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Research Application Summary

# Nutritional composition and sensory evaluation of jam and juice processed from shea fruit pulp from Uganda

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## Abstract

Shea butter tree is a member of the family *Sapotacae* and is divided into two subspecies: *nilotica* and *paradoxa.* However, this research focuses exclusively on *Vitellaria paradoxa* subsp. *paradoxa*, which produces fruits elliptically shaped fruits. The fruit is green when mature and changes to a more yellowish colour when fully ripe. Shea fruits are normally consumed in the dry season when other fruits and foods crops are out of season. Development of value added products is expected to increase consumption of these Shea fruits in northern Uganda and with possible outcome of averting food insecurity and malnutrition which is common in this region of Uganda. The focus of this research was therefore to develop more nutritious, safe, convenient and appealing value added products (Jam and juice) from Shea fruit pulp. Value addition is one of the strategic actions to alleviate fruit wastage. Three different formulations of Shea fruit jam, with ratio of fruit pulp to sugar at 50:50, 40:60 and 80:20 percentages and three different formulations of Shea fruit juice 10% fruit juice, 25% fruit juice and 50% fruit juice were developed and evaluated for nutritional composition and consumer acceptability. The results were subjected to paired preference test and the best ratio was used. While sensory evaluations of the jams did not reveal differences between formulations (P>0.05), significant differences were, however, obtained for the juices, with formulation of 25% being preferred. According to consumer preference, jam to sugar ratio 50:50 was preferred as were juice ratios of 25% pulp. Quality, colour, and taste were acceptable. The nutritional composition indicated that Shea juices and jams are rich sources of carbohydrates, energy, vitamin C, proteins and calcium, magnesium, iron and zinc with values of 14.55%, 253.3kj/100g, 13.4mg/100ml,0.177%, 14.09 mg/100g, 5.5mg/100ml, 3.3mg/100g, 0.3% for 25% Shea juice and 68.24%, 1176.23kj/100g, 3.8 mg/100ml, 0.95mg/100, 30.343 mg/100g, 6.4mg/100g, 3.0 mg/100g, 0.37mg/100g for Shea jam (50:50) respectively. These results indicate that Shea fruit pulps are very nutritious and have the potential of alleviating malnutrition and food insecurity. Microbiological analyses indicate that good quality jam and juices can be processed using simple procedures suitable for small-scale commercial production including open kettle jam-making process and mechanical juice extraction followed by hot water pasteurization.

Key words: Formulations, shea fruits, shea jam, shea juice

**Résumé**

Le karité est un membre de la famille des *Sapotacae* qui est divisée en deux sous-espèces: *nilotica* et *paradoxa*. Cependant, cette recherche se concentre exclusivement sur *Vitellaria paradoxa* sous esp. *paradoxa*, qui produit des fruits elliptiques. Le fruit est vert à maturité partielle et change à une couleur plus jaunâtre à pleine maturité. Les fruits de karité sont normalement consommés pendant la saison sèche, quand d'autres cultures fruitières et vivrières sont hors de saison. Il est anticipé que le développement de produits à valeur ajoutée augmentera la consommation de ces fruits de karité dans le nord de l'Ouganda avec la possibilité de parer à l'insécurité alimentaire et la malnutrition qui est commun dans cette région de l'Ouganda. L'objectif de cette recherche était donc de développer des produits plus nutritifs, sûrs, pratiques, et attrayants à valeur ajoutée (confitures et jus) à partir de la pulpe de fruits de karité. La valeur ajoutée est l'une des actions stratégiques pour atténuer le gaspillage des fruits. Trois formulations différentes de confiture des fruits de karité, avec un rapport de pourcentages de pulpe de fruits au sucre de 50:50, 40:60 et 80:20, et trois formulations différentes du jus de fruits de karité 10% de jus de fruits, 25% de jus de fruits, et 50% de jus de fruits ont été développés, et évalués pour la composition nutritionnelle et l'acceptabilité par des consommateurs. Les résultats ont été soumis à un test de préférence en pairs et le meilleur ratio a été utilisé. Alors que les évaluations sensorielles des confitures n'ont pas révélé de différences entre les formulations ($P > 0,05$), des différences significatives ont été obtenues pour les jus de fruits, avec la formulation de 25% étant la plus préférée. La qualité, la couleur, et le goût étaient acceptables. La composition nutritionnelle a indiqué que des jus et des confitures de karité sont riches en hydrates de carbone, l'énergie, la vitamine C, les protéines, le calcium, le magnésium, le fer, et le zinc avec des valeurs de 14,55%, 253.3kj / 100g, 13.4mg / 100ml, 0,177%, 14,09 mg / 100g, 5,5 mg / 100 ml, 3.3mg / 100g, 0,3% pour les jus ayant 25% de pulpe de karité, et de 68,24%, 1176.23kj / 100g, 3,8 mg / 100 ml, 0.95mg / 100, 30,343 mg / 100 g, 6,4 mg / 100 g, 3.0 mg / 100g, 0.37mg / 100g pour la confiture de karité (50:50), respectivement. Ces résultats indiquent que les pulpes des fruits de karité sont très nutritives et ont le potentiel de réduction de la malnutrition et l'insécurité alimentaire. Les analyses microbiologiques indiquent que la bonne confiture et le jus de qualité peuvent être traités en utilisant des procédures simples adaptées à la production commerciale à petite échelle, y compris processus de fabrication de confiture dans la bouilloire ouverte et l'extraction mécanique du jus suivie par la pasteurisation à l'eau chaude.

Mots clés: Formulations, fruits de karité, la confiture de karité, jus de karité

## Background

The quest for food is a universal imperative which supports a diversity of life on earth and its insufficiency and shortage threaten viability of life. This prompts humanity to conserve and sustainably utilize a spectrum of resources such as domesticated crops, wild food plants, indigenous fruits and under-utilized species (Mawula, 2009). Northern Uganda has characteristically been faced with intermittent food shortages owing to climatic variability and over two decades of armed conflict that weakened agricultural production systems in the region. The food situation in northern region has brought to the fore the value of

domesticating and commercialization of indigenous fruits as an integral component to food security. Indigenous fruits can contribute to increased food security, nutrition, household income, farm diversity, and environmental resilience (Akinnifesi *et al*., 2006). Edible fruits harvested from indigenous fruit trees provide vitamins and essential minerals for the proper maintenance of human health. However, these fruits have a short shelf-life and thus high post-harvest losses. In this study, we assessed the nutritional composition and sensory characteristics of jam and juice processed from Shea (*Vitellaria paradoxa* subsp. *paradoxa*) fruit pulp from Uganda

## Materials and methods

**Collection of Shea fruits.** Forty kilograms of Shea fruits were collected from the three sub-counties that make up Otuke district between April and August, 2015 and April 2016. The fruits were mixed and washed thoroughly in distilled water to remove dirt, reduce microbial load and other extraneous materials including plant debris. Only undamaged ripe fruits with no symptoms of visible discoloration and infection were utilized. Shriveled fruits were separated from the good and mature fruits. The fruits were stored in cooler boxes and transported back to the Food Science Department at Makerere University. At the Laboratory, fruits were stored in the freezers for preservation prior to processing and laboratory analysis.

## Study design

This study involved assessment of nutritional composition of Shea fruit pulp and development of prototypes for value added products (jam and juices) from the Shea fruit pulp. Different formulations of varying pulp and water blended with other ingredients were developed. Sensory evaluation was carried out to determine the acceptable range of pulp to water blends using hedonic rating of 1-9 based on a panel of 20 semi-trained participants aged 25 to 40 years. The mean scores of hedonic rating tests were subjected to analysis of variance.

**Preparation of Shea fruit pulp.** Frozen Shea fruits were thawed and washed in clean running water. The fruits were peeled and the edible portions separated from the seed. The edible pulps were viscous, making it very hard to blend and so 500 % W/V of distilled water was added into pulp to ease blending.

**Preparation of Shea fruit pulp jams' formulations.** Different formulations of Shea jam were developed according to FAO guidelines (FAO, 1997; Dietz, 1999). The first formulation had pulp to sugar ratio of 50:50. As such 250g of pulp were mixed with 250g of white sugar and heated, 10g pectin (previously mixed with some white sugar) were added and mixed thoroughly. Preservatives, potassium sorbate (0.08g) and sodium benzoate (0.12g), were added and the mixture boiled for five minutes. To ensure that the jam had set, wrinkles and spreadability tests were conducted following the procedure laid-down by Dietz (1999). The processed jam was hot filled into sterilized glass jars to avoid contaminations. For the second and third formulations, the same procedures were followed but with different percentages of Shea fruit pulp to sugar ratio of 40:60 and 80:20 respectively. Commonly consumed mangoes were purchased from the market and processed into jam as a reference product for comparison.

**Preparation of Shea fruit pulp juices' formulations.** Three formulations of Shea fruit pulp juices were made according to FAO guidelines (FAO, 1997). For the first juice formulation (25% pulp), 200g of pulp were mixed with 600g of boiled water and filtered to remove the residues. The mixture was heated to 60 $^0$c before 2.4g of carboxymelthylcellulose (previously blended with water) was added to the mixture. Later 48g of white sugar was added to the mixture bringing the Brix to 12$^o$. 4g of citric acid was added to the mixture to lower the pH. This was followed by addition of 0.005% Ascorbic acid to maintain the colour of the juice. 0.01% sodium metabisulphite, 0.24g of potassium sorbate and 0.16g of sodium benzoate were later added to the mixture and heated to 85 $^0$c for 5 minutes. The resultant formulated juice was cooled to 60 $^0$c before being poured into clean plastic bottles previously rinsed in 0.2% Sodium metabisulphate. The bottles were allowed to cool to room temperature (25 $^0$c) and stored in a cool dry place. This process was replicated three times. For the second and third juice formulations, same procedure were followed but with different percentages of Shea pulps and distilled water.

**Nutritional compositions of Shea fruit pulp jam and juice samples.** The proximate analysis of both the different Shea jam and juices were analyzed using standard methods (AOAC, 1990). Crude ash was determined by incineration of 5g of sample in a muffle furnace at 55$^o$c for two hours. Crude protein was estimated by micro kjeldahl method and the crude protein was calculated as N% *6.25. Vitamin C was determined by standardizing iodine solution and then titrating iodine solution with Shea juice solution using 1% starch solution as the indicator until the endpoint is reached when the colour changes to blue, carbohydrates were determined by difference using the method in AOAC (1997) and calorific values were analyzed by calculation. Minerals (calcium, magnesium, iron and zinc) of the samples were then analyzed with Atomic Absorption Spectrophotometer model AAnalysit-400. The pH of jam and juice samples were measured at 200 $^o$C using a MP 220 Ph meter (Mettler- Toledo GmbH, schwerzenbach, Switzerland). The Brix values were carried out using a refractometer.

**Consumer sensory evaluation of the formulated Shea fruit pulp jam and juices.** A trained 20 member panel (11 women and 9 men) drawn from the Uganda Industrial Research Institutes' community, evaluated the sensory characteristics (appearance, taste, consistency, wholesomeness, sweetness and flavour) of the various products using a 9-point hedonic scale ranging from least preferred (1) to most preferred (9) (Watts *et al.*, 1989). During product testing, panel members washed their mouths between evaluations. Each assessor was asked to taste three randomly coded samples of each product and score each product for preference on a nine point scale. Jam and juice from local variety of mango was developed following the same procedures as that of the Shea jam and juice. The colour, flavour, taste, consistency, wholesomeness, sweetness and overall acceptability of the different mango jam and juice were also evaluated. All jams and juices were presented to the panelists at room temperature under normal lighting conditions in transparent plastic glass.

**Statistical analysis .**All statistical analyses were performed using the Statistical Analysis for Social Scientist (SPSS) version 20.0 package. One-way analysis of variance (ANOVA) was used to test the sensory evaluations of the different fruit juice and jam formulations developed. The means were separated by Duncan's Multiple Range Tests at 5 % ($P < 0.05$).

## Results and discussions

**Proximate composition of the formulated Shea fruit pulp jam.** The proximate compositions for the formulated Shea fruit pulp jam and the reference product (mango jam) are provided in Table 1. Moisture content of jam formulated from the Shea fruit pulp to sugar ratio of 80:20 was highest and was significantly different ($P<0.05$) from all the other formulated jam but not significantly different from the reference jam. This formulation also had the lowest Brix value. The highest Brix value was found in formulated jam of the Shea fruit pulp to sugar ratio of 50:50 and 40:60. Crude ash and protein contents of all the different formulated Shea fruit pulp jam was significant higher ($P<0.05$) than that of the reference product (mango jam). There was no significant difference ($P<0.05$) in vitamin C (Vit. C) and calcium (Ca) contents of the formulated Shea fruit pulp to sugar ratios of 80:20 and 40:60 respectively. However, these values were significant less compared to those from the reference product (mango juice). Iron (Fe) content were significantly higher in the formulated Shea jams compared to that from the reference product. Zinc (Zn) content in the formulated jam from the Shea fruit pulp to sugar ratio of 80:20 compared favorably to that of the reference product. Magnesium (Mg) content was however; lower in three formulated jams from the Shea fruit pulp as compared to that from the reference product (mango jam). There was no significant differences ($P<0.05$) in titratable acidity values of jam formulated Shea fruit pulp to sugar ratio of 40:60 and that of the reference product. Carbohydrate contents and calorific values of the of jam formulated from Shea fruit pulp to sugar ratios of 40:60 and 50:50 were significantly higher than that of reference mango jam.

**Proximate composition of the formulated Shea fruit juices.** The pH values of the formulated juices ranged from 4.3 to 4.4 compared to reference mango juice (pH, 4.5) (Table 2). The moisture contents of the formulated juices from Shea fruit pulp contents of 10% and 25% were within range (86.3 – 84.9) of that of the reference juice (89.5). Ash contents were also highest in all the formulated juices compared to that of the reference product (mango juice). The total soluble solids (Brix) of the formulated juices from Shea fruit pulps were within range ($12^o$ – $14^o$) of that of the reference product (mango juice) ($13^o$). The titratable acidity was highest in formulated juice of 50% Shea fruit pulp and there was significant differences ($P<0.05$) in titratable acidity values of juice formulated 50% Shea fruit pulp and that of the reference product. The carbohydrates and calorific values of all the formulated Shea fruit pulp juices were significantly higher ($P>0.05$) than that of the mango juice. The protein content was highest in formulated 50% Shea fruit pulp. There were no significantly differences ($P>0.05$) in the protein content of formulated juice of 25% and 10% Shea fruit pulps and these values were comparable to that of the reference juice. Calcium contents of the formulated juices from the Shea fruit pulp were within range from 10.41mg/100g (10% Shea pulp), 14.01mg/100g (25% Shea pulp) to 30.02mg/100g (50% Shea pulp) compared to that of the reference juice (20.06mg/100g). Like in formulated jams, magnesium content was significantly lower in three formulated juices from the Shea fruit pulp as compared to that from the reference product (mango juice). Like also in the formulated jams, iron contents were significantly higher in the formulated juices from Shea fruit pulp compared to that from the reference product (mango juice). Zinc content in the formulated juice from the Shea fruit pulp ranged from 0.154 – 0.346mg/100g compared to the reference product (0.422mg/100g).

**Table 1. Proximate composition of formulated shea pulp jam and the reference product (mango jam)**

| Pulp to sugar ratio | Moisture content (%) | Ash (%) | Protein (%) | Vit. C, mg/100ml | Carbo-hydrate, (%) | Calorific value, KJ/100g | pH | Titratable acidity (%) | Fe mg/100g | Ca mg/100g | Mg mg/100g | Brix, º | Zn, mg/100g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80:20 | 57.576a | 0.714a | 0.954a | 11.632b | 40.757d | 709.084d | 3.400a | 0.233b | 3.305a | 32.071b | 6.750b | 35.400d | 0.485a |
| 40:60 | 23.628d | 0.545ab | 0.848b | 11.975b | 74.979a | 1289.062a | 3.320b | 0.310a | 3.007b | 32.229b | 6.697b | 68.200b | 0.398b |
| 50:50 | 30.196c | 0.605a | 0.943a | 3.819c | 68.256b | 1176.438b | 3.300b | 0.231b | 2.996b | 30.343c | 6.385b | 68.500a | 0.372b |
| Mango | 48.036b | 0.330b | 0.605c | 24.60 a | 51.033c | 877.804c | 3.380a | 0.330a | 2.625c | 33.950a | 37.885a | 67.000c | 0.480a |

Mean scores in the same column followed by the same superscript letter are not significantly different from each other (P>0.05)

**Table 2. Proximate composition for the formulated shea pulp juice and the reference product (mango juice)**

| % shea pulp | Moisture content (%) | Ash (%) | Protein (%) | Vit. C, mg/100ml | Carbo-hydrate, (%) | Calorific value, KJ/100g | pH | Titratable acidity (%) | Fe mg/100g | Ca mg/100g | Mg mg/100g | Brix, º | Zn, mg/100g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 86.273b | 0.1683a | 0.1033d | 4.211d | 13.077c | 224.09c | 4.4000c | 0.0689c | 2.2913c | 10.416d | 4.3303d | 12.000d | 0.1542d |
| 25 | 84.895c | 0.2928b | 0.1775b | 13.494b | 14.792b | 254.20b | 4.3000d | 0.1104b | 3.3056a | 14.091c | 5.4778c | 12.500c | 0.3027c |
| 50 | 24.010d | 0.3063b | 0.3575a | 8.2220c | 75.474a | 1286.8a | 4.4133b | 0.1911a | 3.1681b | 30.020a | 6.3072b | 14.000a | 0.3461b |
| Mango | 89.454a | 1.1955a | 0.1830b | 23.392a | 9.1696d | 159.01d | 4.5000a | 0.2000a | 0.8800d | 20.075b | 35.355a | 13.100b | 0.4215a |

Mean scores in the same column followed by the same superscript letter are not significantly different from each other (P>0.05)

**Sensory evaluation of Shea fruit jams.** There were no significant differences (P>0.05) in flavour between the different formulated jam from Shea fruit pulp and that of the mango jam (reference product) (Table 3). There were also no significant differences (P>0.05) in colour and appearance of the formulated Shea pulp jam of Shea pulp to sugar ratio of 40:60 and 50:50 with the reference jam (Mango jam) but significantly different with formulated Shea pulp jam of Shea pulp to sugar ratio of 80:20. The consistence of the formulated Shea pulp jam of Shea pulp to sugar ratio of 80:20 and 50:50, respectively were not significantly different (P>0.05) from the mango jam. However, the consistence of the formulated Shea pulp jam of Shea pulp to sugar ratio of 40:60 was significantly different (P<0.05) from that of the reference mango jam. The sweetness was highest in formulated Shea jam of Shea pulp to sugar ratio of 50:50 and was not significantly different (P>0.05) with sweetness of formulated Shea fruit jam of Shea pulp to sugar ratio of 40:60 and the reference product. There were no significant differences in the overall acceptability (wholesomeness) of the formulated Shea pulp jam of Shea pulp to sugar ratio of 50:50 and that of the mango jam (reference product), meaning that Shea fruit pulp can actually produce jam which is acceptable to the consumers.

**Sensory evaluation of Shea fruit juices.** There were no significantly difference (P>0.05) in the taste, colour and consistency of the formulated juices from Shea fruit pulp but significantly different (P>0.05) from that of the reference product (mango juice) (Table 4). There was no significant difference (p<0.05) in the flavour score (6.75) of juice formulated with 25% Shea fruit pulp to that of the reference product (6.85).The sweetness score was highest in formulated juice of Shea pulp ratio 25% and lowest in formulated Shea juice of pulp ratio 10%.The appearance score of Shea fruit pulp juices formulated from 25% and 10% Shea fruit pulp were not significantly different from that of the reference juice (mango juice). The 25% Shea fruit juice had the highest consumer acceptance (wholesomeness) of 6.5 which is comparable to the reference product (mango juice), meaning that Shea fruit pulp can actually produce juices which are acceptable to the consumers.

## Discussion of results

**Nutritional composition of Shea fruit pulp jam.** pH of all the jam formulations from the Shea fruit pulp i.e. 80:20, 40:60 and 50:50 pulp to sugar ratios ranged from 3.40, 3.31 to 3.30 respectively compared to reference product (mango jam) with 3.38. These pH values are within range of pH values of 2.8 to 3.3, which is needed for optimum gel formation depending on the nature of the pectin in fruit (Desrosier, 1970; Goldthwaite, 1911). The most common cause of gel failure in jam is insufficient acid. Goldthwaite (1911) reported that ideal fruit jam with a good gel should: quiver, not flow, when removed from its mold; be a product with texture so tender that it cuts easily with a spoon; be a clear product that is neither syrupy, gummy, sticky nor tough.

For a good jam preserve titratable acidity have been reported to vary from 0.3 to 1.1%. The formulated jam from the Shea fruit pulp and also from the reference mango had titratable acidity (0.231 – 0.330) falling in this range. Acids present in food not only improve its palatability but also influences their nutritive value. The acid influence the flavor, brightness

**Table 3. Sensory evaluation of jam**

| Pulp to sugar ratio | Colour | Taste | Flavour | Appearance | Consistency | Sweetness | Whole someness |
|---|---|---|---|---|---|---|---|
| 50:50 | 6.65±1.84$^{ab}$ | 7.2±1.20$^{a}$ | 7.05±1.23 $^{a}$ | 6.8±1.24$^{a}$ | 6.2±51.94$^{ab}$ | 7.60±0.99$^{a}$ | 7.25±1.16$^{a}$ |
| 40:60 | 7.05±1.82$^{a}$ | 6.9±1.45$^{a}$ | 6.20±1.58$^{a}$ | 6.4±2.14$^{a}$ | 5.2±01.67$^{b}$ | 7.35±1.60$^{a}$ | 6.20±1.40$^{a}$ |
| 80:20 | 5.6±2.09$^{b}$ | 6.0±51.85$^{a}$ | 6.55±1.91$^{a}$ | 4.9±52.60$^{b}$ | 6.4±51.82$^{a}$ | 6.65±1.76$^{a}$ | 6.55±1.61$^{a}$ |
| Mango jam | 7.2±1.44$^{a}$ | 6.9±51.85$^{a}$ | 6.35±1.76$^{a}$ | 7.05±1.28$^{a}$ | 6.90±1.30$^{a}$ | 7.05±1.67$^{a}$ | 7.15±1.53$^{a}$ |

Results are expressed as mean ± standard deviation. Scale: 1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much, and 9=like extremely. Mean scores in the same column followed by the same superscript letter are not significantly different from each other (P>0.05)

**Table 4. Sensory evaluation of juices extracted from shea pulp (evaluations of sweetness)**

| % shea pulp | Flavour | Taste | Colour | Appearance | Consistency | Whole someness |
|---|---|---|---|---|---|---|
| 10 | 6.25±1.52$^{a}$ | 4.85±2.43$^{b}$ | 4.8±2.57$^{b}$ | 6.25±1.59$^{a}$ | 5.3±2.27$^{b}$ | 5.65±1.46$^{b}$ |
| 25 | 6.75±1.59$^{a}$ | 5.80±1.99$^{b}$ | 5.75±2.13$^{b}$ | 6.15±1.63$^{a}$ | 5.8±1.88$^{ab}$ | 6.50±1.73$^{ab}$ |
| 50 | 5.55±2.19$^{a}$ | 5.75±1.68$^{b}$ | 5.5±1.64$^{b}$ | 5.55±1.79$^{a}$ | 5.9±1.89$^{ab}$ | 6.35±1.57$^{ab}$ |
| Mango juice | 6.85±2.26$^{a}$ | 6.85±1.23$^{a}$ | 7.85±1.26$^{a}$ | 6.7±52.29$^{a}$ | 7.05±1.76$^{a}$ | 7.45±1.90$^{a}$ |

Results are expressed as mean ± standard deviation. Scale: 1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much, and 9=like extremely. Mean scores in the same column followed by the same superscript letter are not significantly different from each other (P>0.05)

of color, stability, consistency and keeping quality of the product (Adedeji *et al.*, 2006). The formulated Shea fruit pulp jams had high ash contents ranging from 0.54 – 0.71%. High values of ash content indicated high mineral constituent (Adedeji *et al.*, 2006). From the result it could be seen that the formulated Shea fruit pulp jam of pulp to sugar ratio 80:20 with 0.71% ash content was the best in terms of mineral content.

A moisture level of any food material is a measure of the longevity or life span of the food. It indicates how long a food material can be stored without becoming mouldy (Fellows, 2007). On this basis, the formulated jams from Shea fruit pulp to sugar ratio of 40:60 and 50:50 with 16.77 % and 30.2 % moisture contents respectively were the best jams that could have longer shelf life under storage. These moisture contents are within range of moisture contents (20 – 35%) of many fruit and vegetables jams, jellies, marmalades, conserves (Pomeranz, 2013). Low moisture content indicates that the jams have a long shelf life. The °Brix value of 68.2 of the formulated jam with Shea fruit pulp to sugar ratio of 40:60 and 68.5 of formulated jam with Shea fruit pulp to sugar ratio of 50:50 conforms to values recommended for jam to hinder microbial growth and maintain keeping quality (Moyls et al., 1962; Aina and Adesina, 1999; Malcolum, 2000). The °Brix value of the jam is also

close to 67 °Brix recorded for syrup produced from black-plum fruit (Egbekun et al., 1996). The values are also the value of the reference product in this study, mango jam (67 °Brix).

Protein contents of all the different formulated Shea fruit pulp jam was significant higher than that of the reference mango jam. Protein is indispensable part of the food for human as it is the chief constituent of the protoplasm which forms the vital part of every living cell. Protein repair body tissue by continuous catabolism in the body and syntheses of new proteins from the amino acids. Plasma protein regulates water balance Protein involved in the regulation of acid-base balance (Lokonuzzaman, 2015)

The energy provided by the jams was rather high. Jam processed from Shea fruit pulp to sugar ratio of 40:60 provided the highest energy (1289.2kj/100g) while the jam from Shea fruit pulp to sugar ratio of 80:20 gave the lowest energy (709kj/100g). The differences in the energy content between all the three jam formulations from Shea fruit pulp and also from the reference mango juice could be attributed to the different sugar ratios of the different formulations. Sugar is a great source of energy (USDA, 2011) and so as expected the jam formulation with the highest added sugar would give the highest energy. All the formulated jams from Shea fruit pulp had significantly lower vitamin C contents compared to reference mango juice. The low contents of vitamin C content jams could be linked to the destructive nature of jam-making process. Processing of fruits into jams have been revealed to be most damaging towards vitamin C (Uckiah *et al.*, 2009) which explains low vitamin C content in jams in this study. Valente *et al.* (2014) reported that vitamin C is integral in biochemical process in human body. In addition, it is also extensively used as an antioxidant and food additive.

Jam processed from Shea fruit pulp to sugar ratios of 40:60 and 50:50 had the highest carbohydrate contents than even the reference mango jam, and also pineapple and jackfruit jams (Eke-Ejiofor and Owuno, 2013). High carbohydrate content in the two jam formulations above can be associated with the large presence of sugar added during the jam preparation. All the formulated jams rich in the mineral elements (Ca, Fe and Zn) relative to the reference mango jam. Consumption of the Shea fruit jams could significantly therefore contribute to the daily nutrient intake of Ca, Fe and Zn as recommended by United States' National Research Council (NRC) (1989). Mg contents were relatively low in the jams.

**Nutritional composition of Shea fruit pulp juices.** The value for moisture content for two juice formulations, one with 10% Shea fruit pulp and the other with 25% Shea fruit pulp ranged between 86.3% -84.9 % respectively. These moisture contents are within the acceptable range of 80 – 95% for fruit and vegetable juices (Kareem & Adebowale, 2007) Other fruit juices that fall within this range are cocktail juices (90.72 – 92.78%), fresh beetroot juice (91%) and 89.31 – 92.10% for mangoes and soy-carrot-beetroot drinks (Banigo, E.B Kiin-Kabari, D.B. Owuno, 2015). Like with the formulated jam, all the formulated Shea fruit pulp juices had high ash contents ranging from 0.17 – 0.31%. As said before, high values of ash content indicated high mineral constituent (Adedeji *et al*., 2006). From the result it could be seen that the formulated Shea fruit pulp juice of the 50% Shea pulp with 0.31% ash content was the best in terms of mineral content.

The overall range of pH is 2.5 to 4.5 for most common processed fruit juices (Falguera and Ibarz, 2014). In this study, the pH of all the three different formulated Shea fruit pulp juices and also of the reference mango juice varied from 4.3 to 4.52, implying that all the different formulated juices from Shea fruit pulp are suitable for consumption. pH is considered primarily a means of growth inhibition of existing pathogens in foods and juices. However, at low pH values many micro-organisms will even be destroyed if held at that pH for significant time (Falguera and Ibarz, 2014). The pH range of 4.3 to 4.5 also shows that the formulated juices can be consumed but with consideration to their acidic content (pH) in relation to their effect on the gastrointestinal tract, the stomach and the intestine (duodenum) as the case may be.

Titratable acidity is a measure of the total acid present in a juice, and it has been shown that it is a better indicator of its erosivity than its pH (Grenby *et al.*, 1989). Titratable acidity for most fruit juices vary widely from about 0.08% to 1.8% in 100mL of juice (Grenby *et al.*, 1989). The titratable acidity for the formulated juices in the current study especially the 25% and 50% Shea fruit pulp juice formulations falls in this range, implying these juices can be consumed with less erosive impact of tooth/teeth enamel. $^{o}$Brix values of juices often give information on the sugar concentration and the composition of the juice. In the current stud, the brix values of the formulated juices including the reference mango juice ranged from 12 to 14. USAID (2009) gives a range of brix values of single strength fruit juices such as apple, grapefruit, guava, mango, orange, passion fruit, and pineapple juices from 9.5 to 15. This implies that brix of the formulated juices from Shea fruit pulp in study falls within acceptable range for quality tastes.

Most of the common fruits are low in protein. A considerable proportion of the protein content of fruits is insoluble and consequently remains in the pomace; therefore most fruit juices are usually very low in protein contents. In this study, protein content in Shea fruit pulp juice processed from 25% Shea fruit pulp was comparable to that of the reference mango juice. Generally the results indicated low protein levels from the various fruit juice formulations after analysis, with the highest (0.36%) amount recorded in juice processed from 50% Shea fruit pulp, indicating that the Shea fruit pulp juices are very safe for consumption with respect to protein content.

The carbohydrates and calorific values of all the formulated Shea fruit pulp juices were significantly higher than that of the reference mango juice. This is an indication that Shea fruit pulp contains high of carbohydrate calorie values. The values for carbohydrate and calorie in this study are high compared to the carbohydrate and calorie value for fresh beetroot juice of reported by Emelike *et al.* (2015). All the formulated juices from Shea fruit pulp had significantly lower vitamin C contents compared to reference mango juice. The low value for vitamin C reported in this study contradicts with literature which opines that most fruits are good source of vitamin C (Franke, Cooney, Henning, & Custer, 2008). Generally, the result indicates that the fruit juices are highly rich in the mineral elements analyzed, hence can be a very good source of mineral nutrients as they are of great importance and contributes to the wellbeing of the body.

**Sensory evaluation of Shea fruit pulp jams.** Sensory evaluation indicated that Shea fruit pulp jam was acceptable to consumers. The jam formulated from Shea fruit pulp to sugar ratio of 50:50 and 40:60, however, had the highest mean scores for all attributes being compared.

**Sensory evaluation of Shea fruit pulp juices.** Compared with reference mango juices, juice formulation from 25% and 50% Shea fruit pulp seems to be the most preferred considering flavour, appearance, consistency and wholesomeness/mouth feel. These two formulations are more preferred than that processed from 10% Shea fruit pulp, whose score values are generally below 6, but considered acceptable by the panel. It is interesting that the entire panel members were not familiar with the Shea fruit.

## Conclusions

Shea fruit pulp can be used in making jam and juice. Overall, the formulated Shea fruit pulp jam at 50:50 Shea fruit pulp to sugar ratio and formulated Shea fruit pulp juice at 25% Shea fruit pulp were the most preferred by consumers. The combination with other fruits could serve to improve better sensory properties of the jam and juice such as the colour, taste and consistency. African indigenous fruits are under-utilized; efforts should go toward finding more commercial uses for them. Most indigenous fruits like Shea fruits, are still being collected from the wild and there are no deliberate attempts to domesticate and cultivate them. Expanding the utilization of these crops particularly through value addition will be an incentive for farmers to cultivate them.

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