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PROXIMATE AND MINERAL COMPOSITION OF SHEA (*VITELLARIA PARADOXA* C.F. GAERTN) FRUIT PULP IN UGANDA

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ABSTRACT

The shea tree *(Vitellaria paradoxa*,C.F.Gaertn*)* is an indigenous fruit tree distributed in the shea parklands of Africa. The shea fruit is an important source of food for rural communities especially at time of food shortages, hunger and other disasters in addition to providing enormous health benefit and income. Because of its role in combating food insecurity and sustaining rural livelihoods, an assessment of the nutritional composition of shea fruit pulp was carried out in Uganda. Samples of shea fruits were collected from Katakwi, Lira, Pader and Arua districts in Teso, Lango, Acholi and West Nile sub regions in Uganda, respectively, between April and August 2007. For each district, a composite shea fruit sample was analysed for moisture content, total ash, crude oil, crude fibre, crude protein, vitamin C, carbohydrates and calorific values. The mineral composition was analysed for calcium, sodium, potassium, magnesium and iron. The total ash, crude oil, crude fibre, crude protein, total carbohydrate, vitamin C and caloric values ranged between 3.6-5.9%, 1.5-3.5%, 10-15%, 3.1-4.2%, 12.4-19.4%, 85.6-124.9mg/100g and 77.6-89.2 Kcal/100g, respectively (dry weight basis). Ca, K, Mg, Na and Fe values in the pulp ranged from 35.2-95.6 mg/100g, 42.0-63.6 mg/100g, 18.1-24.2mg/100g, 7.1-18.1mg/100gm and 3.4-3.8 mg/100g, respectively. There was a significant variation ($P \leq 0.05$) in the crude proteins, crude fibre, Vitamin C values and mineral compositions of the shea fruit pulp from the different shea sub-regions in Uganda. These variations could be due to differences in prevailing environmental factors. The results show clearly that shea fruit pulp has adequate nutrients equivalent to other edible fruits and should be promoted in human nutrition. Its Na/K ratio (0.14-0.35) also makes the shea fruit a valuable resource for managing high blood pressure; an emerging non-communicable disease in most developing countries. To promote wide consumption of shea fruits, the influence of environmental factors and season of harvest on its nutritional composition needs to be investigated.

Key words: Indigenous, nutrition, shea tree, fruit

INTRODUCTION

Wild and semi-wild indigenous fruit trees play an important role in sustaining the livelihoods of rural people. These fruits are important sources of food for rural communities especially at time of food shortages, hunger and other disasters in addition to providing enormous health benefit and income [1, 2]. In developing countries, there is a tremendous increase in the number of people who are under-nourished [3]. Moreover, up to 25% of African population has been reported to be suffering from chronic food insecurity and receiving less than 80% of recommended calorie intake [2]. In order to eliminate food insecurity, hunger and malnutrition in developing countries, alternative sources of nutritious food in these areas need to be identified.

One such indigenous fruit tree in northeastern and northwestern Uganda is the shea butter tree. The shea tree (*Vitellaria paradoxa*) is an indigenous fruit tree with enormous nutritional benefits [4]. It is found in the parkland belts stretching from Senegal through Sudanian region, north-eastern Uganda to Western part of Ethiopia where it has been consumed for centuries [5, 6]. The fruit has been reported to be vital for supporting the livelihoods of the parklands communities [7, 8]. It is also valued as a source of food for other animals such as elephants, sheep, pigs, bats and birds in addition to being sold in local markets [9, 10]. Since the *V. paradoxa* fruit is familiar to many indigenous communities in the shea parklands, its promotion as a source of nutritious fruit is crucial in times of acute food shortage, hunger and hard manual labour requirement.

The nutritional and economic importance of shea oil has been emphasized over that of the shea fruit. The fleshy shea fruit pulp is sometimes fermented, given to animal or left to rot and is discarded in favour of the shea nuts for shea oil production. Although the research on the shea fruit in Uganda has remained neglected with limited nutritional information, earlier studies elsewhere have reported the existence of important nutrients in the shea fruit pulp, normally consumed by the local population to supplement diet from staple foods [11, 12]. Despite the fact that rural communities in the shea parklands most often depend on staple foods like cassava and millet (as a source of food nutrients), they can be deficient in the basic nutrients; that has led to malnutrition in the area. In order to find means of enriching diets of rural communities within the shea belt of Uganda and to raise the nutritional potential of shea fruit pulp, it was deemed important to assess the proximate and mineral composition of the shea fruit pulp.

In this study, an assessment of the proximate values and mineral composition was conducted on shea fruit pulp samples from the different shea zones in Uganda. The aim of the study was to provide information on the nutritional values of shea fruit pulp in Uganda. The specific objectives were twofold: (i) to determine proximate values and mineral composition of shea fruit pulp and (ii) to ascertain variations in the proximate and mineral compositions of shea fruit pulp from the different shea zones in Uganda.

MATERIALS AND METHODS

Five kilograms (5kg) of shea fruits were collected from each district of Katakwi, Lira, Pader and Arua in Teso, Lango, Acholi and West Nile sub-regions in Uganda, respectively between April and August 2007. The fruits were collected from different trees in one Sub county, stored in a cooler at 4^{o}C and transported to laboratory for analysis.

Sample preparation: The fruits were sorted and cleaned with cold tap water before depulping manually. The pulp was dried in an oven at a temperature range of 40-50^{o}C for 5 days before being crushed in an electric grinder (Brooks Crompton Series 2000, UK) after analysis of moisture content. The dry pulp was analysed for vitamin C, total ash, crude oil, crude protein, total carbohydrates proximate and mineral, Ca, Mg, K, Na and Fe composition.

Proximate analyses: The moisture, ash and crude fibre contents were analysed according to standard methods [13]. Nitrogen was assayed using Kjeldahl method and the nitrogen content converted to protein by a multiplication factor of 6.25. Total carbohydrates were determined by difference. Vitamin C was determined by titration with 2, 6-dichlorophenolindophenol [14]. The values of Vitamin C were converted as dry matter after analysis. Proximate analyses were carried out in triplicate and results expressed as percentage of the sample analyzed. Calorific values were estimated (in kcal/g) from carbohydrate, protein and fat contents [15].

Mineral element analysis: Mineral element analyses were determined using Atomic Absorption Spectrophotometer (Model-Shimatzu AA-6300). The shea fruit was analysed for calcium, potassium, sodium, magnesium and iron elements. The dried shea fruit pulp (2.0 g) were mixed with 5.0 ml of distilled water, 25 ml of concentrated nitric acid and digested under reflux over a water bath at 90^{o}C for 4 hours. The refluxed solution was cooled and 10 ml of concentrated perchloric acid added. The samples were further digested for 1hour and cooled. Concentrated hydrochloric acid (2ml) was then added to the sample and made to 100ml with distilled water. The analyses of minerals were then carried out in triplicate and all values expressed as mg/100g.

RESULTS

The proximate values of *V. paradoxa* (The shea butter) fruit pulp are presented in Table 1. The dry shea fruit pulp contained vitamin C that ranged between 85.6 and 124. 8 mg/100g. The moisture, total carbohydrate, crude fibre, total ash, crude protein, crude fat contents ranged from 72.4-75.3%, 12.4-19.4%, 10-15%, 3.6-5.9%, 3.1%- 4.2% and 1.5% -3.5% respectively. The estimated caloric value ranged from 77.6-89.2 kcal/100g. There were significant variations (P≤ 0.05) in crude fibre, carbohydrates, crude protein and vitamin C of shea fruit pulp in the shea zones of Uganda (Table 2).

The most predominant mineral found in the shea fruit pulp was calcium with values up to 95.6 mg/100g. Potassium and magnesium were also high with values of 52.0 mg/100g and 24.2 mg/100g respectively. Sodium and iron minerals were generally low in the shea fruit pulps with values of 18.1mg/100g and 3.8 mg/100g, respectively. The highest value of calcium, magnesium and sodium were found in the samples from Katakwi district while the lowest values of the respective minerals were observed in the samples from Arua district. Potassium was highest in the samples from Pader district and the lowest in the samples from Lira district. Although iron was generally low in concentration, the highest value was registered in the samples from Pader and Arua districts (Table 3).

DISCUSSION

Indigenous tree fruits in the African parklands such as the shea fruits constitute a great source of essential nutrients such as vitamins, mineral, carbohydrates, crude fibre and proteins. This study shows that the vitamin C content of shea fruit pulp (86-125 mg/100) is higher than in other common fruits such as oranges (41 mg/100g), lemon (41 mg/100g), pawpaw (69 mg/100g) and mango with a value of 28 mg/100g [16]. Comparatively, the vitamin C content of the Uganda shea fruit pulp reported in this study is lower than that reported for shea fruit pulp in Ghana [17]. This variation could be attributed to environmental condition and post harvest handling practices [17]. Although the values of vitamin C were high, it was also noted that there were significant variations ($P<0.05$) in the different shea zones of Uganda (Table 2). The variation of vitamin C content in the different shea zones could also be due to environment factors and the ability of the shea fruit to synthesize vitamin C [18, 19].

The vitamin C content (85-111mg/100g) of ripe shea fruits is even higher than most un-ripe edible fruits considered to be rich in vitamin C. This higher value makes vitamin C an important nutrient in the shea fruit pulp at the time of shea fruit consumption. As the ripe shea fruit is commonly consumed by rural communities within the shea belt, vitamin C in it is one of the essential nutrients needed by the human body. Besides, being a good antioxidant, Vitamin C can also facilitate lowering of blood pressure while enhancing human body immunity. It is also anti-carcinogenic and prevents colds. According to recommended daily allowance (RDA) for vitamin C, 100-120 mg per day is good for adults and lack of it may result in scurvy [19]. Regular consumption of shea fruits, therefore, can raise the nutritional profile and health status of the local communities within the shea parklands at this time when there are food shortages and rampant emerging diseases such as cancer and blood pressure in the world.

Like other edible fruits, shea fruits are rich in different carbohydrates such as glucose, fructose and galactose [20]. As the shea fruits' harvesting season normally coincides with high energy requirement for farm planting, energy demand would be met through consumption of shea fruits. Shea fruit has more carbohydrates that are vital in nutrition and are also good sources of energy [21]. The consumption of the shea fruit

pulp after hard labour, thus, provides an immediate source of energy for the farmers. This, therefore, justifies the promotion of consumption and commercialization of shea fruits in the shea zones of Uganda and beyond.

The value of crude fibre content for shea fruit pulp of 10-15% is within the crude fibre values of most wild and domesticated fruits [22] and higher than in legumes with mean values ranging between 5-6% [23]. As crude fibre helps in the maintenance of normal peristaltic movement of the intestinal tract, diets containing high fibre content could reduce occurrence of such disorders as constipation, colon diseases, diabetes, cardiovascular diseases and obesity [24]. This study, thus, has indicated that shea fruit pulp is a rich source of energy and capable of supplying the daily energy requirements of the body. It also implies that promoting consumption of shea fruit is of great benefit to the human diet.

A significant variation was exhibited in the percentages of crude protein content ($P \leq 0.05$) across the different shea zones in Uganda (Table 2). These percentages of the shea fruit crude protein content fall within the range reported for most wild and edible fruits that are lower than 5% [25]. Even if the values of crude protein content reported for shea fruit are not different from that of other fruits [25], it is; however, lower than that reported for the shea fruit pulp samples from West Africa [26]. Such variation in crude protein is normally associated with differences in environmental conditions. As proteins play an important role in nutrition through catalyzing, regulating, protecting and providing energy, their deficiency can cause growth retardation, muscles wasting, edema, kwashiorkor and collection of fluids in the body. Since the shea fruit protein can supplement plant protein sources such as bean and peas widely consumed in many rural homes, encouraging consumption of shea fruits among rural communities can lead to provision of a good protein supplement in the human diet.

The amount of calcium content of 68 mg/100g exhibited in this study is higher than that of other studies for calcium of 36 mg/100g but not for magnesium (26mg/100g), which has been reported to be higher than 21 mg/100g [27]. The reported potassium amounts of 400 mg/100g are much higher than the value of 42.0-52.0 mg/100g exhibited in this study. The value of iron in shea fruit pulp obtained in this study is the least (Table 3). Although these variations in proximate and mineral contents of shea fruit pulp could be due to differences in analytical methods used and also prevailing environmental factors [17, 18, 19], the relationship between the prevailing environmental factors and nutritional composition of shea fruit pulp, were not investigated. There is, thus, a need to investigate the relationship.
Since minerals are important in the diet because of various functions they perform in the body such as building strong bones, transmitting nerve impulses, making hormones and regulating body fluids [28], consumption of shea fruit pulp is highly recommended. Calcium, for example, serves as cofactors for many physiologic and metabolic functions such as bone formation, functioning of nervous system, hormonal secretions, activation of enzymes and blood coagulation [28]. Potassium on the other hand is important in protein synthesis, water balance, normal functioning of the

nervous and muscles and absorption of glucose and glycogen. Magnesium also assists enzymes involved in the synthesis and breakdown of carbohydrates, fats, proteins and synthesis of DNA and RNA [28].

The mineral nutrients from shea fruit can also contribute 8.8%, 2% and 6% of required calcium, potassium and magnesium, respectively to the daily nutrient intake when compared with Recommended Daily Allowance (RDA) reported by United States National Recommended Council (NRC) [29]. As 100g of the shea fruit pulp can provide 2%, 6% and 8.8% RDA of potassium, magnesium and calcium, respectively, eating of shea fruit pulp can easily supplement the available minerals required by the body.

The Na/K ratio is of significant importance in the control of high blood pressure where a value of less than 1 is recommended for controlling high blood pressure [29]. In this study, the Na/K ratio range was found to be 0.17-0.35. This Na/K ratio values make shea fruit pulp a valuable resource in the management of high blood pressure; one of the non communicable diseases emerging in developing countries including Uganda. Thus, promoting the consumption of shea fruit would provide an alternative measure for mitigating incidences of emerging high blood pressure among the shea parkland communities.

CONCLUSION

Given the proximate and the mineral composition values obtained in this study, it can be concluded that the shea fruit pulp is rich in vitamin C, total carbohydrates and crude fibre. The proximate and the mineral composition values also indicate that the Ugandan shea fruit pulp has adequate nutrients equivalent to other edible fruits for the shea producing communities. Due to the nutritional value and health potential of the shea fruit pulp, growing of shea butter tree and consumption of its nutritious fruits should be promoted in Uganda and beyond. Since variations in proximate and mineral composition of the shea fruit pulp exist in the different shea districts of Uganda, there is also need to investigate the influence of environmental factors and season of harvest on these variations.

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Table 1: Proximate values (based on dry matter basis) of shea fruit pulp in the shea districts of Uganda

Parameter	District				LSD
	Lira	Katakwi	Pader	Arua	
Moisture content (g/100g) FP	[a]72.4 ±0.1	[a]73.7±0.9	[b]75.3 ±1.2	[a]74.2 ±1	1.44
Ash content (g/100g)	[a] 3.6±0.2	[b] 5.9±1.9	[b] 5.5±0.2	[b] 4.6±0.3	1.30
Crude oil (lipid) content (g/100g)	[a]1.5±0.7	[a]2.0±1.4	[b]3.5±0.5	[a]2.5±0.7	1.25
Crude fibre content (g/100g)	[a]14.5±1.7	[a] 14.4±1.2	[b]10.1±0.1	[a]14.6±0.6	1.46
Crude Protein (g/100g)	[a]3.1±0.1	[b]4.2±0.3	[a]3.2±0.1	[c]3.7±0.1	0.26
Total carbohydrates (g/100g)	[a]19.4 ±0.6	[b]14.2±1.5	[b]12.6±0.4	[b]14.9±0.5	3.06
Calorie value (kcal/100g)	[a]89.3	[b]77.7	[b]81.5	[b]83.3	8.3
Vitamin C (mg/100gm)	[a]111.9±20.6	[a]124.9±0.8	[a]109.9±1.1	[b] 85.6±5.5	19.64

FP- fresh pulp. Values are means of triplicate analyses. ^{a,b,c} *means with same letter superscript are not significantly different* ($P \geq 0.05$) *and those with different letter superscripts are significantly different* ($P \leq 0.05$)

Table 2: Variation of proximate values for shea fruit pulp in shea districts of Uganda

Parameter	P- values for comparing mean values of two districts					
	LK	**LP**	**LA**	**KP**	**KA**	**PA**
Crude oil (lipid) content	0.698 [a]	0.106 [a]	0.293 [a]	0.317 [a]	0.698 [a]	0.292 [a]
Crude fibre content	0.959 [a]	0.070 [a]	0.959 [a]	***0.035*** [b]	0.880 [a]	***0.009*** [b]
Crude Protein	0.049 [b]	0.565 [a]	***0.030*** [b]	0.062 [a]	0.208 [a]	0.055 [a]
Total carbohydrates	0.439 [a]	0.647 [a]	0.531 [a]	0.743 [a]	0.64 [a]	0.931 [a]
Vitamin C	0.098 [a]	0.571 [a]	0.108 [a]	***0.0*** [b]	***0.00*** [b]	***0.00*** [b]

LK- Lira and Katakwi, LP- Lira and Pader, LA – Lira and Arua, KP- Katakwi and Pader, KA- Katakwi and Arua, PA- Pader and Arua. [a] *Not significantly different (P≥ 0.05),* [b(bold)] *Significantly different (P≤ 0.05).*

Table 3: Mineral composition of shea fruit pulp in the shea districts of Uganda

Mineral	District				
(mg/100g)	Lira	Katakwi	Pader	Arua	LSD
Sodium	[a] 8.9±0.1	[b]18.1±0.2	[a]9.0±0.2	[c]7.1±0.3	0.50
Potassium	[a]47.9±0.2	[b]52.0±0.3	[c]63.6±0.3	[d]42.0±0.3	1.20
Calcium	[a]69.4±0.1	[b]79.0±0.2	[c]95.6±0.2	[d]37.2±0.3	2.59
Magnesium	[a]18.1±0.3	[b]23.8±0.2	[b]24.2±0.3	[c]21.0±0.5	1.13
Iron	[a]3.6±0.1	[b]3.4±0.1	[a]3.8±0.1	[a]3.8±0.1	0.16
Na/K ratio	0.19	0.35	0.14	0.17	0.42

Values are means of triplicate analysis. ^{a,b,c} *means with same letter superscript are not significantly different and those with different letter superscripts are significantly different at* $P \leq 0.05$

REFERENCES

1. **Okafor JC** Selection and improvement of indigenous topical trees. *Journal of Trop. Resour.*, (1985); *1: 87-95.*

2. **FAO.** Corporate Document Repositotry, Minor oil Crops Accessed on2007. 23.3.2007. http://www.fao.org/docrep/X5043E/x5043E0b.htm

3. **UNSSCN.** United Nation System Standing Committee on Nutrition 5th report on World Nutrition situation, 2004**,** pp.5-21.

4. **Maranz S and Z Weisman** Evidence of indigenous selection and distribution of the shea trees (*Vitellaria paradoxa*) and is important significance to prevailing parkland savanna tree patterns in Sub Saharan Africa north of equator. *Journal of Biogeography,* 2003; ***30****: 1505-1516.*

5. **White F** The vegetation of Africa. *Natural Resources Research,* 1983, 20 pp. 356.

6. **Katende AB, Birnie A and BO Tengnas** Useful trees and shrubs of Uganda. Identification, propagation and management for agricultural and pastoral communities. Technical book No.10. Regional Soil Conservation Unit (RSCU), 1995. pp. 710.

7. **Hall JB**, **Aebischer PD, Tomlinson HF, Osei-Amaning E and JR Hindle** *Vitellaria paradoxa*: a monograph. School of Agricultural and Forest Sciences University of Wales, Bangor, UK, 1996, pp. 105.

8. **Okullo JBL, Hall JB and J Obua** Leafing, flowering and fruiting of *Vitellaria paradoxa* subsp. *nilotica* in savanna parklands in Uganda. Agroforestry Systems, 2004; **60**: 77-91.

9. **USAID.** Shea butter value chain, production transformation and marketing in West Africa. WATH Technical report No.2, 2004**.**

10. **Maranz S, Kpikpi W, Wiesman Z, Sauveur AD and B Chapagain** Nutritional values and indigenous preferences for shea fruits (*Vitellaria paradoxa* C.F. Gaertn. F.) in African Agroforestry Parklands. *Journal of Economic Botany,* 2004; ***58 (4): 588-600.***

11. **CRIG.** Research and development of shea trees and shea products. The cultivation and processing of shea nuts. Cocoa Research Institute of Ghana (CRIG), A case study, University of Ghana, 2002**.** Retrieved on 19.9.08 http://www.solutions-site.org/cat11_sol119.htm.

12. **Mbaiguinam M, Mbayhoudel K and C Djekota** Physical and chemical characteristics of fruits, pulps, krnels and butter of *Butyrospermum parkii* (sapotaceae) from Mandoul, Southern Chad. *Asian Journal of Biochemistry*, 2007; ***2 (2): 101-110.***

13. **AOAC.** Association of Official Analytical Chemists. Official methods of analysis. 17th Ed. Washington, DC, 1997. pp. 202.

14. **Pearson D** *The Chemical Analysis of Foods*, 7th Ed. London, Churchill Livingstone, 1976. pp. 7-11.

15. **Yusuf AA**, **Mofio BM and AB Ahmed** Proximate and mineral composition of *Tamarindus indica Linn* 1753 Seeds. *Science world journal*, 2007, *Vol. 2 (No.1).*

16. **Nji FF and F Onajobi** The Vitamin C content of some tropical fruits. Challenges to Organic Farming and Sustainable Land use in the Tropics and Sub tropics, Books of Abstracts, University of Bonn, Institute of Animal Nutrition, 2002. pp.273.

17. **Wilhelmina K** Effect of production and processing factors on major fruits and vegetables anti oxidant. JFSR: Concise reviews/Hypotheses in food Science, 2004.

18. **Naidu KA** Vitamin C in human health and disease is still a mystery? An overview. *Nutrition Journal*, 2003, *pp 1-10*, Accessed on 19.9.2008. http://www.nutritionj.com/content/2/1/7.

19. **Laing W and S Bulley** What control vitamin C levels in plants, 2007. Accessed on 2/9/2008 http://www.isb.vt.edu/articles/oct0703.htm.

20. **Neuwinger HD** *African Ethnobotany, Poisonous drugs, Chemistry, Pharmacology, Toxicology*, 1994, pp. 823-826.

21. **Anwange BA, Ajibola VO and SJ Oniye** Chemical studies of the seeds of *Moringa oleifera* (Lam) and *Detarium Microcarpum* (Guill and Sperr) *Journal of Biological sciences*, 2004, *pp. 711-715.*

22. **Ramulu P and PU Rao** Total, insoluble and soluble dietary fibre contents of Indian fruits. *Journal of food composition and analysis*, 2003; ***16: 677-685.***

23 **Aremu MO, Olonisakin A, Bako DA and PC Madu** Compositional studies and physicochemical characteristics of cashew nut (*Anarcadium occidentale*) flour. *Pakistan Journal of Nutrition, 2006; 5: 328-333.*

24. **Omosuli SV, Ibrahim TA, Oloye D, Agbaje R and B Jude-Ojei** Proximate and mineral composition of roasted and defatted Cashew Nut (*Anarcadium occidentale*) flour *Pakistan Journal of Nutrition 2009; **8** (10): 1649-1651.*

25. **Marakoglu T**, **Arslan D, Ozcan M and H Hacıseferogulları** Proximate composition and technological properties of fresh blackthorn (*Prunus spinosa* L. subsp *dasyphylla* (Schur.) fruits. *Journal of Food engineering,* 2005; ***68 (2): 137-142.***

26. **Prokarite** La Base de Donnees, *Vitellaria*, World Agroforestry Centre, 2007. Accessed on 19.3.07. http://prokarite.org/*Vitellaria*-dbase/fat-percentage.html

27. **PROTA.** Plant Resources of Tropical Africa 14, 2007, pp.182-185.

28. **Agatemor C and ME UKhun** Nutritional potential of the nut of Tropical Almond (*Terminalia catappia L.). Pakistan Journal of Nutrition*, 2006; ***5 (4): 334-336.***

29. **NRC.** Recommended dietary allowances, National Research Council, (NRC), 1989**.** 10th Edn.National Academic Press Washington, DC, pp: 24.