UDS International Journal of Development [UDSIJD]
Volume 7 No. 1, 2020
http://www.udsijd.org
ISSN: 2026-5336

EFFECT OF SHEA FRUIT SUGAR CONTENT ON SHEA (*Vitellaria paradoxa* L.) BUTTER QUALITY

[1*]Quainoo, A. K., [1]Jibrim, A., [2]Chimsah, F.
[1]Department of Biotechnology, University for Development Studies, Tamale, Ghana.
[2]Department of Horticulture, University for Development Studies, Tamale, Ghana.

Corresponding Author's Email: aquainoo@uds.edu.gh

Abstract
This study uses the indigenous knowledge of rural women in the shea parkland areas who are engaged in shea nut picking and processing to determine the effect of shea fruit sugar content on shea butter quality. The study was conducted within the shea parkland area in the Zoolanyili community in the Tolon District of Ghana. Shea fruits from different trees were characterized based on the sweetness of the fruit pulp into three taste groups: very sweet fruits (T1), sweet fruits (T2) and tasteless fruits (T3). The sugar content (Glucose, Fructose and sucrose) of the fruit pulp were determined using gas chromatography. Generally, T1 recorded the highest fructose, glucose and sucrose levels followed by T2 and T3 respectively. Shea butter from T1 recorded the lowest mean free fatty acids (FFA) 1.35 % while T3 recorded the highest mean value of 9.76 %. Shea butter from T1 and T2 recorded low FFA values and of higher quality than T3 which recorded high FFA value. FFA of shea butter extracted from T1 and T2 were below 3% (< 3) hence first grade quality shea butter while the FFA of T3 was greater than 8% (>8) hence third grade shea butter. The correlation matrix revealed inverse relationship between the individual sugars in the shea fruit pulp and butter FFA in the shea nut. Percentage FFA decreased as fructose, glucose and sucrose in the shea fruits increased. There were no significant difference in the moisture content of the nuts obtained from the characterized shea fruits.

Keywords: **Shea Fruit, Sugar Content, Free Fatty Acids, Moisture Content, Butter Quality**

Introduction
The shea tree (*Vitellaria paradoxa* L.) is a large, long-lived tree that is native to the Sahel region of West Africa and is a key species in traditional agroforestry systems and an important source of edible oil shea butter, which is derived from the seed (Wiersema & Leon, 1999). The shea tree is an economic tree that thrives in northern Ghana, it is valued medicinally and used in the confectionary and cosmetic industries. The nut from the shea tree serves as the main source of livelihood for the rural women and children who are engaged in its gathering and processing. Shea oil is the main edible oil for the people of northern Ghana and is the most important source of fatty acids and glycerol in their diet (Lovett & Haq, 2000).

The she butter is the most important product from the shea tree and literature on shea nut chemical compositions across the Sahel region has shown great diversity for fat and fatty acid. The West African shea butter is solid and features mainly in confectionary products while the East African butter is fluid and features mainly in the cosmetic and pharmaceutical products (Di Vincenzo, Maranz, Serraiocco, Vito, Wiesman & Bianchi, 2005; Davrieux, Allal, Piombo, Kelly, Okulo, Thiam, Diallo & Bouvet, 2010).
Since the shea nuts picked for butter extraction come from different shea cultivars growing together, it stands to reason that if shea nuts are picked and extracted for butter based on cultivar lines, the outcome will be shea butter with different fat and fatty acid composition, quality and market premium (Quainoo, 2016). There is an increase in the global demand for quality shea products (Global Shea

Alliance, 2013), but the accessibility of superior quality shea butter on the market remains a challenge because shea butter producers are unable to supply the requisite consistency of quality (Lovett & Haq, 2000). This study address issues of shea butter quality using the indigenous knowledge of rural women in shea parkland areas the who are engaged in shea nut picking and processing to determine the effect of shea fruit sugar content on shea butter quality.

Methodology

Experimental Site

The experiment was carried out in 2016 (March to June) within the shea parkland areas in the Zoolanyili community near Nyankpala in the Tolon District of Ghana. The area lies within latitudes 9º 25' N and longitude 0º 58' W in the Northern Guinea Savanna Agro-ecological zone of Ghana (Savannah Agricultural Research Institute [SARI] 2004).

Experimental Procedure

The research team paid an initial visit to the Zoolanyili community to introduce themselves to the opinion leaders including women who are mainly engaged in shea nut picking and processing. Based on focus group discussions, the essence of the studies was made known to them and their assistance was sought as stakeholders by using their indigenous knowledge in the study. 20 voluntary shea nut pickers were selected for the study. Shea fruits were collected from different trees, characterized into varieties based on the taste of the fruits (sweetness of the fruit pulp) using the indigenous knowledge of the pickers. This resulted in three taste groups (very sweet fruits (T1), sweet fruits (T2) and tasteless fruits (T3) for the shea fruits (Table 1). The various shea fruits based on indigenous knowledge were analyzed for sugar content and the shea nuts for FFA and moisture content.

Sample Preparation

Mature shea fruits based on the above characterization were collected and sent to the laboratory for analysis at the Kwame Nkrumah University of Science and Technology, Ghana. The fruits were washed and the fruit pulp were scooped into plastic containers to determine the sugar content (Glucose, Fructose and sucrose). This was done using Association of Official Analytical Chemists (AOAC) official method 971.18 for determination of carbohydrates in fruits using gas chromatography.

The depulped shea nuts were washed and partially boiled for 10 minutes to reduce fungal or mould growth and enhance the removal of the shell from the kernels. The kernels were dried in an oven (Chopin) at 103^{0}C for 16 hours and the crude fat (shea butter) extracted using a chemical solvent (hexane). The butter was stored in plastic containers at room temperature for further analysis.

FFA (Oleic acid %) of the extracted shea butter was determined using the American Oil Chemists Society (AOCS) official method Ca-5a-40:

$$FFA = \frac{\text{Alkali volume (ml) x alkali normality x 28.2}}{\text{Sample weight (g)}}$$

The moisture content of the extracted shea butter was determined using the AOCS Ca 2c official method:

$$\% \text{ moisture content} = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100$$

Results and Discussion

All the characterized shea fruits showed similar results for physical parameters (Table 1).

Table 1. Physical Characteristics of the Shea Fruits Based on Indigenous Knowledge

Characterized fruits	Mean fruit diameter (cm)	Mean fruit length (cm)	Mean fruit Weight (g)
Very Sweet fruits (T1)	3.80	5.40	11.95
Sweet Fruits (T2)	3.83	5.76	12.06
Tasteless Fruits (T3)	3.81	5.68	12.06

Sugar Content of Characterized Fruits

The pulp sugar content of the characterized shea fruits showed significant ($p > 0.05$) differences in the glucose, fructose and sucrose levels (%). Fructose recorded the highest sugar content followed by glucose and sucrose respectively in that order for all the individual characterized shea fruits (T1, T2 and T3). Generally, T1 recorded the highest fructose, glucose and sucrose levels followed by T2 and T3 respectively. However, the sucrose content of T1 and T2 were the same (Figure 1). Results of Dugalic et al., (2014) investigation of the sugar content of the plum fruits revealed that fruits with higher glucose, fructose and sucrose levels tasted sweeter than those with lower levels. The results of this paper on the sweetness of the characterized shea fruits based on indigenous knowledge in the shea parkland area conform to their finding.

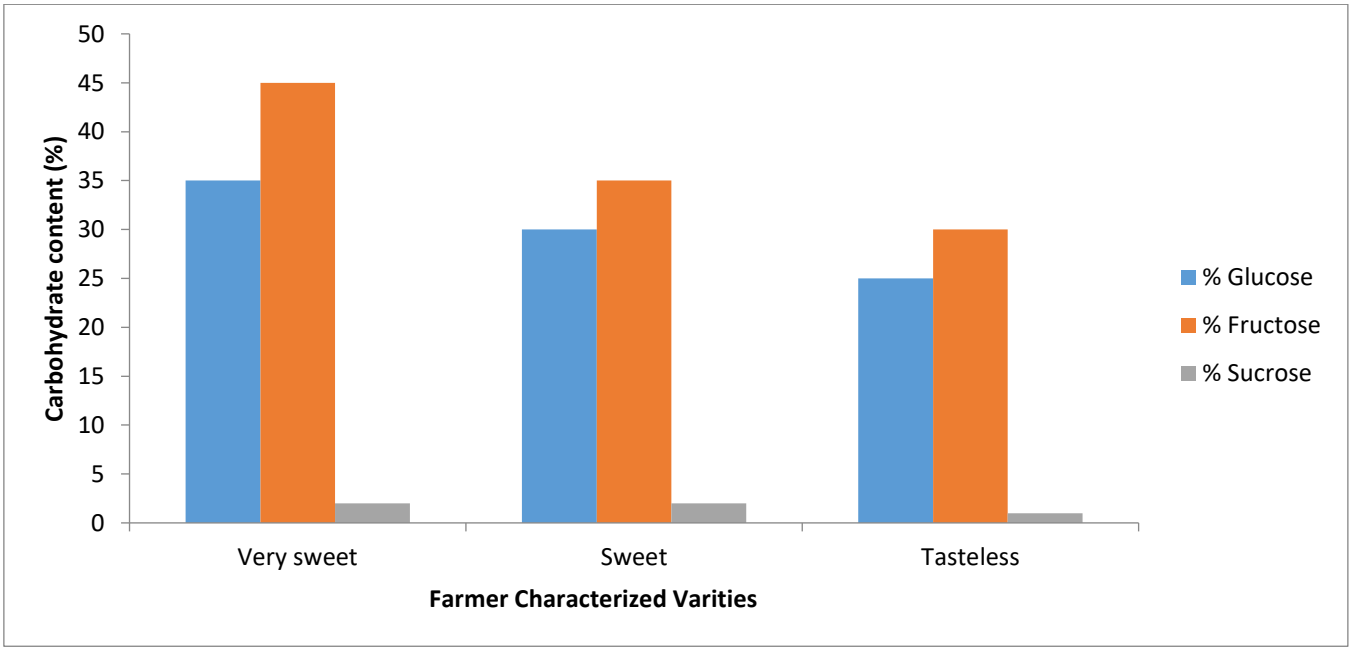

Figure 1: Sugar Content of Characterized Shea Fruits

Effect of Pulp Sugar Content on Free Fatty Acid Content of Shea Butter

The FFA content of the characterized shea nuts (T1, T2 and T3) showed significance at $p < 0.001$ in the shea butter quality. T3 was significantly different from T1 and T2 while there were no significant difference between T1 and T2. Shea butter from T1 recorded the lowest mean FFA 1.35 % while T3 recorded the highest mean value of 9.76 % (Figure 2).

Figure 2: Effect of Pulp Sugar Content on Free Fatty Acid Content of Shea Butter

FFA is an indication of the degradation and hence the quality of the shea butter. Therefore, shea butter with lower FFA levels are preferred for quality. Results indicated that shea butter from T1 and T2 recorded low FFA values and therefore of higher quality than T3 which recorded high FFA value (Figure 2). Results from this study show that FFA of shea butter extracted from T1 and T2 falls below 3% (< 3) which is the FFA range for first grade quality shea butter (Table 2) and can therefore be used in the food and cosmetic industries (Lovett et al., 2012; Global Shea Alliance, 2013). FFA of shea butter extracted from T3 was greater than 8% (>8) which is the FFA range for third grade shea butter.

Table 2: International Quality Standards for Shea Butter

No.	Parameter	Grade A	Grade B	Grade C
1	FFA	< 3%	3% - 8%	> 8%
2	Nut moisture	< 8%	8% - 10%	> 10%

Source: *Global Shea Alliance, (2013)*

Effect of Pulp Sugar Content on Moisture Content of Characterized Shea Nuts

There were no significant ($p > 0.05$) differences in the moisture content of the nuts obtained from the characterized shea fruits (T1, T2 and T3). T3 however recorded the highest moisture content (3.42%) and T1 the lowest (3.22%) (Figure 3).

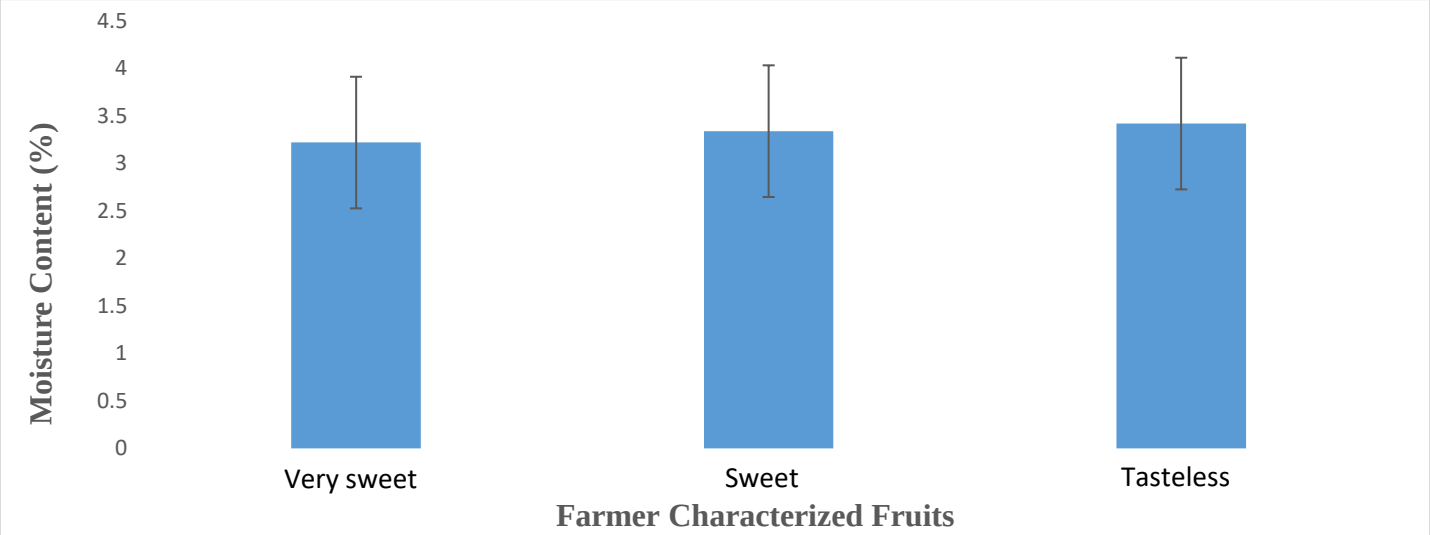

Figure 3: Effect on Pulp Sugar Content on Moisture Content of Shea Nuts

Correlation Matrix of Tested Parameters

The correlation matrix revealed inverse relationship between the individual sugars in the shea fruit pulp and butter FFA in the shea nut. Percentage FFA decreased as fructose, glucose and sucrose in the shea fruits increased. Glucose content of the shea fruits were found to have positive correlation with fructose and sucrose content, and a negative correlation with FFA shea butter and fruit weight which were all significant ($p < 0.05$) (Table 3). The same observations were found in *Sclerocarya birrea* in semi-arid lands of southern Africa (Leakey et al., 2005). The observed diversity in the sugar content of the shea fruits and FFA of the shea butter in the study area demonstrates that opportunities exist for genetic selection between different shea trees.

Table 3: Correlation Matrix of Tested Parameters of the Shea Fruit

	% Glucose	% Fructose	% Sucrose	% Nut moisture	Diameter (cm)	% FFA	Length (cm)
% Glucose							
% Fructose	0.9797						
% Sucrose	0.6873	0.5724					
% Nut moisture	0.1493	0.0759	0.718				
Diameter (cm)	0.2994	0.2511	0.7469	0.9783			
FFA %	-0.8524	-0.7578	-0.6124	0.0639	-0.0079		
Length (cm)	0.2228	0.1506	0.7579	0.9971	0.9882	0.0026	
Weight (cm)	0.1745	0.0971	0.7375	0.9994	0.9792	0.0313	0.9983

Figure 4: Farmer Characterized Shea Fruits

Note: A= T3, B=T2 and C=T1

Conclusion and Recommendation

The study demonstrates that the shea fruit pulp sugar content has an effect on the FFA of the shea butter. Shea nuts from T1 and T2 recorded the lowest FFA content, and T3 recorded the highest FFA. Strong inverse relationship exists between the individual sugars in the shea fruit pulp and the FFA in the shea butter. Percentage FFA decreased as fructose, glucose and sucrose in the shea fruits increased. It is recommended that shea nut producers should identify and collect T1 and T2 shea fruits in order to produce quality shea butter with low FFA.

Acknowledgement

We acknowledge the contribution of the opinion leaders and the voluntary shea nut pickers from the Zoolanyili community for using their indigenous knowledge to characterize the shea fruits.

References

Association of Official Analytical Chemist (AOAC) official method 971.18. http://www.aoac.org/aoac_prod_imis/AOAC/AOAC_Member/PUBSCF/OMACF/OMAP_M.aspx

Davrieux F., Allal F., Piombo G., Kelly B., Okulo J. B., Thiam M., Diallo O. B., Bouvet J. M. (2010). Near infrared spectroscopy for high throughput characterization of Shea tree (*Vitellaria paradoxa*) nut fat profile, ***Journal of Agricultural and Food Chemistry***, 58 (13): 7812-7819

Di Vincenzo D., Maranz S., Serraiocco A., Vito R., Wiesman Z., Bianchi G., (2005). Regional variation in Shea butter lipid and triterpene composition in four African countries, ***Journal of Agriculture Food Chemistry,*** 53: 7473-7479.

Dugalic, K., Sudar, R., Viljevac, M., Josipovic, M. and Cupic, T., (2014). Sorbitol and Sugar Composition in Plum Fruits Influenced by Climatic Conditions. ***Journal of Agricultural Science and Technology,*** 16: 1145-1155.

Global Shea Alliance (2013). Industry quality standard for shea kernel. ***Proposal to General Assembly***, GSA 001.

Leakey, R. P. B., Tehoundjei, Z., Schreckenberg, K., Shackleton, S. E., Shackleton, C. M., (2005). Agroforestry tree products (AFTP)s) targeting poverty reduction and enhanced livelihoods. ***International Journal of Agriculture Sustainability,*** 3:1-23.

Lovett P. N., Haq N. (2000). Evidence for anthropic selection of the Shea nut tree (*Vitellaria paradoxa).* ***Agroforestry systems,*** 48: 273288.

Official and Tentative Methods of the American Oil Chemists' Society, 4th ed., edited by D. Firestone, American Oil Chemists' Society, Champaign, 1989.

Quainoo, A. K. (2016). ***Unearthing the hidden potentials of the shea tree*** (Vitellaria paradoxa).

Savannah Agricultural Research Institute (2004). ***Annual report for the year 2004***, Nyankpala.

Wiersema and Leon (1999). Overview of Vitellaria paradoxa, National Research Council, 2006, International Union of Conservation of Nature, 2012.