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Preliminary studies on the effect of shea kernel size on shea butter quality

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The study was carried out between March, 2012 and January, 2013 at the University for Development Studies, Nyankpala campus, Ghana. The objectives of the study were to characterize farmer shea nut varieties to determine the physical and chemical characteristics of the shea nut butter and determine appropriate shea nut quality for the domestic market. The shea nuts were characterized as T1 (small nuts), T2 (medium nuts), T3 (big nuts) and T4 (very big nuts). These nuts were arranged in a completely randomized design and replicated three times for shea nut butter extraction and assessed for free fatty acid (FFA), moisture content and sensory quality. The study reveals strong correlation between shea nut size and butter quality with bigger shea nuts recording lower FFA and moisture content hence higher butter quality. There were differences in colour and texture of the shea butter extracted from the different shea nut sizes. It is recommended that, further research be carried out at different geographical locations to assess the effect of shea nut size on butter quality.

Key words: Shea kernel, free fatty acid, moisture content, sensory quality.

INTRODUCTION

Shea nut is known as '*Kpihi*', '*Nyuuni*' and '*Kyuuma'* among the Dagomba, Frafra and Wala people of Ghana, respectively. It is obtained from the fruit of shea tree *(Vitellaria paradoxa),* which exists in the wild and grows in an uncultivated state in most parts of Africa. Shea fruit is made up of a green epicarp, a fleshy mesocarp (pulp) and a relatively hard shell (endocarp) which encloses the shea kernel (embryo). The kernel, according to Axtell et al. (1993) contains about 60% edible fat (shea butter) and the residual product, from which the butter is extracted (shea cake), is an excellent ingredient for livestock feed production. Shea butter is as good as table oil because of its high nutritive value. It is widely used locally for curing leprosy and other ailments. It also has various industrial uses that include edible oil, soap making, cosmetics, pharmaceuticals, lubricants and paints. According to Russo and Etherington (2001), shea products such as solid fat (butter or stearin) and the liquid oil (olein) are ideal for use as raw materials for cooking oils, margarines, cosmetics, soaps, detergents and candles. However, they have found their primary market as a substitute for cocoa butter in the chocolate and

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confectionary industry.

According to the American shea Butter Institute (ASBI, 2004), 100% pure natural shea butter is an all-natural vitamin A cream. Shea butter has been shown to be a superb moisturizer, with exceptional skin healing properties. ASBI (2004) compiled a list of skin conditions where 100% shea butter has been proved to be effective in healing. These skin conditions are dry skin, skin rash, skin peeling after tanning, blemishes and wrinkles, itching skin, sunburn, shaving cream for a smooth silky shave, small skin wounds, skin cracks and tough or rough skin (on feet). Others are cold weather, frost bites, stretch marks prevention during pregnancy, insect bites, health skin, muscle fatigue, aches and tension, skin allergies such as poison ivy or poison oaks, eczema, dermatitis and skin damage from heat. It is because of these unique healing properties that the shea tree is called karite tree which means tree of life (ASBI, 2004). It was reported by ASBI (2004) that shea butter has unparalleled moisturizing property and this is due to several natural moisturizers present in it. It was also discovered by ASBI (2004) that the moisturizers in shea butter are the same moisturizers produced by the sebaceous glands in the skin.

In the same development, ASBI (2004) reported that the positive biochemical and physiological effects that shea butter has on skin injuries make it ideal for wound healing. Reports from many users of shea butter have shown that this product promotes and accelerates wound healing. Furthermore, vitamin E in shea butter is helpful to the skin and such benefits could be accomplished by increasing the microcirculation to the skin. This eventually results in increased blood supply to and from the skin. Also, vitamin E in shea butter may serve as an anti-free radical agent thereby preventing the deleterious effects of sun and environmental exposure.

Determination of free fatty acid of shea nut butter is important especially for the screening purposes of large quantities of samples during processing and marketing (Quainoo et al., 2012).

MATERIALS AND METHODS

The study was carried out from March, 2012 to January, 2013 at the Spanish Laboratory, University for Development Studies, Nyankpala. Nyanpkala is located between latitude 09° 25.925 N and longitude 01° 00,420 W. The area is in the Tolon District of the Northern Region of Ghana. The Agro-ecological zone of the area is Guinea Savanna. Shea nut samples were collected in the Zoolanyili community located in the Tolon district near Nyankpala. They were collected by farmers based on their own characterization into the various nut sizes from trees that bare fruits of different sizes. The farmer varieties were re-classified into four size groups for the purpose of this study. The four size groups are shown in Table 1 and Plates 1 to 4, respectively.

Treatments comprising four farmer varieties were used to carry out the study. The four treatments were arranged in a completely randomized design and replicated three times for laboratory analysis for FFA's and moisture content.

Table 1. Size ranges of nut varieties.

Treatment no.	Treatment description	Kernel length (cm)
(T1)	Small nuts	2.45 – 2.60
(T2)	Medium sized nuts	2.65 – 2.81
(T3)	Big nuts	2.95 – 3.00
(T4)	Very big nuts	3.25 – 3.45

Plate 1. Small nuts.

Plate 2. Medium sized nuts.

Snowball sampling was used to select respondents for sensory quality survey on butter colour and texture. Forty (40) women were selected from the Tamale Metropolis for the sensory quality survey on color, texture, taste and aroma.

Shea butter made from the different size categories (Plate 1a and b) were used for the study.

Plate 3. Big nuts.

Plate 4. Very big nuts.

Butter extraction procedure

Until recently, almost all shea butter was extracted by use of small-scale extraction methods. In Ghana, the method of extraction used locally is the same throughout the north. The collection and extraction of the shea nut were carried out based on the following procedure: collection of the shea nuts from the field, drying of the shea nuts, extraction of the kernels from the shells for further drying, washing of the dry kernels and crushing of the kernels into pieces to ensure roasting.

The roasted kernels were cooled and milled into paste using a grinding mill. The paste was then mixed thoroughly with cold and hot water until a cream coloured crude butter separated and floated on the surface of the water. The crude butter on top was collected, washed in clean water and then boiled to separate the oil from the impurities in the cream crude butter. The oil was put in clean containers and cooled whilst steering until it solidified into the familiar solid shea butter.

Laboratory determination of FFA

1% Phenolphthalein in 95% ethanol; 0.1 N potassium hydroxide; Standard solvent: Mix 25 mL ether, 25 mL 95% alcohol and 1 mL of 1% phenolphthalein solution and neutralize with N/10 alkali.

Procedure

1-10 g of oil or melted fat was dissolved in 50 ml of the standard solvent in a 250 mL conical flask. Few drops of phenolphthalein was added to the oil in the standard solvent and titrated against 0.1 N potassium hydroxide. The content was shaken until a pink colour persisted for fifteen seconds.

Calculation

$$\text{Acid Value (mg KOH/g)} = \frac{V_1 - V_0 \times N \times 56.1}{W}$$

V_1 = Titrate value of sample; V_0 = titrate value for blank solution; N = normality of titration; W = weight of sample in grams; the free fatty acid (as oleic) is estimated by dividing the acid value by 1.99.

Laboratory determination of moisture content

The digital moisture content analyzer (Sartorius, MA 45C-000230V1, June 2003) was used for the estimation of moisture content. Sample of the butter was placed on a sample holder and placed inside the analyzer. The machine was tarred and set to record the moisture content of the butter. The machine also recorded the weight of the sample, the dry matter content and the moisture dry matter ratio.

Analysis of data

Microsoft excel and genstat was used to analyze the data and standard error of difference (SED) to compare the means.

RESULTS

Effect of shea nut size on FFA content of shea butter

Figure 1 shows the levels of FFA (expressed as % oleic acid) in shea butter extracted from shea kernels. There were significant differences in the mean FFA values of butter extracted from the shea nuts of the various sizes used in this study. Shea butter extracted from big nuts recorded the lowest mean FFA value of 1.133 (Figure 1).

The Ghana Standards Authority criteria indicated that butter extracted from big, medium and small nuts with mean FFA values of 1.133, 2.227 and 2.420 respectively were grade two while very big nuts with mean FFA value of 3.637 was grade three (Table 2).

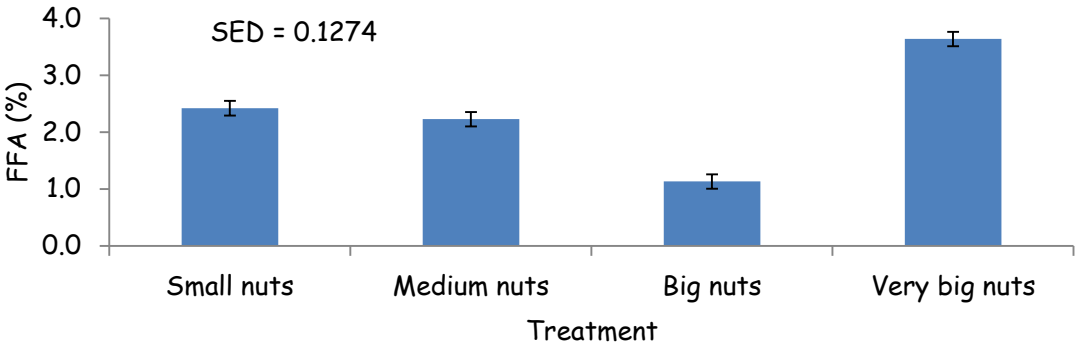

Figure 1. Effect of shea nut size on free fatty acid content of shea butter.

Table 2. Ghana Standards Authority grading of FFA values of shea butter.

Treatment	Grade 1 (1)	Grade 2 (>1.0-3.0)	Grade 3 (>3.0-8.0)
Small nuts	-	2.420	-
Medium nuts	-	2.227	-
Big nuts	-	1.133	-
Very big nuts	-	-	3.637

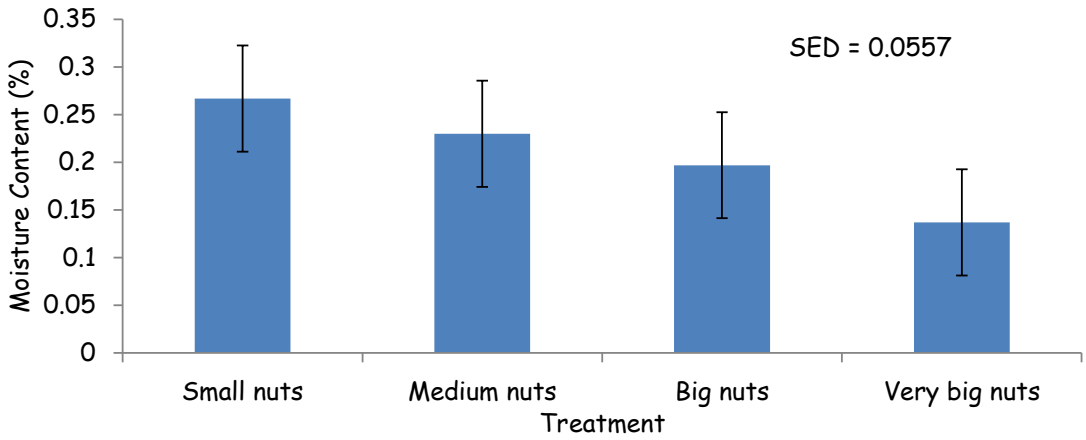

Figure 2. Effect of shea nut size on moisture contents of butter.

Effect of nut size on moisture content of shea butter

The result of the mean moisture contents of shea butter extracted from the different shea nuts is presented in Figure 2.

The results indicate that there were no significant differences in the mean moisture content values of shea butter extracted from the shea nuts of different sizes. Butter extracted from very big shea nuts has the least amount of moisture with a mean moisture content of 0.137% with small shea nuts recording the highest moisture content of 0.267% (Figure 2).

The Ghana Standards Authority criteria indicated that shea butter extracted from very big and big shea nuts with mean moisture contents of 0.137 and 0.197% respectively, were grade 2 while butter from medium and small shea nuts with mean moisture contents of 0.230 and 0.267% respectively, were grade 3 (Table 3).

Sensory qualities of shea nut butter

The sensory qualities of shea nut butter studied were color, texture, taste and aroma. These qualities were

Table 3. Ghana Standards Authority grading of moisture content of shea butter.

Treatment	Grade 1 (0.05%)	Grade 2 (>0.05-0.2%)	Grade 3 (>0.2-2.0%)
Small nuts	-	-	0.267
Medium nuts	-	-	0.230
Big nuts	-	0.197	-
Very big nuts	-	0.137	-

Table 4. Sensory qualities of shea nut butter as assessed by forty respondents.

Treatment	No. of respondents who agreed on purity of butter colour	No. of respondents who agreed on the smoothness of butter texture
Small nuts	16	18
Medium nuts	12	11
Big nuts	8	7
Very big nuts	4	4

observed based on indigenous knowledge. Individual participants did not find any distinction in the taste and aroma of the shea butter extracted from the different shea nut sizes. There were differences in colour and texture of the shea butter extracted from the different shea nut sizes (Table 4).

Table 4 indicated that for color, sixteen people observed shea butter extracted from small nuts to be the whitest, followed by butter from medium nuts with twelve people, then butter from big nuts with eight people and finally, butter from very big nuts with four people observing it to be the whitest.

For texture, 1 people observed shea butter extracted from small nuts to be the smoothest, followed by butter from medium nuts with eleven people, then followed by butter from big nuts with seven people and four people observing butter from very big nuts to be the smoothest.

DISCUSSION

Free fatty acid (FFA)

Shea nut butter extracted from the big nuts recorded the lowest mean FFA value with shea nuts from the very big nuts recording the highest mean FFA value. The lower mean FFA value for the shea nut butter extracted from big shea nuts may be attributed to their lower moisture contents.

The study revealed that, generally the bigger the shea nut kernels, the lower the FFA values and the higher the quality according to Ghana Standards Authority GSA (Figure 1). The only exception was the very big nuts which had very high FFA content. This indicates the need for further classification and categorization of nuts in repeated experiments to arrive at a conclusive relationship between the nut size and the FFA content

Shea nut butter quality is high when its free fatty acid content is low. Free fatty acid content is naturally low in fresh nuts, but it increases rapidly through hydrolysis under poor storage conditions. Hydrolysis occurs through the lipolytic activity of the fruit lipase and micro-organisms and halted by heating by reducing the moisture content to levels lower than 8%.

Results obtained by grading the four different shea nut sizes revealed that shea nut butter from big nuts, medium nuts, and small nuts were graded as high quality butter (grade 2) and can meet the requirement of the food industry (confectionary, chocolate, edible oil or as basis for margarines) based on the GSA grading criteria. However, shea nut butter from very big nuts was graded as low quality butter (grade 3) and may serve the needs of the soap making industries or can be refined for direct consumption (Table 2).

Moisture content

Shea nut butter extracted from the very big nuts recorded the lowest moisture content with shea nut butter from the small nuts recording the highest moisture content. The results show that, the bigger the nuts, the lower the moisture content and this may be attributed to the fact that, bigger nuts have a larger surface area and are therefore subject to more rapid drying than smaller nuts (Figure 2).

Results obtained from grading the four different shea nut sizes based on GSA grading criteria on moisture content revealed that, shea nut butter extracted from very big nuts and big nuts were graded as high quality butter (grade 2), and may serve the needs of the food industry (confectionary, chocolate, edible oil or as basis for mar-

garines). Whiles butter from medium nuts and small nuts were graded as low quality butter (grade 3) and may serve the needs of the soap-making industry or may be refined for direct consumption (Table 3).

Furthermore, shea nut butter with low or no moisture content stores better than one with high moisture content. This is because shea nut butter with higher moisture content is prone to spoilage within one year of storage (Yidana, 2007).

Also, high moisture content in plant fats and oils usually leads to increased microbial load and lipid oxidation resulting in rancidity (Hee, 2011).

Sensory qualities

The colour of the shea nut butter samples after extraction maintained a bright colour with slight differences among them. Sensory analysis conducted by Akingbala et al. (2006) found that unrefined shea nut butter gained lower scores than refined shea nut butter based on color. However, refining procedure also caused the loss of minor but valuable components such as unsaponifiable fraction with medicinal properties (Tasan and Demirci, 2005; Moharram et al., 2006; Van Hoed et al., 2006).

Texture of the extracted shea nut butter was similar to commercially available body butter or vaseline. Since the shea nut butter samples were all solid at room temperature, the first feeling was to take a small portion from the bulk shea nut butter using the fingertip but it was not as smooth as creams or lotion. However, once applied on the skin, all the samples were melted and showed nice creamy texture when spread over the back of the hand.

The results obtained from the study however indicated that for shea nut butter colour, butter extracted from small nuts was the brightest, followed by shea nut butter from medium, big nuts and very big nuts in that order respectively. The texture of the shea nut butter from the small nuts was the smoothest, followed by medium, big and very big nuts respectively in that order. The variations in colour and texture of the shea nut butter extracted from the different shea nut sizes may be probably due to some varying responses of the nut sizes to practices in the extraction process especially washing and roasting of the shea nut kernels.

The quality criteria usually used by buyers at the market level to assess shea nut butter for purchases are color and texture since the two characteristics of shea nut butter may be easily assessed visually and by feeling. Bright solidified shea nut butter with smooth texture is usually preferred by buyers.

Conclusion and recommendation

The research was carried out to assess the chemical and physical characteristics of shea kernel samples obtained from the Zoolanyili community in the Tolon District of Northern Region. The usefulness of shea nut butter is based on its chemical composition. However, the market value of the shea nut butter is determined by both the physical appearance and the chemical composition. The results of the FFA and moisture content test carried out indicated that nut size have a significant effect on the quality of the extracted shea nut butter.

It is recommended that, further research be carried out at different geographical locations so as to provide more thorough understanding of the effects of shea nut kernel size on the quality of shea nut butter.

Conflict of interests

The authors did not declare any conflict of interest.

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