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PHYSICOCHEMICAL PROPERTIES AND FATTY ACID COMPOSITION OF SHEA BUTTER FROM TAMALE, NORTHERN GHANA

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Abstract
Shea butter is a significant source of fat in the diet of many rural dwellers in northern Ghana. It is produced from the seeds of shea tree and its suitability as dietary fat or use in cosmetic industry is greatly influenced by its physicochemical properties and fatty acid composition. The aim of this study was to determine the physicochemical properties and fatty acid profile of shea butter sold in Tamale Central market and to compare the qualities with other edible oils. The samples of shea butter were analyzed for refractive index, unsaponifiable matter, saponification, iodine, acid and peroxide values and fatty acid composition. Physicochemical properties of shea butter obtained in this study were refractive index of 1.5 at 25oC, saponification value (198 mg/KOH/g), iodine value (45.6 I2g/100g), unsaponifiable matter (19.8 %), acid value (3.2 mgKOH/g) and peroxide value (9.84 meq/kg). The predominant unsaturated fatty acids were: oleic (36.3%), linoleic (5.4%) and alpha linoleic (0.14%). The most dominant saturated fatty acids found were stearic (52.4%) and palmitic acids (3 %), arachidic (1.5%). Data suggests that shea butter sold in Tamale compared favourably with shea butter from countries within the West African sub region and Uganda and also to other edible oils. The implication of all these is that shea butter is a good cooking oil and is safe for human consumption.

Keywords*: Shea butter, physicochemical, fatty acid, edible oil, Vitellaria paradoxa*

Introduction

Shea butter is a fat extracted from the seeds of the shea tree. The tree (*Vitellaria paradoxa* L.) is indigenous to sub-Saharan Africa and grows from Guinea Bissau in West Africa to Ethiopia in the East. In Ghana the shea tree grows in the savannah vegetation particularly in the Upper East, Upper West and Northern regions with scattered growth in northern parts of Brong Ahafo and Volta regions. It was estimated that Ghana currently produces over 130,000 metric tonnes of shea nuts annually (Hatskevich *et al.*, 2011). The shea butter industry is a very important source of income (Elias and Carney, 2005) and also provides significant source of edible oil and energy for many rural communities (Honfo *et al.*, 2014). Besides its edibility, shea butter serves as raw material for the local soap industry, cosmetics especially during the harmattan and also as a base in traditional medicine (Okullo *et al.*, 2010, Goreja, 2004).

Globally there is an increasing demand for shea butter as a substitute for cocoa butter in food, cosmetics and pharmaceutical industries (Hatskevich *et al.*, 2011, Okullo *et al.*, 2010). Quality demands from developed countries in the global shea butter trade require development of improved production standards for enhanced quality product by producer countries. Shea butter from West Africa was shown to have significant variations in both physicochemical and fatty acid composition and in some instances differences between trees in the same

locality were reported (Maranz *et al.*, 2004, Salunkhe, 1992). It is important therefore that data on characteristics on shea butter be updated for improvement in product quality.

Fats and oils have often been implicated in many health complications including heart disease (Siri-Tarino *et al.,* 2010). However, as vegetable oil, shea butter could be an important provider of vitamins *A, D, E, K* and essential fatty acids in human diet (Moreira *et al.*, 2004, Salunkhe, 1992). Some of these fat soluble vitamins especially A and E are known to be very important antioxidants and the essential fatty acids are necessary for the synthesis of cell membranes, nerve tissues, and steroid hormone formation (Uauy *et al.*, 2000).

These suggest that information on physicochemical properties of shea-butter and its fatty acid profile must be available to help consumers, food producers, processors and health care givers to make informed and healthy choices concerning cooking fats and oils. This study was to determine the physicochemical properties and fatty acid composition of shea butter sold in Tamale Central market and to compare the qualities with other edible oils.

Materials and Methods

Sample collection and laboratory analyses

Samples of shea butter were purchased from three shea butter sellers in the Central market of Tamale Metropolis. Refractive index of the samples was also obtained using Abbe refractometer (Carl Zeiss121554, Germany). Saponification value, iodine value, unsaponifiable matter, acid value and peroxide value were determined using standard methods of AOAC., 1990.

Fatty acid profile of shea butter was determined following the procedure described by Ezeagu and associates (2010). This involved transmethylation of shea butter oil using trimethylsulfonium and esters produced analyzed in gas liquid chromatograph equipped with flame ionization detector.

Results and Discussion

Physicochemical properties of shea butter

Physicochemical characteristics of shea butter from Tamale metropolis are presented in Table 1. The iodine value is indicative of extent of saturation and a measure of storability or shelf-life of oil. It relates positively to the degree of unsaponification (Shahidi and Zhong, 2010).The iodine value of 45.6 I_2g/100g oil (Table 1) obtained in this study is higher than the range of values (36.6 – 41.4 I_2g/100g oil) reported for shea butter from Districts of Uganda (Okullo *et al.*, 2010). It is however consistent with 44.6 I_2g/100g oil for shea butter from Southern Guinea savanna (Enaberue *et al.,* 2014), compares favourably with 43.3 I_2g/100g oil (Chukwu and Adgidzi, 2008) but lower than values reported by (Chibor et al., 2017). The shea butter in the current study was more saturated than soybean oil (124-139 I_2g/100g oil) and palm oil (50-55) (Stan, 2013) This probably explains why it solidifies even at room temperature and has low liability towards oxidative rancidity which makes it a desirable cooking oil. Also shea butter may be recommended for human consumption because its iodine number is higher than the recommended codex standards for coconut oil (6.3 - 10.6) and palm kernel oil (14.1-21) (Stan, 2013).

Table 1: Physicochemical Properties of Shea Butter oil

Sample	Refractive index at 25°C	Saponification value (mg/KOH/g)	Iodine value I_2g/100g oil	Unsaponifiable matter %	Acid value mgKOH/g oil	Peroxide value meqO_2/kg
Shea Butter oil	1.46 ± 0.01	198 ± 1.22	45.6 ± 1.21	9.8 ± 0.35	3.2 ± 0.31	9.8 ± 0.42

Peroxides formed during storage account for rancidity off-flavours of oils. The peroxide value of 9.8 meqO_2/kg recorded in current study (Table 1) relates positively to 10 meqO_2/kg (Chukwu and Adgidzi, 2008) but lower than 14.2 and 29.5 meqO_2/kg reported by Adetuyi *et al.* (2015) and Dandjouma *et al.* (2009) respectively. Differences in the figures reported by different authors may be due to factors such as storage duration of the fat (Kirk and Sawyer, 1991) and type of kernel (fermented) (Dandjouma et al., 2009). According to Kirk and Sawyer (1991) peroxide is the initial product of unsaturated fat oxidation and that the process starts slowly at the early stages depending on temperature and type of oil. The peroxide concentration in this study showed that the shea butter was relatively fresh. Kirk and Sawyer (1991) reported that fresh oil usually has peroxide values below10 meqO_2/kg, but when this value increases to between 20 and 40 meqO_2/kg, a rancid taste is produced. This is associated with complex changes and formation of volatile compounds of ketones, aldehydes and hydroxyl groups as agents of the characteristic off-flavours and odours of oils (Abdulrahim *et al.*, 2000). The peroxide value of 9.8 meqO_2/kg registered on this study makes the shea butter from Tamale a good oil for the food industry. As explained by Honfo *et al.* (2014), for use in the food industry, shea butter must have peroxide value less than 10 meqO_2/kg, whilst oil of 1 meqO_2/kg peroxide value is good for cosmetic industry.

Chukwu and Adgidzi (2008) reported acid value of 3.8 mg KOH/g oil which is consistent with results of the current study (3.2 mg KOH/g oil). Adetuyi *et al.* (2015) recorded 1.8 mg KOH/g oil, a value much lower than registered on this study. Okullo *et al.* (2010) on the other hand reported acid values in the range of 2.3 to 12.6 mg KOH/kg oil. The shea butter in this study may be classified as acidic since the acid value is greater than 2 mg KOH/g oil above which oil is considered acidic (Chukwu and Adgidzi, 2008). In relation to the acid value, consumption of shea butter will have no detrimental effect on health. This is because groundnut oil with acid value of 4 mg KOH/g oil is consumed extensively in Nigeria without any reported health challenges (Chukwu and Adgidzi, 2008). Acid value may be expressed as percentage free fatty acid which defines the extent of degradation of triglycerides in the oil by lipase or other factors such as light and heat (Kirk and Sawyer, 1991). The acid content of oil is felt at the palate when oleic acid concentration reaches 0.5-1.5 % (Farid *et al.*, 2014, Kirk and Sawyer, 1991). Free fatty acid content of shea butter is affected by duration of storage, processing, packaging material, germinating stage of fruit of shea nut and general climatic conditions (Okullo *et al.*, 2010, Kapseu *et al.,* 2001). This may explain the observed differences between values reported here and finding by other studies.

Shea butter has saponification value of 198 mg/KOH/g which compares favourably with the recommended codex standard of many edible oils such as soybean (189 - 194 mg KOH/g oil) and palm oil (190 -209 mg KOH/g oil) but lower than that of palm kernel oil (230 - 254 mgKOH/g oil) (Stan, 2013). Chibor *et al.* (2017) reported a saponification value of 227.9 mgKOH/g oil. For shea butter from different districts of Uganda, Okullo *et al.* (2010) reported saponification values in the range of 160.4 – 192.2 mgKOH/g oil. Saponification value is used as a measure of the proportion of the fatty acids present in the fat. The high saponification value makes shea butter in this study good for soap production (Enaberue *et al.*, 2014)

The unsaponifiable matter (USM) of 9.8% of shea butter by far exceeds all the values recommended by the codex standards for most vegetable fats (Stan, 2013). Shea butter was reported to have very high levels of USM (4 – 11%) compared to other plant oils (Nahm *et al.*, 2013). Honfo *et al.* (2014) reported unsaponifiable matter of shea butter from many authors in the range of 1.2 to 17.6% whilst unsaponifiable matter of 0.95 % and 0.4 % were reported by Chibor *et al.* (2017) and Chukwu and Adgidzi (2008) respectively. Shea butter essentially consists of triglycerides and unsaponifiable matter which influences its industrial relevance (Akihisa *et al.*, 2010). The significant variations in unsaponifiable matter content of shea butter is influenced by factors such as degree of ripening of the fruit and variations in annual rainfall (Honfo *et*

al., 2014). The high proportion of unsaponifiable matter indicates availability of desirable secondary plant metabolites such as antioxidants, anti-inflammatory, antibacterial and vitamins (Nahm *et al.,* 2013). Even though the antioxidants offer protection against oxidative rancidity, the high proportion of unsaturated fatty acids associated with plant oils may cause some degree of oxidative rancidity in storage (Shahidi *et al*., 2010; Moharram *et al*., 2006). This suggests duration and conditions of storage must be carefully monitored to prevent deterioration in quality characteristics of shea butter.

Fatty acid composition of shea butter

Shea butter in this study contains appreciable amounts of essential fatty acids (Table 2); alpha linolenic (0.14%) and linoleic (5.43%) acids, which the body cannot manufacture and must be supplied in the diet. Linoleic acid content compared closely to the concentrations obtained from three districts of Uganda (6.86, 6.4 and 6.2 %) but lower than 7.8% from a fourth district (Okullo *et al*., 2010) and mean value of 7.7% of shea nuts from different locations in Northern Ghana (Quainoo *et al*., 2012). It is a very important polyunsaturated fatty acid in human diet and is known to prevent coronary heart diseases and atherosclerosis among others (Bello *et al.*, 2011).

Considering linoleic acid values reported from Uganda and 6.6% to 7.2 % reported from two savannah zones of Nigeria (Ugese *et al*., 2010), shea butter sampled from Tamale may be viewed as moderate source of essential fatty acids.

Table 2: Fatty Acid Composition of Shea Butter

Fatty Acids	Ratios	Weight (%)
Saturated		
Lauric	C12:0	0.14 ± 0.01
Myristic	C14:0	0.06 ± 0.00
Palmitic	C16:0	2.97 ± 0.08
Stearic	C18:0	52.36 ± 0.22
Arachidic	C20:0	1.48 ± 0.05
Unsaturated		
Oleic	C18:1 (cis-9)	36.29 ± 0.13
Cis vaccenic	C18:1	0.52 ± 0.00
Linoleic (n-6)	C18:2 (C-9, C-12)	5.43 ± 0.04
Alpha linolenic	C18:2 (C-9, C-12 C-15)	0.14 ± 0.00

These fatty acids are used in the production of postagladins, et althromboxanes, postacyclines and leukotrienes which are involved in a number of activities in the body including the control of inflammations (Calder, 2006). Of the 16 saturated and 16 unsaturated fatty acids that define shea butter fat , oleic, palmitic, stearic, arachidic and linoleic acids are the most abundant (Di Vincenzo *et al.,* 2005). The most dominant saturated acid in this study was stearic acid (52.4%) which was higher than the amount reported for shea butter from four districts in Uganda (28.6 to 30.9%) (Okullo *et al.,* 2010) and values (45.1 to 49.7%) reported by Ugese *et al.* (2010). The high stearic proportion gives shea butter solid characteristics at room temperature and therefore useful for the manufacture of bakery fat and margarine (Chibor *et al.*, 2017) and also as cocoa butter improver in the chocolate industry (Ugese *et al*., 2010).

The major unsaturated fatty acid, oleic acid with percentage proportion of 36.3% which was higher than 23.3 % of soybean oil (Ezeagu *et al.*, 2004), was consistent with 37.2%, but lower than 40.2 to 43.4%

reported for nuts from seven different locations in Nigeria (Ugese *et al.*, 2010). Oleic acid has lower melting point (16.3^{o}C) than stearic acid (69.6^{o}C) and therefore affects the degree of hardness depending on its relative proportion in shea butter (Ugese *et al.,* 2010). This suggests that the higher stearic acid to oleic acid ratio, the harder the shea butter. The unsaturated fatty acid content gives shea butter a much higher degree of unsaturation than coconut or palm kernel oil (Stan, 2013). Consumption of oleic acid has the benefit of reducing low-density lipoprotein (LDL) cholesterol concentration in the blood thus lowering risk of coronary heart disease (Okullo *et al.*, 2010). However, shea butter may not be a very good source of linoleic acid when compared to the levels in sunflower oil (48 to 74 %) (Díaz *et al*., 2006) and soybean oil (53.7%) (Ezeagu *et al.*, 2004).

Several studies (Mensink *et al*., 2003, Rosqvist *et al.*, 2017) indicate that concentration of cholesterol in the serum is dependent on the type of fatty acid. Blood serum cholesterol increases with saturated fatty acids but decreases with unsaturated fatty acids. Palmitic acid concentration (3%) recorded in this study compared favourably with 4.1 % reported by Chibor *et al.* (2017) but lower than 6.5-8.1% recorded by Okullo *et al.*, (2010). According to Ogungbenle and Anisulowo (2014), palmitic acid consumption constitutes a very significant risk factor for coronary heart disease. Myristic, palmitic and lauric acids are considered strong hypercholeromic agents of all the saturated acids (Zock *et al.*, 1994). It is therefore important that humans consume fats and oils that contain less of these fatty acids. Fortunately shea butter in the current study contained less myristic (0.06%) and palmitic acids (3%) than palm oil which contains 0.7 % and 36.7 % respectively (Ramos *et al*., 2009). Again, the level of lauric acid (0.14%) in shea butter is far below that found in palm kernel oil (45 -55 %) (Stan, 2013) and so may not increase serum cholesterol to any appreciable level.

The saturated acid, stearic acid (52.4%) in shea butter is higher than 41.6 % reported by Quainoo *et al.* (2012) from shea nut seeds in Northern Ghana. Importantly, however, stearic acid does not elevate LDL cholesterol (Mensink, 2006).

Conclusion

Physicochemical characteristics of shea butter sold in Tamale compared favourably with that of many edible oils and to those of shea butter oil within the West Africa sub region. These together with saturated and unsaturated fatty acid composition make shea butter from Tamale a potential raw material for the food, soap and cosmetic industries. It could serve as a good source of essential fatty acids in the diet of many rural dwellers.

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