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AMINO ACIDS, MINERAL AND VITAMIN COMPOSITIONS OF RAW AND PROCESSED AFRICAN STAR APPLE *(Chrysophyllum albidum)* KERNELS

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ABSTRACT
Effect of different processing methods on amino acids, mineral and vitamin compositions of African star apple (*Chrysophyllum albidum*) kernels was investigated. Raw African star apple kernels were collected for the study. Four different processing methods (boiling, fermentation, soaking and roasting) were carried out. All the processed kernels were milled and taken to the laboratory for amino acids, minerals and vitamins analyses. All the processing methods significantly ($P<0.05$) increased the contents of all the amino acids analyzed except leucine and lysine. Boiling, fermenting and soaking significantly ($P<0.05$) reduced the contents of leucine and lysine. Also, Processing significantly affected the mineral contents of the African star apple kernels ($P<0.05$). All the processing methods except soaking reduced iron content in the kernel. The phosphorus content of the kernel (2.98-3.09 mg/100g) was not significantly affected by any of the processing methods. The result of the vitamin composition shows that thiamine, riboflavin and ascorbic acid content were significantly reduced ($P<0.05$) by the different processing methods. The other vitamins (retinol, cholecalciferol, a-tocopherol and menadione) were not significantly affected by any of the processing methods. It was concluded that African star apple kernel should be processed through boiling, fermenting, roasting or soaking before being used in livestock feed.

Keywords: African star apple kernels, raw, processing, amino acids, minerals, vitamins.

INTRODUCTION
African star apple (*Chrysophyllum albidum*), a wildly grown plant in the Southwestern part of Nigeria belongs to the family of trees known as *Sapotaceae*. It is commonly known as "*Agbalumo*" or "*Osan*" (Yoruba) or "*Udala*" (Igbo) in the local languages. Its fruit which is pale yellow with pink coloured endocarp is relished by both children and adults when in season. Its fully ripe fruit becomes available from January through March in the Southwestern part of Nigeria. The pink-coloured pulp and the whitish cover of the brown-coloured seeds of the fruit are consumed, while the empty pale yellow pericarp is discarded.

Nutritionally, *Chrysophyllum albidum* seeds have been reported to contain 14.66 % moisture, 10.13% crude protein, 1.22 % crude fibre, 9.72 % lipid and 7.25 % ash (Agbabiaka *et al.*, 2013). However, Information on amino acid, vitamin and mineral compositions of raw and processed African star apple kernel is scanty. This study was therefore carried out to determine the effect of different processing methods on amino acids, minerals and vitamin compositions of African star apple kernel with a few to providing preliminary information towards effective utilization of this kernel in livestock feed.

MATERIALS AND METHODS
Experimental site
This experiment was carried out at the Teaching and Research Laboratory, Department of Animal Production, School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Niger State, Nigeria. Minna is located between latitude 9°37′ North and longitude 6°33′ East. It is located in the Southern Guinea Savanna vegetation zone of North Central Nigeria. The mean monthly minimum and maximum temperatures are 38 °C and 42°C respectively. The mean annual rainfall is between 1200 mm – 1300 mm while the mean monthly relative humidity is 65 % (Climatemp, 2016).

Sample collection and preparation

The seeds of African star apple used for this research were collected from African star apple fruit farmers in Osogbo, Osun State, Nigeria. The seeds were washed thoroughly with water, sundried and dehulled to expose the mesocarp (kernel). The mesocarp was divided into 5 batches as follow:

Raw

One kilogram of African star apple kernels was airdried, milled using a hammer mill with a sieve size of 3mm and labeled as raw African star apple kernel meal.

Fermentation

One kilogram of African star apple kernel was fermented in water for 72 h at the rate 1 kilogram kernel to 5 litres of water as described by Agbabiaka *et al.* (2013).

Roasting

One kg of African star apple kernel was roasted at 70 ^{0}C for 30 minutes using fire wood with iron pot mixed with sand according to the method described by Sola-Ojo *et al.* (2013).

Soaking

One kilogram of African star apple kernel was soaked in cold water for 24 h at the rate 1 kilogram kernel to 5 litre of water as described by Sotolu and Faturoti (2008); Saulawa *et al.* (2014).

Boiling

One kilogram of African star apple kernel was subjected to boiling at 100 °C for 15 minutes at the rate 1 kilogram kernel to 5 litre of water as described by Ahamefule *et al.* (2008); Jimoh *et al.* (2014) after which water was drained off by means of 10mm sieve and the boiled kernels were air dried for three days.

Samples were subjected to laboratory analysis to determine the amino acid, minerals and vitamin compositions according to AOAC (2006) at the Animal Science Laboratory, University of Ibadan, Oyo State.

Data Analysis

Data generated were subjected to Analysis of variance (ANOVA) using the general linear model of statistical analysis system, Version 9.3 (SAS, 2015).

RESULTS AND DISCUSSION

Amino acid composition

The results of the amino acid composition of raw and differently processed African star apple kernel is shown in Tables 1. The results show that there were significant differences ($P<0.05$) in all the amino acids analysed except phenylalanine, cystine and serine. Arginine was the most concentrated (6.83 mg/100 g crude protein) essential amino acid while glutamic acid was the most concentrated non essential amino acid (7.29 mg/100 g) in the raw African star apple kernel.

The value of leucine (5.37 mg/100g) obtained in this study for raw kernel agrees and compares favourably with values of 5.17 mg/100g reported by Gbago *et al.* (2014) on studies of Monkey Apple (*Anisophyllea laurina R. Br. ex Sabine*) seed. Glutamic and aspartic amino acids made up (13.61 mg/100 g protein) as the most abundant non-essential amino acids in the raw kernel. This confirms the reports by some workers (Adeyeye, 2004; Aremu *et al.*, 2006) that glutamic and aspartic acids are the most abundant amino acids in some Nigerian plants. The least concentrated essential amino acid is methionine (0.99 mg/100 g) while ornithine (0.22 mg/100g) is the least concentrated non essential amino acid protein in the raw sample. All the processing methods significantly ($P<0.05$) increased the contents of all the amino acids analyzed except leucine and lysine. Boiling, fermenting and soaking significantly ($P<0.05$) reduced the contents of leucine and lysine in this study. Aremu *et al.* (2009) had earlier reported that transamination and deamination reactions might be responsible for the slight changes in the amino acid profiles of raw and processed red kidney bean seed flours. The authors observed that as heating proceeds in boiling, protein quality increases to a maximum before declining again with continued heating; thus reduction is likely to be related to increasing Maillard browning causing lysine to be rendered unavailable (Aremu *et al.*, 2010). The other amino acids (phenylalanine, cystine and serine) were not significantly affected by the processing methods.

Mineral and Vitamin Compositions

The result of the mineral and vitamin compositions of raw and differently processed African star apple kernel is shown in Tables 2.

There were significant differences (P<0.05) in all the minerals analysed except phosphorus. The most abundant mineral in the raw kernel sample was potassium (551.00 mg/100 g), sodium (41.00 mg/100 g), while the least concentrated mineral was manganese (0.2 mg/100 g). The kernels of African star apple were also rich sources of the following nutritional valuable minerals: Ca (20.65 mg/100 g) and Fe (2.59 mg/100 g). The concentrated values of phosphorus (2.98 mg/100 g), calcium and iron would make African star apple kernel suitable for bone formation for livestock. The value for sodium in the raw kernel (41.00 mg/100 g) is similar with the value of 43.33 mg/100g reported as a mean for three different varieties of African star apple fruits studied by Adepoju and Adeniji (2012). Furthermore, the results of this study confirm the report of Agbabiaka *et al.* (2013) that potassium is the most abundant mineral in African star apple kernel followed by sodium, copper was however found to be least concentrated. Processing significantly affected the content of some minerals in the kernel (P<0.05). All the processing methods except soaking reduced iron content in the kernel. The phosphorus content of the kernel was not significantly affected by any of the processing methods. Phosphorus is always found with calcium in the body, both contributing to the blood formation and supportive structure of the body (Ogunlade *et al.*, 2005). Modern foods rich in animal protein and phosphorus can promote the loss of calcium in urine (Shills and Young, 1992). Also, Sodium and potassium are required for the maintenance of osmotic balance of the body fluids, the pH of the body to regulate muscles and nerves irritability, control glucose absorption and enhance normal retention of protein during growth (NRC, 1994).

The result of the vitamin composition of raw and differently processed African star apple kernel shows that only thiamine, riboflavin and ascorbic acid were significant different (P<0.05). The other vitamins (retinol, cholecalciferol, a-tocopherol and menadione) were not significantly affected by any of the processing methods. Processing significantly (P<0.05) reduced the thiamine, riboflavin and ascorbic acid content of the kernels.

CONCLUSION

Results from this study have shown that the amino acids, minerals and vitamin compositions of raw and differently processed African star apple kernels differ significantly (P<0.05). Some of the processed kernels were found to contain higher amounts for amino acids and minerals compared to the amounts contained in the raw kernels. The results of this study have clearly demonstrated that African star apple kernels could be used more as feed ingredient in animal feed if properly processed through boiling, fermenting, soaking or roasting.

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Table 1: Amino acid Composition of Raw and differently processed African star apple kernels

Amino acid (mg/100g)	Raw	Boiled	Fermented	Roasted	Soaked	SEM	P-value
Essential Amino acids							
Methionine	0.99^{c}	1.37^{a}	1.16^{b}	1.27^{ab}	1.28^{ab}	0.04	0.0034
Tryptophan	1.20^{c}	1.81^{a}	1.51^{b}	1.81^{a}	1.64^{ab}	0.09	0.0056
Lysine	2.72^{b}	2.25^{c}	2.07^{c}	3.04^{a}	2.17^{c}	0.09	0.0005
Leucine	5.37^{a}	4.17^{b}	3.71^{c}	5.28^{a}	4.10^{b}	0.12	0.0001
Arginine	6.83^{b}	7.15^{a}	6.48^{c}	6.21^{d}	7.38^{a}	0.06	0.0001
Valine	2.83^{a}	3.28^{b}	1.89^{c}	2.95^{a}	2.19^{b}	0.10	0.0006
Isoleucine	2.61^{a}	2.28^{b}	2.71^{a}	2.75^{a}	2.08^{b}	0.16	0.0062
Histidine	1.57^{b}	1.68^{ab}	1.40^{c}	1.75^{a}	1.61^{ab}	0.06	0.0102
Threonine	2.21^{a}	2.08^{ab}	1.92^{b}	2.32^{a}	2.17^{a}	0.06	0.0095
Phenylalanine	3.24	3.69	3.42	3.50	3.55	0.32	0.6985
Non Essential Amino acids							
Proline	2.16^{d}	2.88^{a}	2.60^{bc}	2.46^{c}	2.81^{ab}	0.09	0.0033
Glycine	3.35^{a}	2.16^{b}	2.88^{bc}	2.72^{c}	3.05^{ab}	0.12	0.0225
Alanine	3.05^{b}	3.27^{a}	2.85^{c}	3.17^{a}	3.19^{a}	0.04	0.0008
Cystine	1.38	1.51	1.24	1.52	1.37	0.09	0.1190
Tyrosine	2.85^{b}	3.26^{a}	2.93^{b}	2.86^{b}	3.14^{a}	0.05	0.0011
Ornithine	0.22^{a}	0.24^{a}	0.12^{b}	0.24^{a}	0.20^{ab}	0.04	0.0455
Serine	2.87	3.13	2.86	3.15	3.08	0.19	0.0581
Amino butyric acid	0.52^{b}	0.68^{a}	0.37^{c}	0.58^{b}	0.54^{b}	0.03	0.0021
Aspartic acid	6.32^{c}	6.77^{a}	5.23^{d}	5.25^{d}	6.60^{b}	0.03	0.0001
Glutamic acid	7.29^{d}	8.91^{a}	7.16^{e}	8.35^{c}	8.65^{b}	0.02	0.0001

*All values are means of triplicate determinations. abc= mean with different superscripts on the same row are significantly different (P<0.05), SEM= Standard error of mean, P = Probability value.

Table 2: Mineral and Vitamin Compositions of raw and differently processed African star apple kernels

Minerals (mg/100g)	Raw	Boiled	Fermented	Roasted	Soaked	SEM	P-value
Sodium	41.00^{d}	42.90^{a}	41.70^{c}	42.00^{b}	41.05^{d}	0.09	0.0021
Potassium	551.00^{e}	592.61^{c}	604.94^{b}	657.00^{a}	568.10^{d}	0.35	0.0008
Phosphorus	2.98	3.00	3.08	3.04	3.09	0.12	0.0561
Calcium	20.65^{b}	22.00^{ab}	21.03^{b}	23.11^{a}	23.80^{a}	0.78	0.0012
Manganese	0.20^{b}	0.60^{a}	0.26^{b}	0.30^{b}	0.60^{a}	0.10	0.0001
Iron	2.59^{a}	1.56^{b}	1.36^{b}	1.88^{b}	3.10^{a}	0.87	0.0008
Zinc	3.71^{a}	3.98^{a}	3.51^{a}	2.98^{b}	4.30^{a}	0.33	0.0032
Copper	1.20^{bc}	1.75^{ab}	1.60^{b}	2.04^{a}	1.90^{ab}	0.21	0.0061
Vitamins (mg/100g)							
Thiamin	0.38^{a}	0.20^{c}	0.30^{b}	0.13^{d}	0.33^{ab}	0.02	0.0005
Riboflavin	0.14^{a}	0.05^{cd}	0.08^{bc}	0.03^{d}	0.11^{ab}	0.01	0.0052
Ascorbic acid	5.48^{a}	2.95^{d}	3.53^{c}	2.06^{e}	4.28^{b}	0.02	0.0001
Retinol	0.19	0.17	0.17	0.19	0.18	0.01	0.0599
Cholecalciferol	0.06	0.05	0.06	0.07	0.05	0.01	0.0675
α-tocopherol	0.07	0.06	0.07	0.08	0.06	0.01	0.0512
Menadione	0.02	0.02	0.02	0.03	0.02	0.01	0.0671

*All values are means of triplicate determinations. abc= mean with different superscripts on the same row are significantly different (P<0.05), SEM= Standard error of mean, P = Probability value.