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Mineral Content of the Pulp of Shea Butter Fruit (*Vitellaria Paradoxa* C. F. Gaertn.) Sourced from Seven Locations in the Savanna Ecology of Nigeria

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ABSTRACT

Fruit samples of the shea butter tree, *Vitellaria paradoxa*, were collected from seven locations across the southern Guinea savanna, northern Guinea savanna and Sudan savanna of Nigeria in the early part of the rainy season (the main period for fruit fall) in 2006. Oven dry samples of fruit pulps were subjected to laboratory analysis to determine their mineral nutrient content. Results of analysis of variance showed remarkable variations in Na, K, Mg and Fe content across the three ecologies. Similarly, all nutrient elements considered were significantly ($P < 0.05$) influenced by location (accession). Accession obtained from Lokoja recorded higher concentrations of Na, P and K, but the Kano accession had higher values for Ca, Mg, Fe and Zn. Principal component analysis appeared to suggest Na, P, Fe and Zn as nutrient traits capable of being used in classifying shea fruit pulp in the savanna of Nigeria. There were significant positive correlations among the nutrient elements. Relatively high values of nutrient elements as obtained in this study suggest that Shea butter fruit pulp is capable of combating malnutrition by meeting the nutritional requirement of rural dwellers among which shea fruit is already recognized and cherished as a food source.

Keywords: accession, correlations, elemental nutrient, Nigeria, principal components

INTRODUCTION

One of the key woody species that prominently adorns the African savannah landscape is the shea butter tree, *Vitellaria paradoxa* (Salle *et al*. 1991) which belongs to the family Sapotaceae. *Vitellaria* exist hand in hand with the locust bean tree, *Parkia biglobosa*, the two being the dominant woody components of the agroforestry systems of the African savanna (ICRAF 1997).

The species, also known by its French name *karite*, produces a fruit containing an oil-rich nut. The oil extract, known as shea butter, is an export item to the European market. Because of its excellent properties, it has carved a place for itself in the food and cosmetic industries both internationally and locally (Umali and Nikiema 2002). Besides, the oil is used locally as a lamp illuminant and for soap production (Vickery and Vickery 1969). It is also effective in the treatment of minor bone dislocation (Badifu 1989) and inflammations.

The fruit pulp is sweet and edible when ripe (ICRAF 2000) and is widely consumed among indigenous peoples (Maranz *et al*. 2004). Its role in alleviating hunger during the period of seasonal food scarcity has also been highlighted (Lamien *et al*. 1996). Generally, fruits from agroforestry species have been known to supplement dietary needs. The vital nutrients and essential vitamins they contain help to improve the nutritional content of staple foods thereby curtailing malnutrition among growing children (FAO 2001).

Although fruits and other products from agroforestry trees are often considered of minor importance compared to products from mainline agricultural species, rural dwellers that depend on these species for their daily needs recognize their actual worth (FAO 2005). Investigation into the nutritional content of indigenous Malaysian fruits established that they were comparable, if not superior in some respects, to the nutritional content of commonly cultivated species except for vitamin C (Hoe and Siong 1999).

A review of the nutritional content of various agroforestry species by Leakey (1999) presents their potential as competent sources of novel food products. Excitedly, a product – shea jam – made of shea fruit pulp and honey has been produced by a women's association in Burkina Faso. Going by the brand name Karidelice, the product is now on sale locally, in neighbouring African countries and some European countries (Belgium, France, and Switzerland) as well as in Canada (Spore 2008). A report of the excellent proximate qualities of shea fruit from Nigeria has already been made (Ugese *et al*. 2008). Our major task in this work was to explore the elemental nutrient composition of shea butter tree fruit pulp obtained from the savanna zone of Nigeria, an area that defines the species' major zone of occurrence.

MATERIALS AND METHODS

Fruit samples were collected from seven locations (Lokoja, Makurdi, Akwanga, Kachia, Jalingo, Yola and Kano) across the southern and northern Guinea savanna, and the Sudan savanna zones in July, 2006. In each location ripe fallen fruits were collected from 25 trees. The fruits from each site were then bulked together. The fruits were depulped and fruit pulp oven dried at 65°C to a constant weight.

Milled samples were subjected to laboratory analysis to determine the following seven elements after digestion in sulfuric acid: Sodium (Na), Phosphorus (P), Potassium (K), Magnesium (Mg), Calcium (Ca), Zinc (Zn) and Iron (Fe). But while Na, P and K were determined at the Crop Science Laboratory of the University of Nigeria, Nsukka, the other elements were estimated at the Central Science Laboratory, Obafemi Awolowo University, Ile-Ife, Nigeria.

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Short Communication

Table 1 Agro-ecological variations in nutrient composition of Shea fruit pulp sourced from the savanna of Nigeria.

Agroecological zone	Na (mg/100 g)	P (mg/100 g)	K (mg/100 g)	Ca (mg/100 g)	Mg (mg/100 g)	Fe (mg/100 g)	Zn (mg/100 g)
Southern guinea savanna	27.0	69.8	883.0	2.6	52.1	15.6	2.0
Northern guinea savanna	13.4	76.5	442.0	2.4	64.5	10.1	1.7
Sudan savanna	13.6	68.8	976.0	2.5	76.0	20.6	1.8
LSD(0.05)	10.7	NS	418.3	NS	21.2	5.7	NS

NS: Non-significant difference

Table 2 Elemental nutrient composition of shea fruit pulp sourced from seven locations in Nigeria.

Accession	Na (mg/100 g)	P (mg/100 g)	K (mg/100 g)	Ca (mg/100 g)	Mg (mg/100 g)	Fe (mg/100 g)	Zn (mg/100 g)
Lokoja	45.0	94.0	147.0	1.4	50.2	20.8	1.9
Makurdi	18.0	36.9	588.0	4.9	56.7	13.7	2.3
Akwanga	18.1	78.4	590.0	1.5	49.5	12.2	1.8
Kachia	17.9	51.7	295.0	ND	75.2	ND	ND
Jalingo	9.0	101.4	589.0	2.2	53.8	4.7	1.5
Yola	9.3	55.4	591.0	0.6	44.9	15.2	1.2
Kano	17.9	82.1	136.0	4.4	107.2	25.9	2.4
Mean	19.3	71.4	783.3	2.5	62.5	15.4	1.9
LSD(0.05)	1.2	1.5	1.8	0.2	0.9	0.4	0.2

ND – Not determined

P concentration was determined by atomic absorption spectrophotometry (Spectrumlab 21A), while Na and K were determined by flame photometry using Galenkamp flame analyzer. The rest were also estimated by means of atomic absorption spectrophotometer (Alpha 4). For each mineral, sample determinations were made in triplicate.

Data collected were subjected to analysis of variance and Principal Components by means of GENSTAT Discovery edition 3, Release 7.2DE (GENSTAT 2007). Correlations among all the nutrient elements were determined by use of SPSS version 10.

RESULTS

The concentrations of Na, K, Mg and Fe were significantly ($P < 0.05$) influenced by agro-ecological zones (**Table 1**). The concentration of Na was highest in the fruits of the wetter southern guinea savanna zone; in contrast Fe was more abundant in the fruits collected from the drier Sudan savanna zone. It was notable that Shea fruits in the northern guinea savanna zone had the least amount of Ca. The southern guinea savanna fruit pulp had the lowest concentration of Mg which was however, not statistically different from that of the northern guinea savanna.

Table 2 is a summary of nutrient concentrations across individual accessions (collection sites). Results showed significant ($P < 0.05$) variability in nutrient concentration due to accessions. The highest amount of Na was found in fruits sourced from Lokoja (45 mg/100 g), while the lowest was found in fruits obtained in Jalingo (9.0 mg/100 g) and Yola (9.3 mg/100 g) origins. It was remarkable that the Lokoja accession also gave significantly higher amount of K and was second only to Jalingo in P content. Fruits obtained from Makurdi had the lowest P concentration while those from Kachia were least in K. Lokoja and Kano had comparatively higher concentration of K in their fruits. Kano fruits also recorded highest values for Mg, Fe and Zn. Concentrations of Fe varied from 0.6 (Yola) to 4.9 mg/100 g (Makurdi). Fruits with the lowest amount of Fe and Zn were those of Jalingo and Yola, respectively.

Table 3 Principal component analysis showing eigen vector values of mineral content of shea fruit pulp sourced from the savanna zone of Nigeria.

Nutrient element	PRIN 1	PRIN 2	PRIN 3
Na	0.27538	-0.46014	0.50669
P	0.04030	-0.51351	-0.68342
K	0.40759	-0.43254	-0.08261
Ca	0.35676	0.46082	-0.09320
Mg	0.42575	0.23546	-0.45095
Fe	0.46835	-0.11594	0.22190
Zn	0.47803	0.23714	0.08994
Latent roots	3.229	2.036	0.869
% of total variation explained	46.13	29.08	12.41

Principal component analysis revealed that Fe and Zn explained about 46% variation in elemental composition of Shea butter fruit pulp obtained in Nigeria. Similarly, P and Na explained about 41% of the total variance. The three component axes together explained 87.62% of the total variation (**Table 3**).

The correlation matrix of all the nutrient elements is presented in **Table 4**. Sodium (Na) had positive significant relationship with Fe and K. Its association with Mg and Ca was negative though non-significant. Phosphorus (P) had positive relationship ($P < 0.05$) only with K; similarly, K had positive significant correlation with Fe and Na. Magnesium recorded positive statistical linkage with Zn, Fe and Ca. The element with the highest number of significant linkages was Fe which maintained such relationship with four other elements: Zn, Mg, K and Na.

DISCUSSION

The comparatively higher amounts of K, Mg and Fe in the drier Sudan savanna ecology seem to agree with results of

Table 4 Correlations among mineral content of shea fruit pulp sourced from the savanna zone of Nigeria.

	Na	P	K	Ca	Mg	Fe	Zn
Zn	0.321	-0.159	0.380	0.838**	0.650**	0.539*	-
Fe	0.500*	-0.051	0.716**	0.256	0.627**	-	
Mg	-0.068	0.025	0.338	0.630**	-		
Ca	-0.092	-0.322	0.110	-			
K	0.679**	0.532*	-				
P	0.278	-					
Na	-						

*, **: Significant at 5% and 1% probability levels, respectively.

Maranz *et al*. (2004) who found higher amounts of K, Ca and Mg in the drier Sahel zone of Mali and Burkina Faso, and ascribed it to lower leaching levels. However, in the current study, Ca did not show significant variation across ecological zones. Sodium, which alongside K, Ca and Mg is noted to be mobile and the second most easily leached class of chemicals (Ahn 1970), was significantly more highly concentrated in the wetter southern guinea savanna fruits. This may suggest that both genetic and soil factors need to be explored to satisfactorily explain such occurrence rather than exclusive reliance on the climatic factor.

The higher concentrations of most minerals in fruits of the Kano accession may largely be due to resistance offered by the environment to leaching losses due to its comparatively more dry nature (Agboola 1979).

The range in values of the elements reported in the present study was 36.9–101.4, 295–1470.0, 0.6–4.9, 44.9–107.2, 4.7–25.9 and 1.2–2.4 mg/100 g for P, K, Ca, Mg, Fe and Zn respectively. Corresponding ranges of these nutrients from work by Maranz *et al*. (2004), are 9–128, 318–3660, 72–1103, 1.2–2.4, and 4.7–25.9 mg/100 g. The ranges of the later are wider probably because the sampled area was larger (Mali, Burkina Faso, Ghana, Cameroon and Uganda), and involved higher number of *Vitellaria* populations. Thus, mean values for the various elements were also generally higher compared to ours. However, the means observed for Mg and Fe in this study are generally higher than the 26 and 2 mg/100 g, respectively reported for those elements by Umali and Nikiema (2002), who simply reported Zn as occurring in trace amounts.

Data from Maranz *et al*. (2004) revealed that mean values of shea fruit pulp for P and Fe were higher than those of mango (63 and 5 mg/100 g respectively). However, mango fruit values for Mg, Ca and K were higher than those reported in this study. Mean Zn values for the two species were similar (1.9 mg/100 g). It has been reported earlier that protein content of the shea fruit pulp is superior to that of mango (Ugese *et al*. 2008).

The excellent nutritional properties of shea fruit pulp may justify the sale of shea fruits, though at very cheap rates, at a market on the outskirts of Makurdi, the Benue state capital (in Nigeria). This is remarkable since the guinea and sudan savanna have been adjudged Nigeria's major mango and citrus producing zones (Olaniyan 2004), with Benue state giving the highest overall production of the two commodities (Avav and Uza 2002). Traditionally, shea fruit is known to play some nutritional role in Tiv society especially among children. This was particularly more pronounced a few decades ago when millet cultivation was more popular. Farmers then would engage their children to scare away birds as the crop began to ripen. Since this period is generally characterized by food shortages, the children had to recourse to consumption of shea fruit which happen to fall at this time. That shea fruit consumption could endure even in the presence of expanding production of agricultural tree species like mango and citrus in this important fruit zone serves to reinforce the relevance of shea fruits.

Studies elsewhere (Seignobos 1982) has linked *Vitellaria* with non-nomadic ethnic groups who normally depend on it for provision of dietary fat. In Nigeria, while the nomadic Fulani may not be linked to this species in terms of extracting its fat, informal evidence during the course of fruit collection indicates that they also appreciate and consume its fruit pulp. Since they normally stay in the hinterland or the outskirts of settlements and move from place to place, they may even have advantage in detecting trees with superior fruit quality that occur far from normal settlements. Thus the usefulness of the shea tree, particularly as regards its fruit pulp, may cut across more ethnic boundaries than might ordinarily be understood. This is especially so as we also found shea fruit on sale at a food market in Jalingo (another sampling site) even though it was gathered that the inhabitants do not generally extract shea fat. Fortunately, data presented here supports the opinion that shea fruit is capable of meeting the nutritional needs of rural inhabitants.

When compared with such agroforestry species like marula (*Sclerocarya birrea*), mineral content of *Vitellaria* fruit pulp appears to be generally lower (Maranz *et al*. 2004). However, they are higher than the K (28.4 mg/100 g) and Ca (1.156 mg/100 g) values reported for baobab, *Adansonia digitata* (Saka 1994).

The positive significant correlations among the nutrient elements may indicate some nutritional implications. For instance, since Fe had positive significant correlations with four other elements, K, Na, Mg and Zn, it suggests that fruits high in Fe will invariably contain high concentrations of these four elements. A further implication could be that any effort, whether genetic or agronomic, made towards increasing the Fe content of fruits will most likely result in an increase in the associated elements as well.

It has been demonstrated by this study, that considerable variation exist in the mineral content of shea butter tree fruit pulp across the savanna region of Nigeria. Also, the values of these minerals compare favourably with those of established agricultural and agroforestry species. The pulp of shea fruit has been shown to be nutritionally competent enough to meet the dietary needs of the rural populace.

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