International Journal of Plant & Soil Science
4(1): 54-60, 2015; Article no. IJPSS.2015.005
ISSN: 2320-7035

SCIENCEDOMAIN *international*
www.sciencedomain.org

Effects of Shea (*Vitellaria paradoxa* C. F. Gaertn) Nuts Storage Environments on the Quality of Shea Butter in Dry Savannah Environment of Adamawa State, Nigeria

N. Bukar[1*], D. T. Gungula[2] and J. Kapsiya[3]

[1]Department of Agricultural Technology, Federal Polytechnic Mubi, P.M.B.35 Mubi, Adamawa State, Nigeria.
[2]Department of Crop Production and Horticulture, Modibbo Adama University of Technology, P.M.B. 2076 Yola, Adamawa State, Nigeria.
[3]Department of Horticultural Technology, Federal College of Horticulture, P.M.B. 108 Dadinkowa, Gombe State, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author NB managed the experiment, wrote the protocol, wrote the first draft of the manuscript and managed the analysis of the study. Author DTG designed the study and performed the statistical analysis. Author JK managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2015/9522
Editor(s):
(1) L.S Ayeni, Adeyemi College of Education, Nigeria.
(2) Sławomir Borek, Faculty of Biology, Department of Plant Physiology, Adam Mickiewicz University, Poland.
(3) Bin Gao, Dept. of Agricultural & Biological Engineering, University of Florida, USA.
Reviewers:
(1) Anonymous
(2) Anonymous
(3) Aliyu Ahmad Warra, Department of Biochemistry, Kebbi State University of Science and Technology, Nigeria.
(4) Anonymous
(5) Anonymous
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=651&id=24&aid=5966

Original Research Article

Received 15th Feb 2014
Accepted 25th July 2014
Published 6th September 2014

ABSTRACT

An experiment was conducted from September, 2009 to June, 2010 at the Modibbo Adama University of Technology, Yola to study the effects of storage environments on shea nuts as it affects the quality of shea butter in Yola. A Randomized Complete Block Design (RCBD) was used for the experimental design. The treatment consisted of two storage environments (open space and

**Corresponding author: E-mail:bukarnuhu@yahoo.com;*

laboratory, under ambient condition). The physicochemical parameters and fatty acid composition determined were oil yield, oil density, refractive index, specific gravity, iodine value, saponification value, unsaponifiable matter, free fatty acid, stearic acid, oleic acid, linoleic acid, linolenic acid and palmitic acid. The results showed that storage environments significantly affected refractive index, iodine value, saponification value, free fatty acid, stearic acid, oleic acid, linoleic acid and linolenic acid (P<.01).Based on the parameters measured, laboratory storage environment performed better in terms of oil yield 42.24%, oil density 0.937 g/cm^3, free fatty acid 2.53%, iodine value 50.89 I_2g/100g, linoleic acid 5.05 % and palmitic acid 6.13% as compared to open space storage environment which had oil yield 39.41%, oil density 0.936 g/cm^3, free fatty acid 4.61 %, iodine value 49.43 I_2g/100g, linoleic acid 4.94 % and palmitic acid 6.17%. It was therefore, concluded that laboratory storage environment was a better choice for storage of shea nuts than open space. It may be recommended that local structures like the thatch house with adequate ventilation should be raised to provide shade as an alternative to laboratory during storage of shea nuts for better quality shea butter.

Keywords: Shea nuts; processing; physicochemical; fatty acids; ambient.

1. INTRODUCTION

Shea nut oil is produced from shea nuts derived from the shea tree [1] and has multi-uses [2]. Shea butter is becoming more popular because of its unsaturated fatty acid composition as well as the potential utility of its unsaponifiable fraction now being used in pharmaceutical and nutraceutical applications [3]. Traditionally, shea butter is used as a decongestant, an anti-inflammatory for sprains and arthritis, a healing salve for babies' umbilical cords, a lotion for hair and skin care, as cooking oil, and for lamp fuel [4].

How shea kernels are stored or the environment in which it is stored, have a great effect on the quality of the shea butter that will be extracted from the kernels. Dried kernels of shea have to be kept with care in a well ventilated area; otherwise the fat may go rancid [5]. Improper storage reduces the percentage of oil obtained and the fat breaks down and decomposes [5].

The value of the shea butter depends very much on the market on which it is sold [6]. It is however, unfortunate that most of the developing countries do not meet the international standards as regards to marketing of agricultural products. This is mostly as a result of low quality products, which arises from the use of poor storage techniques. Most of those who gather shea nuts and process them into butter in Nigeria are local farmers who use traditional practices they inherited from their parents. The nuts are not processed immediately they are collected; rather they are stored for some time (about six months) before they are processed. However, most of them are not aware of better ways of storing the nuts so as to have nuts that can be processed into higher quality shea butter. The objective of this study was to evaluate the effects of two storage environments on the shea butter quality in Yola, Adamawa State.

2. MATERIALS AND METHODS

2.1 Experimental Site

The research work was carried out at the laboratory of the Department of Crop Production and Horticulture, Modibbo Adama University of Technology, Yola, Adamawa State. Yola is situated at 9º16^{1}N, 12º35^{1}E and is 152 m above sea level, with an average rainfall of 910.8 mm.

2.2 Sample Collection and Preparation

Physiologically matured shea butter fruits were harvested from the bush from August to September, 2009 for this research work. Harvesting was done when the fruits began to fall to the ground naturally. The fruits were de-pulped and nuts were dried using the traditional method by spreading them on the ground for 2 to 3 hours daily under sun for about 7 days before storage [7]. Storage was done for a period of nine (9) months before oil extraction.

2.3 Shea Butter Extraction

The dry nuts were de-husked manually by cracking them between two stones [8]. The kernels were then roasted, milled into powder before the oil extraction. Oil from the milled kernels was extracted with n-hexane solvent using Soxhlet apparatus [9,10]. The extraction was done at the Chemistry Departmental

Laboratory, Modibbo Adama University of Technology, Yola.

2.4 Experimental Design and Layout

The experimental design used was Randomized Complete Block Design (RCBD) with three replications. The treatments consisted of two storage environments which were open space where the nuts were exposed to the effect of weather elements like rainfall, wind, etc as practiced by the local farmers in Adamawa State of Nigeria. The other environment was an ambient room environment where the nuts were kept in the laboratory with cross ventilation.

2.5 Data Collection

2.5.1 Physicochemical properties

Oil yield, density, specific gravity, refractive index, free fatty acids, iodine value, saponification value, unsaponifiable matter were determined as described by [11].

2.5.1.1 Oil yield

This was determined by taking the initial weight of the sample before oil extraction using electric weighing balance (Toledo mettler no. ab 204) and then taking the weight of the oil for each sample after extraction. Oil yield was calculated as the sum quantity of oil extracted divided by the quantity of raw materials used, multiplied by 100.

$$\text{Oil yield (\%)} = \frac{\text{quantity of oil extracted (g)}}{\text{Raw material used (g)}} \times \frac{100}{1} \quad (1)$$

2.5.1.2 Specific gravity/density

This was determined by thoroughly washing a 50 ml pycometer bottle with water, which was then dried and weighed. The bottle was then filled with water and weighed. After drying the bottle, it was then filled with the oil sample and weighed. Specific gravity and density of the oil were then calculated as:

$$\text{Specific gravity} = \frac{\text{Weight of oil}}{\text{Weight of water}} \quad (2)$$

$$\text{Density} = \frac{\text{Weight of oil(g)}}{\text{Volume of oil (cm}^3\text{)}} \quad (3)$$

2.5.1.3 Refractive index

This was determined by using the Abbe's refractometer. The oil sample was smeared on the lower prism of the instrument and closed. Light was passed through the angle mirror. Using the fine adjustment, the telescope tubes were moved until the black shadow appeared central in the cross wire indicator, and then the refractive index was read.

2.5.1.4 Free fatty acids

About 25 ml diethyl ether was mixed with 25 ml alcohol and 1 ml phenolphthalein solution (1%). About 1-10 g of the melted butter was dissolved in the mixed neutral solvent and was titrated with aqueous 0.1 M NaOH shaking constantly until a pink colour which persisted for 15 seconds was obtained. The FFA value was calculated thus,

$$\text{FFA} = \frac{\text{titre x molecular weight of oleic x 0.091}}{\text{Weight of oil}} \quad (4)$$

2.5.1.5 Iodine value

The melted butter was weighed accurately into a small capsule and was transferred to a 250ml glass stopper bottle. About 10 ml of carbon tetrachloride was added to the melted fat and dissolved. About 20ml of wijis' solution was added and the stopper, previously moistened with potassium iodide solution was inserted and was allowed to stand in the dark for 30minutes. About 15 ml of potassium iodide solution (10%) and 100 ml water were added, mixed and titrated with 0.1 M thiosulphate solution using starch as indicator just before the end point (titration = a ml). a blank was carried out at the same time commencing with 10ml of carbon tetrachloride (titration= b ml). The iodine value was computed thus,

$$\text{Iodine value} = \frac{\text{(b-a) x1.269}}{\text{Wt (g) of sample}} \quad (5)$$

Where a = Volume of Potassium iodide solution used for the test sample
b = Volume of Potassium iodide solution used for the blank

2.5.1.6 Saponification value

About2 g of the butter was weighed into a conical flask and 25ml of the alcoholic potassium hydroxide solution was added. A reflux condenser was attached and the flask was heated in boiling water for 1 hour, shaking frequently. About 1 ml of phenolphthalein (1%) solution was added and was titrated hot the excess alkali with 0.5M hydrochloric acid (titration = aml). A blank was also carried out at

the same time (titration =bml). The saponification value was therefore calculated as follows:

$$\text{Saponification value} = \frac{(b-a) \times 28.05}{\text{Wt (g) of sample}} \quad (6)$$

Where; a = Volume of Potassium iodide solution used for the test sample.
b = Volume of Potassium iodide solution used for the blank.

2.5.1.7 Unsaponifiable matter

After the titration of the saponification value, the neutralized liquid alkaline was made with 1 ml of aqueous 3 M potassium hydroxide solution. It was then transferred to a separator and washed with water (50 ml less the volume of 0.5 M hydrochloric acid used). The solution was extracted while still warm 3 times with 50 ml quantities of diethyl ether. Each was poured into another separator containing 20 ml water. After the third extract had been added, the combined ether extracts was shaken with the first 20 ml of wash water and then vigorously with two further 20 ml quantities. The ether extract was washed twice with 20 ml of aqueous 0.5 M potassium hydroxide solution and at least twice with 20 ml quantity of water until the wash water was not longer alkaline to phenolphthalein. The ether extract was poured into a weighed flask, the solvent was evaporated. The residue was dried at 80ºC to constant weight.

2.5.2 Fatty acids profile

Fatty acid profiles were assayed using High Performance Liquid Chromatography (HPLC) (BLC — 10.254 nm flow cell), 15 cm c/8 column, by employing methanol — water (70:30v/v) solvent system (mobile phase). The amount of each fatty acid in the sample was expressed as percentage of the sum of all fatty acids in the sample as indicated below:

$$\%\ \text{Fatty acid} = \left[\frac{\text{Fatty acid peak area} \times 100}{\sum \text{Total fatty acid peak areas}}\right] \quad (7)$$

2.6 Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using Genstat Discovery Edition 3 statistical package. Means were separated using the Least Significant Difference (LSD) at 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Effects of Environments on the Physical Properties of Shea Butter

The mean values for the effects of storage environments on the physical properties of shea butter are presented in (Table 1). Significant differences were observed for storage environments (P= .05) in oil yield and specific gravity. Storage of nuts in the laboratory had the highest mean oil yield and specific gravity. This might be attributed to the harsh weather conditions shea nuts being stored in open space had been exposed to, such as high temperatures from the sun might have aided in the loss of oil during the prolonged time of storage. Similar findings were reported by [12] that when shea nuts are over dried or over heated, oil is lost. The variations observed in the storage environments for specific gravity might be attributed to changes in heating temperature. Specific gravity of shea butter decreases with increase in heating temperature [13]. This was because of the increase in the temperature of heating which brought about increase in the volume of the oil due to its expansion [13].

Highly significant difference (P<.01) was observed in refractive index (Table 1) with nuts stored in open space having the highest mean. This could be due to differences in storage temperatures in the different storage environments. Refractive index varies significantly with the temperature [14]. The value of the refractive index decreases by 0.00035 to 0.00055 for each degree rise in temperature [14]. Refractive index is used for rapid sorting of fats and oils of suspected adulterations [15]. Shea butter continues to be adulterated as heating temperature increased beyond 90ºC [15].

3.2 Effects of Storage Environments on the Chemical Properties of Shea Butter

(Table 2) presents the mean values for the effects of storage environments on the chemical properties of shea butter. Highly significant differences existed for iodine value, saponification value and free fatty acids (P<.01). Storage in the laboratory had the highest mean values for iodine and saponification; it was the least in terms of free fatty acid. No significant effect was observed for unsaponifiable matter (P=.05). The variations observed as it relates to

iodine value might be due to the differences in heating temperatures during butter extraction. Iodine value decreases with increase in heating temperatures of shea butter [13]. It may also be due to the differences in storage environments of the shea nuts as shade affects the iodine value [16].

The differences noticed in the storage environments as regards to saponification value might be linked to temperature variations during extraction, which is inversely proportional to saponification value. The high saponification value noticed in the treatments indicates the presence of high percentage of fatty acids in the oil [17]. High saponification value may suggest possible use of the oil in the soap industry. Therefore, the higher the oil extraction temperature, the lower the chance of the oil being used for the manufacturing of soap.

The variations observed in the storage environments in terms of free fatty acid contents, could either be due to seasonal effects on kernels, or poor storage conditions at source after fat extraction due to oxidation [18]. It may also be attributed to the recalcitrant nature of shea fruits; early germination may increase the free fatty acid of the shea oil [19].

3.3 Effects of Storage Environments on the Fatty Acid Profile of Shea Butter

(Table 3) shows that highly significant differences were observed in stearic, oleic, linoleic and linolenic acids (P<.01); a non-significant difference was observed for palmitic acid (P=.05). Storage in the laboratory had the higher means in terms of stearic and linoleic acid contents as compared to open space. However, it had lower means in terms of oleic and linolenic acid contents.

The differences observed for stearic acid contents with respect to storage environments might have been due to genetic variability [19] among the nuts collected from different sources, or it might be due to the differences in the storage environments; warm climates favour the formation of unsaturated acids [16]. The variations observed in oleic acid contents under different storage environments might be attributed to high temperature in the open space environment where the nuts were stored, as warm climates favour the formation of unsaturated acids.

The differences observed in relation to storage environments with respect to linoleic acid contents may be due to genetic variability among the shea nuts and differences in environmental conditions; warm climates favour the formation unsaturated fatty acids. High linolenic acid contents suggest high essential vitamins available in the shea butter.

Table 1. Effect of treatments on the physical properties of shea butter

Storage environments	Oil yield (%)	Oil density (g/cm^3)	Refractive index	Specific gravity
Open space	39.41	0.936	1.465	0.908
Laboratory	42.24	0.937	1.464	0.909
SE	1.117	0.0005	0.0002	0.0003
LSD	2.397	0.0010	0.0004	0.0006
Prob. of F	.024	.434	< .001	.015

Table 2. Effect of treatments on the chemical properties of shea butter

Storage environment	Iodine value (I_2g/100g)	Saponification value(mgKOH/g)	Unsaponifiable matter (%)	Free fatty acid (%)
Open space	49.43	173.48	6.55	4.61
Laboratory	50.89	175.76	6.52	2.53
SE	0.087	0.172	0.024	0.16
LSD	0.187	0.368	0.052	0.343
Prob. of F	<.001	<.001	.343	<.001

Table 3. Effects of treatments on the fatty acid profiles of shea butter

Storage environments	Stearic acid (%)	Oleic acid (%)	Linoleic acid (%)	Linolenic acid (%)	Palmitic acid (%)
Open space	27.81	49.77	4. 94	0.36	6.17
Laboratory	28.00	49.61	5.05	0.34	6.13
SE	0.02	0.021	0.016	0.00	0.02
LSD	0.043	0.046	0.034	0.000	0.043
Prob. of F	<.001	<.001	<.001	.002	.12

4. CONCLUSION/RECOMMENDATION

The research revealed that laboratory storage environment which was a well ventilated room condition was found to be very suitable for storage of shea nuts before shea butter extraction. It may, therefore, be recommended that for a high quality shea butter to be extracted from shea nuts after storage, it must be stored under shade with good ventilation (e.g. by raising local structures like the thatch house with adequate ventilation), devoid of effects of rainfall and high temperatures associated with open air storage conditions that may lead to low quality shea butter. Under such a condition, the nuts can be kept for long, before butter extraction.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Warra AA. Cosmetic potentials of African shea nut (*Vitellaria paradoxa*) butter. Current Research in Chemistry. 2011;3:80-86.
2. Mohagir AM, Kamga R, Kapsue C, Abi CF. Optimization of some pre-treatments involved in the press extraction of shea (*Vitellaria paradoxa*. Gaertner F.) butter. Asian J Applied Sci. 2009;2:372-384.
3. Moharram H, Ray J, Ozbas S, Juliani H, Simon J. Shea butter: Chemistry, quality and new market potentials. ACS Symposium Series Abs; 2006.
4. Agbanga Karite. Shea butter: Fair trade, unrefined shea butter and African black soap; 2010. Available on: http://www.agbangakarite.com.
5. Kordylas JM. Processing and preservation of Tropical and sub – Tropical foods. UK: Macmillan Publishers Limited; 1990.
6. FAO. Trade and sustainable forest management. FAO corporate document Repository; 2004. Available on: http://www.fao.org/docrep/008/y5918e/y5918eoo.htm.
7. Fobil JN. Research and development of the shea tree and its products; 2010. Available:http://www.solutionssite.org/artman/publish/articlea10.shtml.
8. Salunhe DK, Chavan JK, Adsule RN, Kadam SS. World oil seeds: Chemistry, technology and utilization. In: Fobil JN. Research and Development the Shea Tree and Its Products; 2010. Available:http://www.solutionssite.org/artman/publish/article10.shtml.
9. Pomeranz Y, Meloan CE. Food analysis theory and practice. New Delhi: CBS Publishers and Distributors; 2004.
10. Jacobs MB. The chemical analysis of foods and food products. New Delhi: CBS Publishers and Distributors; 1999.
11. Onwuka GI. Food analysis and instrumentation. Theory and practice. Nigeria: Naphthali Prints; 2005.
12. Ferris RSB, Collinson C, Wanda K, Jagwe J, Wright P. Evaluating the marketing opportunities for shea nut and shea nut processed products in Uganda. Submitted to United States Agency of International Development (USAID); 2001.
13. Olaniyan AM, Oje K. Quality characteristics of shea butter recovered from shea kernel through dry extraction process. J Food Sci Techol. 2007;44(4):404-407.
14. Cheronis ND, Entrikin JB, Hodnett EM. Semimicro qualitative organic analysis. The systematic identification of organic compounds. 3rd ed. Florida: Robert. E. Krieger Publishing Company; 1983.
15. Fashina OO, Ajibola OO. Mechanical expression of oil from conophor nut (*Tetracarpidium conophorum*). In: Olaniyan AM, Oje K. Quality characteristics of shea butter recovered from shea kernel through dry extraction process. J Food Sci Technol. 2007;44(4):404-407.

16. James LE. Some basic research problems in *Macadamia*. California: *Macadamia* Society Year Book; 1961.
17. Omolara OO, Dosumu OO. Preliminary studies on the effect of processing methods on the quality of three commonly consumed marine fishes in Nigeria. In: Okoye COB, Ibeto CN, Ihedioha JN. Preliminary studies on the characterization of orange seed and pawpaw seed oils. Am J Food Technology. 2011;6:422-426.
18. Dei HK, Rose SP, Mackenzi AM, Pirgozliev V. Metabolizable energy in different shea nut (*Vitellaria paradoxa*) meal samples for broiler chickens. Poul Sci. 2008;87:694-699.
19. Okullo JBL, Omujal F, Agea JG, Vuzi PC, Namutebi A, Okello JBA, Nyanzi SA. Physico-chemical characteristics of shea butter (*Vitellaria paradoxa* C.F. Gaertn.) oil from the shea districts of Uganda. African Journal of Food Agriculture Nutrition and Development. 2010;10(1):2070-208.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=651&id=24&aid=5966