results, the pH (9.0) of the shea butter soap (Table 1) was consistent with the normal pH range for soap 9-11 (Rafaela et al., 2016). This value is slightly lower than 9.11- 9.99 for neem – shea butter soap samples. This low value obtained might be due to partial alkali hydrolysis resulting from the saponification process. The reaction can be completed by the addition of excess shea butter oil or any other super fatting agent to reduce the severe nature of the soap or addition of excess caustic soda (Ameh et al., 2013). The prepared soap was not corrosive to the skin because it was made of a salt of a weak acid (such as fatty acid) and a strong base (NaOH). The soap was alkaline (pH~9) in aqueous media. Literature had shown that alkaline substances neutralize the body's protective acid mantle that acts as a natural barrier against bacteria and viruses (George and Raymond, 2015).

5. Conclusion

Shea butter soap was prepared from mechanically pressed shea nuts kernel to obtain the oil. Physico- chemical parameters obtained showed that the soap has 76.0 %, 9.0 %, 3.41 minutes, 9.0, 0.0 %, 3.7 % and 0.87 as its total fatty matter, moisture, foam stability, pH, free caustic alkali, unsaponified matter and specific gravity respectively. These values obtained with shea butter oils fall within the literature values for alternative oils such as palm oil widely used in soap making. Also, it does not require any bleaching as compared to palm oil where the red color must be bleached. This research work shows that shea butter oil soap is one of the quality soaps in terms of health benefits, antioxidants and with favorable medicinal properties that can be used as a substitutes for palm oil.

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