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Full Length Research Paper

Proximate and chemical composition of shea (*Vitellaria paradoxa* C.F. Gaertn) fruit pulp in the Guinea Savanna of Nigeria

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Results of the analysis of variance showed that the mean squares for agro ecology were highly significant (p≤0.05) for proximate (crude protein, crude fibre, crude lipid and ash) and chemical (acid value, peroxide value, iodine value and saponification value). Total ash, fats, crude fibre, crude protein and total carbohydrate, ranged between 5.1-7.3, 17.28-19.22, 9.0-11.55, 6.24-8.36 and 55.35-9.11, respectively. Chemical analysis revealed that acid value and peroxide value ranged between 1.54-2.40 mgKOH/kg and 3.52-7.02 meq/kg, while saponification and iodine values were between 131.54 mgKOH/g and 146.29 mgKOH/g and 36.9 I_2g/100 and 52.2 I_2g/100 g respectively. The proximate and the chemical composition values obtained in this study showed that the shea fruit pulp is rich in protein, total carbohydrates crude fibre and chemical values. The proximate and the chemical composition values also indicate that the Nigerian shea fruit pulp has adequate nutrients equivalent to other edible fruits, thus growing of shea butter tree and consumption of its nutritious fruits should be promoted.

Key words: *Vitellaria paradoxa*, proximate composition, chemical composition, Guinea savanna.

INTRODUCTION

Vitellaria paradoxa C. F. Gaertn belongs to the family Sapotaceae and is divided into two sub-species: *nilotica* and *paradoxa*. The ranges of the two do not overlap, although they have been found within 175 km of one another (Hall *et al.,* 1996). The sub-species, *nilotica* is located primarily in Uganda and Sudan, with some occurrence in Ethiopia, while the sub-species, *paradoxa* is found in areas from the East African Republic to Senegal (Hall *et al.*, 1996). The difference between the two subspecies occurs primarily in the consistency of the butter content found within the nut (Boffa, 2001).

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Shea butter is the fat extracted from the kernels of *V. paradoxa*. On the global scale, the species has made remarkable contributions in the food and cosmetic industries by reason of its butter (Boffa et al., 1999). Locally, *V. paradoxa* is invaluable in traditional medicine, provision of fuel wood and in the production of soap, candle and pomade (Awoleye, 1995). Its dietary importance at the local level is derived from the fat extract which is used for cooking as well as the fruit pulp which is consumed by humans and livestock (ICRAF, 2000). 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

Table 1. Location and geographical coordinates of *Vitellaria paradoxa* in the Guinea savanna of Nigeria.

Agro ecology	Locations	Latitude	Longitude	Altitude
Northern Guinea savanna	Magali	10.238	4.652	154
	Agwongo	10.169	4.652	182
Southern Guinea savanna	Emishurun	9.049	6.186	127
	Gbako-kasarawa	9.142	6.009	157
Transition zone	Saki	8.618	3.402	500
	Ogbomoso	8.178	4.217	358

Table 2. Code names and sources of the shea genotypes.

Agro ecology	States	Locations	Genotypes
Northern Guinea Savanna	Kebbi	Magali	1-10
		Agwongo	11-20
Southern Guinea Savanna	Niger	Emishurun	21-30
		Gbako-kasarawa	31-40
Forest-savanna transition zone	Oyo	Saki	41-50
		Ogbomoso	51-60

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 (Mbaiguinam *et al.,* 2007). In order to find means of enriching diets of rural communities within the shea belt and to raise the nutritional potential of shea fruit pulp, it was deemed important to assess the proximate and chemical composition of the shea fruit pulp. In this study, an assessment of the proximate values and chemical composition was conducted on shea fruit pulp samples from the Guinea savanna of Nigeria. The aim of the study was to provide information on the nutritional values of shea fruit pulp in Nigeria. The specific objectives were (i) determining proximate values and chemical composition of shea fruit pulp and (ii) ascertaining variations in the proximate and chemical compositions of shea fruit pulp from the different shea zones in Nigeria.

MATERIALS AND METHODS

The shea genotypes in this study were naturally established, but selected and preserved by farmers on their cropping areas. Sixty shea genotypes from six locations within three agro ecological zones in the Guinea savanna of Nigeria were used in this study (Table 1). In each state, two locations separated by at least 50 km apart were chosen, and in each location, a single site containing shea trees was randomly selected for sampling. In each location 10 shea trees separated by a distance of at least 25 m were sampled. The study was conducted in Magali and Agwongo (northern Guinea savanna) in Kebbi State, Emishurun and Gbako-Kasarawa (southern Guinea savanna) in Niger State and Saki and Ogbomoso (Forest-Savanna transition zones) in Oyo State, to have a total of six locations (Table 2).

From the ten selected shea trees from each location, shea fruits were randomly collected for physico-chemical analysis. The fruits were stored in dark cool bags before been taken to the laboratory for analysis. The fruits were taken to the Nigerian Institute For Oil palm Research (NIFOR) fruit and oil analysis laboratory. The fruits were de-pulped, oven- dried (between 40 and 50^{o}C) for 7 days and then analysed for proximate analysis (moisture, ash, crude fibre, crude protein, carbohydrate and lipid) and chemical analysis (iodine value, saponification value, peroxide value and acid value) according to standard methods (AOAC, 1997).

RESULTS

Proximate composition

The combined analysis of variance for proximate analysis showed that the mean squares for agroe cology was highly significant ($p \leq 0.05$) for ash, fat, fibre and protein, while genotypes nested within locations was significantly

Table 3. Mean squares derived from the combined analysis of variance for proximate components of *Vitellaria paradoxa* sampled across three agro ecologies in the Guinea savanna of Nigeria .

Source of variation	Df	Ash	Lipid	Moisture	Fibre	Carbohydrate	Protein
Agroecology	2	827.95**	827.95**	4.24	739.18**	38.82	52.21**
Location/Agroecology	3	3.67	3.679	0.70	13.77	33.50	0.12
Genotype/ Location	18	125.70	125.70	378.53	78.19	446.47*	0.72
Error	36	239.45	239.45	753.78	150.84	420.79	0.89
CV %		25.03	15.74	29.97	16.37	5.98	2.07

*, **, Significant F-test at probability levels of 0.05 and 0.01 respectively.

Table 4. Proximate composition of *Vitellaria paradoxa* fruit pulp across three agro ecologies in the Guinea savanna of Nigeria.

Agro ecology	Ash (%)	Crude Lipid (%)	Moisture (%)	Crude Fibre (%)	Carbohydrate (%)	Crude protein (%)
NGS	5.5 ± 0.29b	19.01± 0.68a	15.35± 1.23a	10.25± 0.29b	56.93± 0.76a	8.29± 0.04a
SGS	5.1± 0.40c	18.98 ±0.56a	15.54± 0.96a	9.8± 0.31b	58.22± 0.84a	8.24± 0.04a
TZ	6.9± 0.29a	11.13 ±0.47b	14.90± 0.72a	17.4 ±0.67a	56.28± 1.03a	6.29 ±0.03b

Means with different letter in each column are significantly different (p ≤ 0.05). NGS: Northern Guinea savanna; SGS: Southern Guinea savanna; TZ: Transition zone.

Table 5. Mean squares derived from the combined analysis of variance of the chemical contents of *Vitellaria paradoxa* sampled across three agro ecologies in the Guinea savanna of Nigeria.

Source of variation	Df	Acid value	Peroxide value	Iodine value	Saponification value
Agroecology	2	2.18**	78.02**	2137.58**	1210.63**
Loc./Agroecology	3	1.91**	22.59**	677.82**	447.45**
Gen/Loc.	18	0.64	6.021	336.60	215.41
Error	36	1.62	25.58	557.29	1349.05
CV %		10.78	16.62	8.82	4.48

*, **, Significant F-test at probability level of 0.05 and 0.01 respectively.

different (p≤0.05) for carbohydrate (Table 3). Table 4 illustrates the proximate analysis results of the sixty shea butter trees across three agro ecologies in the Guinea savanna of Nigeria. Result showed that moisture content was not different among agro ecology. Northern Guinea savanna and southern Guinea savanna were not significantly different in lipid content, but were significantly different from transition zone, having the lowest lipid content (11.13%). The percentage crude fibre content was higher in the transition zone (17.4%) than in other zones, thus showing a significant difference (p≤0.05) in crude fibre content between the transition zone and the other zones. Ash content was significantly different (p≤0.05) among agro ecology. Transition zone had the highest ash content (6.95%), followed by northern Guinea savanna (5.5%), while southern Guinea savanna had the lowest ash content (5.1%) content. Protein content was higher in northern Guinea savanna (8. 29 %) than other zones; this was closely followed by southern Guinea savanna. The transition zone had lower protein content (6.29%) and thus significantly different (p≤0.05) from other agro ecologies. Result showed that carbohydrate was not different among agro ecology.

Chemical characteristics

The combined analysis of variance for chemical properties of shea butter showed that the mean square for agro ecology and locations within agro ecology were highly significant (p≤0.05) for acid value, peroxide value, iodine value and saponification value, while the mean square for genotype nested within location was not significant for traits studied (Table 5). The chemical characteristics of the shea butter observed for acid value, peroxide value, saponification value and iodine value

Table 6. Chemical properties of *Vitellaria paradoxa* oil sampled across three agro ecologies in the Guinea savanna on Nigeria.

Agro ecology	Acid value (MgKOH/g)	Peroxide value (mEq/kg)	Iodine value (I_2g/100g)	Saponification value (MgKOH/g)
Northern Guinea savanna	1.87± 0.05b	6.48 ± 0.25a	51.85 ± 0.56a	138.92 ± 2.17b
Southern Guinea savanna	1.79± 0.07b	5.04 ± 0.33b	44.64 ± 2.13b	130.23 ± 1.65c
Transition zone	2.23± 0.06a	3.69 ± 0.14c	37.23 ± 0.68c	140.42 ± 1.02a

Means with different letter in each column are significantly different (p ≤ 0.05).

ranged between 1.79 and 2.23 mgKOH/kg, 3.69 and 6.48 meq/kg, 130.23 and 140.42 mgKOH/g and 37.23 and 51.85 I_2g/100, respectively (Table 6). The mean acid value, peroxide value, saponification value and iodine value of the samples were significantly different across agro ecologies.

DISCUSSION

Proximate composition of shea fruit pulp

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 (Okullo et al., 2010). Like other edible fruits, shea fruits are rich in different carbohydrates such as glucose, fructose and galactose (Neuwinger, 1994). The proximate analysis showed the moisture content of shea fruit pulp to be between 14.90-15.54%. The required moisture contents of shea butter destined for cosmetic and food industries are 0.05% and less than 0.2 %, respectively (Kassamba, 1997). This result indicated low shelf life of the fresh plant hence long storage would lead to spoilage due to its susceptibility to microbial attack. This supports the practice of storage in dry form by users. Moisture content is among the most vital and mostly used measurement in the processing, preservation and storage of food (Onwuka, 2005). A significant variation was exhibited in carbohydrate content (P≤0.05) for the genotypes across the different agro ecological zones in the Guinea savanna of Nigeria. Carbohydrate values obtained in this study was 55.35-59.11%. Shea fruit has more carbohydrates that are vital in nutrition and are also good sources of energy (Anhwange et al., 2004). 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 of shea fruits in the shea zones of Nigeria and beyond. A moderate ash content value of 5.5–6.9% dry matter was obtained from the study. Lower ash content values are desirable because of its effect on biomass energy value**.** The higher the ash content the lower the energy value. Ash in food contributes the residue remaining after all the moisture has been removed as well as the organic material (fat, protein, carbohydrates, vitamins, organic acid etc) have been incinerated at a temperature of about 500°C food (Onwuka, 2005). Ash content is generally taken to be a measure of the mineral content of the original food (Onwuka, 2005).

Variation in crude lipid content of shea fruit pulp across three agro ecologies in the Guinea savanna of Nigeria agrees with findings by Maranz and Wiesman (2003) who found crude lipid content to vary across four climatic zones of several African countries. In this study, no genetic variability was observed for crude lipid, but, recorded the highest crude lipid percentage in shea fruit pulp. This may be suggestive that crude lipid content is simply a response to climatic variables. Crude lipid concentration across the three agro ecology from this study varied from 11.13-19.01%. Other reports have given ranges of 32-38% (Kar and Mital, 1981); 31–62% (Umali and Nikiema, 2000). Maranz et al. (2004) in their broad based African study reported a range of 20-50 %, and also crude lipid percentages as low as 12.4%. They however considered values from less than 20 % as being from immature kernels. Such could arise if immature fruits are blown down by strong winds. During the present study care was taken to avoid such fruits so as not to introduce any confounding factors. The crude lipid percentage range in this study (11.13-19.01%) appears poor when rated against the 20-50 reported by Maranz et al. (2004). According to these authors crude lipid between 20 and 30% are low, those above 30.5% are intermediate and values above 40% are good. Such classification would place shea crude lipid from the Guinea savanna of Nigeria under low or poor lipid content group. Lipid provides very good sources of energy and aids in transport of fat soluble vitamins, insulates and protects internal tissues and contributes to important cell processes (Jones et al., 1985; Pamela et al., 2005).

A significant variation was exhibited in the percentages of crude protein content (P≤0.05) across the different agro ecological zones in the Guinea savanna of Nigeria. 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% (Marakoglu et al., 2005). The values of crude protein content (6.29 -8.29%) reported for shea fruit pulp in this study is higher than that reported for the shea fruit pulp samples from East Africa (3.1-4.2%) and compares to the range of 7-9% by Umali and Nikiema (2000). Such variation in crude protein is normally associated with differences in environmental conditions. Proteins play an important role in nutrition through catalyzing, regulating, protecting and providing energy. 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 (Okullo et al., 2010). The value of crude fibre content for shea fruit pulp in this study was 10.25-17.4% and is within the crude fibre values of most wild and domesticated fruits (Ramulu and Rao*,* 2003) and higher than in legumes with mean values ranging between 5-6% (Aremu et al., 2006). 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 (Omosuli et al., 2009). Crude fibre is made up largely of cellulose together with a little lignin which is indigestible in human.This study, is in agreement with Onwuka (2005), 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. Umali and Nikiema (2000) have given the following ranges of proximate traits of shea: carbohydrate 48-67.5%, protein 8-25%, fats 2-20%, fibre 5-12% and ash 5-7%. Corresponding ranges in this study were 56.28-58.22, 6.29-8.29, 11.13-19.01, 9.8-17.4 and 5.1-6.95%, respectively. The ranges in this study were not too different from the previous study. Similarly, shea lipid content is higher than that of cashew nut meal but comparable to that of soybean meal (Okullo et al., 2010). The proximate analysis study carried out indicated that shea fruit pulp is a rich source of energy and capable of supplying the daily energy requirements of the body and have qualified shea fruit at least as a potential source of feed for livestock.

Chemical composition of shea butter tree oil

The peroxide value from this study ranged from 3.69-6.48 meqO_2/kg. For use in the cosmetic and food industries, the required peroxide values of shea butter utilizations are 1.0 meqO_2/kg and less than 10 meqO_2/kg, respectively (Kassamba, 1997). Kirk and Sawyer (1991) described peroxide as a first product of oxidation of unsaturated fats and oils. Njoku et al. (2000) reported minimum peroxide value of 0.5 meqO_2/kg, while Dandjouma et al. (2009) reported maximum peroxide value of 29.5 meqO_2/kg. The high value reported by Dandjouma et al. (2009) was due to the kernels used for the butter extraction, which were fermented before the extraction. The iodine value expresses the degree of saturation of oil. It is an indicator of the storability of the oil. The higher the iodine numbers, the higher the degree of unsaponification, and the shorter the shelf-life (Hui, 1996). The iodine value from this study ranged from 37.23 – 51.85 I_2g/100g. Fernande et al. (2014) reported an average iodine value of 51.4 I_2/100 g. Nkouam et al. (2007) reported a minimum iodine value of 21.7 I_2/100 g, while Womeni et al. (2004) reported a maximum iodine value of 89.5 I_2/100 g. The low value reported by Nkouam et al. (2007) was due to the method used for shea butter extraction.

The saponification value from this study ranged between 130.23 – 140.42 MgKOH/g. Literature values showed a considerable range for the saponification values, but most fall between 132 MgKOH/g (Ezema and Ogujiofor, 1992) and 207.5 mgKOH/Kg (Womeni et al., 2004), and the average is 180.9 MgKOH/g. The reported acid values of shea butter vary from 0.1 MgKOH/g (Womeni et al., 2006) to 21.2 MgKOH/g (Nkouam et al., 2007), with an average of 8.1 mg KOH/g. The reported acid value from this study ranged between 1.79-2.23 MgKOH/g. The required acid values for butter that is to be used for cosmetic and food applications are 0.3 mgKOH/g of oil and less than 9.0 mgKOH/g of oil, respectively (Kassamba, 1997). However, Nkouam et al. (2007) found a high acid value of 128.2 mg KOH/g in shea oil extracted by supercritical CO_2 in kernels that had been stored for two years.

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