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Shea (*Vitellaria paradoxa)* Pulp Juice Production and Quality Evaluation via Proximate and Mineral Composition Analyses

[*1]KOLO, SI; [2]DADI-MAMUD, NJ; [3]ALIYU-PAIKO, M; [1]JUBRIL, B

*[*1]Department of Food Science and Technology, [2]Department of Biological Science, [3]Department of Biochemistry, Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria*

**Corresponding Author Email: salamatuk@ibbu.edu.ng*
Co-Authors Email: njdadimamud@gmail.com; mo.aleeyu.paiko@gmail.com; babatundejubril@gmail.com

ABSTRACT: Shea trees (*Vitellaria paradoxa*) are common in African countries such as Nigeria, Ghana, Uganda, Sudan, and others. When fully ripe, the Shea tree's green fruit turns yellow. The tree is well-known and valued for its versatility. Its entire composition is useful in the food, pharmaceutical, and cosmetic industries. Among its applications is the production of butter from the nuts, while the rest of the fruit is left to rot or discarded. This study focuses on using other parts of the fruit to create a new product, reduce waste, and expand the Shea value chain. Three formulations of Shea fruit juice were created. The juice were evaluated for nutritional, physicochemical, and mineral compositions. The nutritional composition revealed a high moisture content that ranged from 84.39 to 93.01%, high carbohydrate and caloric values, ranging from 5.84 to 8.96% and 33.51 to 67.31%, respectively. It also had a high concentration of vitamin C (16.45 - 38.99 percent). The mineral composition was observed to increase as the Shea pulp percentage increased. Magnesium was observed to be higher in sample C (36.71±0.24) while sample A recorded a lower magnesium content (18.04±0.06). Calcium was also found to be present in high concentrations (30.07 - 50.64 %). The juice's potassium content ranged from 58.6 - 50.54% in sample C to 24.6 - 60.16% in sample A. The physicochemical analysis revealed a close range of p H values (5.37 - 6.06 %) between the samples and the control, making the juice less susceptible to spoilage. Overall, the results presented a high-quality juice that could compete favorably in the market with other fruit juices.

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Keywords: fruit juices; Shea pulp; Shea juice; proximate composition; *Vitellaria paradoxa*

Shea tree belongs to the family *Sapotacae*. It is divided into two subspecies: *nilotica* and *paradoxa.* However, this research focuses exclusively on *Vitellaria paradoxa* subsp. *paradoxa,* which produces elliptically shaped fruits. Shea tree (*Vitellaria paradoxa*) is commonly found in Africa. The tree is locally abundant in most parts of Africa; the savannah zone of Nigeria, Mali, Burkina Faso, Senegal, Sudan, and Uganda with some occurrence in Ethiopia and the Democratic Republic of Congo (Aguzue *et al.,* 2013, Mbaiguinam *et al.*, 2007). It is both a fruit tree and an oilseed crop (Aguzue *et al.*, 2013). The fruit is green when mature and yellowish in color when fully ripe. Shea fruits are normally consumed in the dry season when other fruits and crops are out of season. The Shea tree is commonly called the "African wonder tree" because of its highly versatile nature. Every part of the tree, from the roots to the fruit, has been discovered to be ecologically, economically, and medicinally significant (Adazabra *et al.*, 2013). The pulp has been proven to be highly nutritious when consumed. Since it is resistant to termite infestation, the Shea tree wood is also a good material for making electric poles and used as fuel for cooking in the form of coal. Butter/oil is also gotten from the kernel and is popularly used in the food, pharmaceuticals, and cosmetic industries (Institute, 2006). As reported by (Adazabra *et al.,* 2013), the roots are used as chewing sticks and the Sap from the barks serves as an invaluable raw material in the gum and rubber industry. Indigenous fruits have been designed to improve food security, nutrition, household income, farm diversity, and environmental

**Corresponding Author Email: salamatuk@ibbu.edu.ng*

resilience (Akinnifesi *et al.,* 2006). Many of these indigenous fruits are known to provide vitamins and minerals necessary for human health maintenance (Napio *et al.*, 2016). Fruit juices have become an essential part of the modern world's diet. They are also one of the most nutritious beverages that contribute significantly to a healthy diet. They are well-known for their delicious, refreshing, and hydrating taste, as a result of the variety of nutrients, found naturally in fruits. (Tireki, 2021). The majority of processed fruit juices are made up of water, sugar, preservatives, color, and fruit pulp. Their consumption is abundant in minerals, vitamins, and enzymes that promote digestibility, increase lifespan and improve overall human well-being. One of such fruits is the Shea fruit (*Vitellaria paradoxa*) (Makin and Gwarzo, 2020, Niji and Onajobi, 2002). The Shea fruit is made up of the epicarp, mesocarp, and the nut. The fruit pulp is edible and sweet when ripe and is about 50–80% of the total fruit weight. Shea fruit is widely consumed among African peoples and sold in local markets (Aguzue *et al.,* 2013, Ugese *et al.,* 2008). The fruit ripens during the early stages of the rainy season. This is also the time of year when there is widespread hunger due to the degradation of stored food and a source of energy for farmers while working on the farm (Lamien *et al.,* 1996).

These fruits, however, have a short shelf life and thus high post-harvest losses. This post-harvest loss is well known in areas where the Shea tree grows. The economic demand for Shea nuts and butter extract has reduced the importance and value of Shea fruit pulp (Ugese *et al.,* 2008). This is demonstrated by the fact that the fleshy pulp of the Shea fruit is fermented, fed to animals, or allowed to rot before being discarded. This is in favor of the Shea nuts for the production of Shea oil or butter (Makin and Gwarzo, 2020). As a result, this practice causes significant economic losses and reduces the Shea value chain. This study therefore assessed the nutritional and elemental composition of juice produced from Shea fruit pulp.

MATERIALS AND METHODS

Collection of Shea fruits: Shea fruits were collected from Bakeko district of Katcha Local Government Area of Niger State. This location was chosen because it is well established and reliable in Shea fruit production. Bakeko district is about 3km from Katcha Local Government and 100km from the state capital (Minna).

Ten (10) kilograms of Shea fruit was collected using stratified random sampling method. The fruits were sorted to remove any that were damaged, discolored, or rotten, leaving only healthy and ripe fruits. It was then thoroughly washed in distilled water to remove dirt, microbial load, and other extraneous materials such as plant debris. The fruits were packed into boxes and delivered to the Food Science Department at Ibrahim Badamasi Babangida University in Lapai. Fruits were stored in freezers at the Laboratory for preservation prior to processing and laboratory analysis.

Preparation of Shea fruit pulp juices: Shea fruits were thoroughly washed in clean running water to remove dirt, microbial load, and other external materials such as plant debris. The hard skin was manually peeled away to reveal the inside fruit pulp, which had been separated from the nut.

The pulps were blended in a blender (Royal Philips, model HR 2167/40, Amsterdam, The Netherlands). To improve viscosity and ease blending, 200 milliliters of distilled water was added. The resulting liquid was collected, further homogenized for 10 - 15 minutes with an electric blender, sieved, pasteurized, and stored for further analysis. Three formulations of Shea fruit pulp juices were made according to (Napio *et al.,* 2016) with some modifications as seen in Table 1. 200g of pulp was mixed with 600g of boiled water and filtered to remove residues for the first juice formulation. The mixture was heated to 60 ^{0}c before adding 2.4g of carboxymelthylcellulose (previously blended with water). To sweeten, lower the p H, and retain the juice color, 48g of white sugar, 4g of citric acid, and 0.005% ascorbic acid were added to the mixture. For preservative effect, 0.01% sodium metabisulphite, 0.24g potassium sorbate, and 0.16g sodium benzoate were added to the mixture and heated to 85 ^{0}c for 5 minutes. The resulting juice was cooled to 60 ° C before being poured into clean plastic bottles that had been rinsed in 0.2% sodium metabisulphate. The bottles were allowed to cool to room temperature (25 ° c.) and stored in a cool dry place. This procedure was carried out three times. The same procedure was used, but with different amounts of Shea pulp and distilled water. All additives were kept constant.

Table 1. Shea fruit juice formulation

Ingredients	**A**	**B**	**C**
Shea fruit pulp (ml)	100	250	500
Boiled water (ml)	700	600	300
Additives			
CMC		2.4g	
White sugar		48g	
Citric acid		4g	
Potassium sorbate		0.24g	
Sodium benzoate		0.16g	
Sodium metabisulphite		0.01%	
Ascorbic acid		0.005%	

CMC, Carboxy Methyl Cellulose; A, B, C, Formulations

Nutritional analysis: Proximate composition was determined AOAC methods (Carbohydrate, Moisture and crude protein content, ash content, and crude fibre) (AOAC, 2000).

Mineral analysis: Minerals (calcium, potassium, sodium, magnesium and iron) of the samples were then analyzed with Atomic Absorption Spectrophotometer (Model-Shimatzu AA-6300) (Napio *et al.,* 2016).

Physicochemical parameters: The pH of the fruit juice was determined using digital pH meter (HI 96107 model). The Total Dissolved Solids (TDS), Total Soluble Solids (TSS), Titratable acidity were determined according to standard methods (AOAC, 2010). This procedure was repeated for the other samples of commercial fruit juices.

Data analysis: The result obtained was subjected to analysis for mean and standard error. The data obtained from the trials were analysed using one-way analysis of variance (ANOVA). Individual means were compared using Bonferroni multiple comparison test. Differences were considered statistically significant at $p<0.05$. All statistical analysis was performed using GraphPad prism version 5.0 software package.

RESULT AND DISCUSSION

Nutritional analysis: The moisture content of juice samples was determined, as shown in Table 2. The formulation values for Shea pulp (10, 25, and 50%) ranged from 84.39 to 93.01 percent. According to the research, these values are within the acceptable range for fruit juices (80-95 percent) (Kareem and Adebowale, 2007, Napio et al., 2016). Shea pulp and Shea jam have also been reported to have a high ash content; similarly, the ash content in juice can be easily translated. (Aguzue et al., 2013). Sample C had the highest ash content as well as the highest concentration of Shea pulp. This is also an indicator of mineral content, as determined by (Adedeji et al., 2008). Most fruit juices are known to have a low protein content (Napio et al., 2016). This could be the case with Shea pulp juice, which had a low protein level (0.61 - 2.72 %). All formulated samples, like the control sample, showed a high presence of carbohydrate caloric values. The presence of Vitamin C is one of the most highly rated qualities of fruit juices. It is an indication that the given juice can improve the immune system. This was found in large quantities in all four (4) samples of Shea pulp juice. The sample B value corresponds to several studies on vitamin C in fruit juices. (Napio *et al.,* 2016).

Table 2. Nutritional analysis of the processed Shea pulp juice

Parameters	Sample A	Sample B	Sample C
Moisture content (g/ml)	$92.87±0.33^{b}$	$89.74±0.49^{a}$	$84.39±0.01^{a}$
crude protein (g/ml)	$0.62±0.04^{a}$	$1.45±0.05^{a}$	$2.72±0.06^{b}$
Ash content (g/ml)	$0.38±0.04^{a}$	$1.03±0.07^{b}$	$1.77±0.05^{b}$
Fat content (g/ml)	$0.92±0.03^{a}$	$0.81±0.02^{a}$	$2.01±0.29^{a}$
CHO (g/ml)	$5.84±0.17^{a}$	$6.84±0.26^{b}$	$8.96±0.06^{b}$
VITC	$16.45±0.23^{a}$	$38.99±0.33^{b}$	$18.935±0.14^{a}$
Energy KCAL (kcal/ml)	$33.51±0.05^{a}$	$48.56±0.53^{b}$	$67.31±0.51^{c}$

Note: values in the same column with different superscript letters are statistically significant (P< 0.05).

*Mineral analysis***:** The general observation of the mineral composition of the juice reveals an increase with increasing Shea pulp composition (see Table 3). As previously stated, the nutritional analysis revealed a high ash content. This was thought to be an indication of the mineral content of Shea juice. Similarly, (Ugese *et al.,* 2008) identified Kachia local government in Kaduna state as one of the locations with high mineral concentrations in Shea pulp samples. The calcium content of the Shea pulp juice ranged from 50.64±0.12 of sample C to 30.7±0.42 of sample A. Magnesium content of the juice was higher at sample C (36.71±0.24) while sample A recorded low magnesium content (18.04±0.06).The sodium content of the juice ranged from 19.35±0.1 of sample B to 8.52±0.22 of the control sample. The potassium content of the juice ranged from 58.65±0.54 of sample C to 24.66±0.16 of sample A. The concentration of Zn ranged from 12.42±0.05of the control sample to 7.25±0.03 of sample A.

Table 3. Mineral composition of processed Shea pulp juice

Parameters	Sample A	Sample B	Sample C
Ca (mg/l)	$30.7±0.42^{a}$	$33.71±0.06^{a}$	$50.64±0.12^{b}$
Mg (mg/l)	$18.04±0.06^{a}$	$29.19±0.31^{a}$	$36.71±0.24^{b}$
Na (mg/l)	$8.69±0.15^{a}$	$9.25±0.23^{a}$	$19.35±0.15^{b}$
Zn (mg/l)	$7.25±0.03^{a}$	$11.67±0.18^{a}$	$16.23±0.71^{a}$
Fe (mg/l)	$1.35±0.02^{a}$	$1.67±0.45^{a}$	$2.87±00.3^{a}$
K (mg/l)	$24.66±0.16^{a}$	$47.29±0.38^{b}$	$58.65±0.54^{b}$

Note: values in the same column with different superscript letters are statistically significant (P< 0.05)

Physicochemical parameters: The physic-chemical parameters are presented in Table 4. The pH value of the sample ranged in an increasing order from 5.37±0.01 of sample A to 5.89±0.08 of sample C. This indicates that Shea pulp juice is acidic-neutral, which could be due to the high citric acid content. Similar findings have been reported by (Ghenghesh *et al.*, 2005) where commercial juices were found to be highly acidic, and the higher the acidity of the fruit juice, the less susceptible to bacterial action .The viscosity, TDS and TSS of the Shea pulp were statistically significant $p<0.05$, the values for viscosity of juice across samples ranged from 9.635±0.36 of sample C to 2.57±0.21 of sample A. The values for TDS across all samples ranged 737.63±5.52 of sample C to 331.05±2.19 of sample A.

Table 4. The physiochemical parameters of the processed Shea pulp juice

Parameters	Sample A	Sample B	Sample C
pH	5.37±0.01^{a}	5.63±0.04^{a}	5.89±0.08^{a}
Viscosity	2.57±0.21^{a}	4.19±0.05^{b}	9.635±0.36^{c}
TDS (Mg/l)	331.05±2.19^{a}	465.31±1.93^{b}	737.63±5.52^{c}
TSS (Mg/l)	205.03±0.53^{a}	290.51±2.06^{a}	366.46±0.76^{b}
TS	550.46±17.21^{a}	756.09±4.25^{b}	1099.25±1.55^{b}
Titratable Acidity (%citric acid)	12.8±0.17^{a}	16.72±0.49^{a}	18.88±0.23^{a}

Values in the same column with different superscript letters are statistically significant (P< 0.05); TDS- Total Dissolved Solids, TSS – Total Soluble Solids, TS – Total Solids.

Conclusion: According to the findings of the study, Shea pulp can be used to produce high-quality juice for human consumption. Based on the results, processed Shea pulp juice is highly nutritious and can compete in the market with other locally produced plant/fruit juice. Focusing on the proximate and mineral composition values obtained in this study, it can be concluded that Shea pulp juice is high in vitamin C, total carbohydrates, crude fiber, and calcium. However, consumer acceptability and safety evaluation of the juice will be required.

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