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Nutritional Composition of African Star Apple (*Chrysophyllum albidum)* Seed obtained from Tunga Market in Minna, Niger State, Nigeria

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ABSTRACT: The nutritional composition of Africa star apple seeds (*Chrysophyllum albidum*) was carried out. This sample seed was obtained from Tunga Market, Minna Niger State, Nigeria. The proximate compositions (crude fats, proteins, ash, fiber, moisture, carbohydrate), minerals (phosphorous, potassium, calcium, sodium, and magnesium), and contents were determined using standard methods. For sample AS1, The moisture content yields 6.49%, crude ash 2.25%, fats yield 5.64%, crude fiber 0.84%, crude protein 10.50%, and carbohydrate content 74.28%. As for the AS2 sample, the moisture content yields 6.42%, crude ash 2.21%, fats 5.66%, crude fiber 0.81%, crude protein 10.50%, and carbohydrate content 74.30%. The AS1 sample had 92.36, 38.64, 229.10, 63.44,108.50/100g of calcium, magnesium, sodium, potassium, and phosphorous respectively. Likewise, the AS2 sample had 90.58, 36.82, 28.64, 65.20,112.30/100g respectively. The seeds had a high concentration of minerals. The seed had significant levels of both essential and non-essential amino acids, and the values of anti-nutrients that were measured were below the accepted benchmark, allowing for safe consumption. The findings indicate that eating African star apple seeds will significantly help meet human nutritional needs for proper growth and provide appropriate protection from diseases brought on by malnutrition.

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As the world's population continues to increase, there is a lot of interest in using lesser-known plants as potential sources of food for humans and animals. (Leroy *et al.,* 2022). Fruits are important food components because they are rich in vitamins, minerals, fiber, and antioxidants. Free radicals can harm the body's cells, but antioxidants help to snuff them out. Fruits have a number of health advantages, including a lower risk of diabetes, cancer, heart disease, and other inflammatory and degenerative conditions (Shaba et al., 2017a; Hua *et al.,* 2019). The African Star Apple (Chrysophyllum albidum) produces large berries with up to five flat seeds per berry. It is a member of the Chrysophyllum genus. The

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plant belongs to the family Sapotaceae. The fruit is referred to in Nigeria by the Yoruba and (Igbo, Efik, and Ibibio) peoples as agbalumo and udaru, respectively. The plant is a genus of approximately 70–80 species of trees that are native to tropical areas of the world, with the greatest number of species being found in Northern South America and central, eastern, and western Africa (Femi *et al.,* 2020). The trees are around 30 meters tall, and they consistently produce seasonal fruit as well as green foliage all year long. Fruits start out green and turn orange as they ripen. Due to their abundance in phytochemical components, the seeds and leaves have significant medicinal and pharmacological value in traditional African medicine for the treatment of numerous diseases (Iseghohi *et al.,* 2015; Tanko et al. 2017). The commercial and nutritional benefits of the fruit pulp are well known. The pulp is processed to create syrup, jellies, concentrates, flavors, marmalades, jam, and stewed fruit. Because it is tasty, nutritious, and succulent, it is also eaten locally in its fresh, ripe form. The leaves are used as an emollient and to cure skin eruptions, stomachaches, and diarrhea. The endosperms from the seeds are used as topical ointments to treat vaginal and dermatological infections. The bark is used to treat malaria and yellow fever. As an evergreen broadleaf plant, some of the trees are also useful as ornamental plants ((Uprety *et al.,* 2016). Typically, the fruits are not plucked from the trees but are instead allowed to fall to the ground naturally (Mathew et al., 2014a). The nutritional and therapeutic value of *Chrysophyllum albidum* has been reported by Adebayo et al. (2010). Therefore, the purpose of this study is to look at the nutritional composition of African star apple seeds (*Chrysophyllum albidum*). It is anticipated to offer more details about the make-up of food items.

MATERIALS AND METHODS

Sample preparation and extraction: The freshly sampled *Chrysophyllum albidum* seeds were gathered in Tunga Market, Minna Niger State Nigeria. The seeds were cleaned, let to air dry three times at room temperature, and then were shelled. The cotyledons obtained were air dried at room temperature and later pulverized using electric blender. 86.96 g of the powdered sample was subjected to cold maceration for 48 h using 99% ethanol. The extract obtained was concentrated using rotary evaporator and subsequently weighed. The obtained 21.03 g crude extract was subsequently partitioned with n-hexane and 99% ethanol. Crude extracts of ethanol and n-hexane were obtained in quantities of 9.10 g and 4.32 g, respectively. Proximate analysis, and other tests were performed on these samples. This study was carried out at the laboratory unit of the Department of water resources, aquaculture and fisheries Technology, Federal University OF Technology Minna, Niger State (Mathew et al., 2014b; Tsado et al., 2018).

Proximate analysis: To gauge the quantity of vital nutrients contained in *Chrysophyllum albidum* seeds, proximate analysis of the seed samples was done using official techniques of analysis of the (AOAC 2010). This standard method were used to determine moisture content, ash, crude fibre, and crude fat, crude protein and carbohydrate contents.

Moisture content determination: The weight difference method was used to calculate the moisture content. A clean, dry, known-weight crucible was filled with the powdered sample (2g). At 1050C for 2 to 5 hours, the crucible and its contents were dried in the oven. After the first 3 hours, it was taken out and weighed every 30 minutes until a steady weight was reached. In terms of weight loss in percentage, the moisture content was measured. The formula stipulates it (AOAC, 2010; Mathew et al., 2020).

$$MC_{db}=\frac{w1-w2}{w2}$$

Where MC_{db} is the moisture content

Total ash determination: Standard method were used for the determination of ash content. The 2g of the powdered sample material was placed into each of the six clean crucibles, numbered 1 through 6. In the muffle furnace, three of the crucibles were heated for four hours at 500-600 °C, producing white (light grey) residue. After the muffle furnace was switched off to allow cooling, all of the crucibles were taken out, desiccated to cool, and reweighed. Ash was determined for the three replicates using the air-dried contents of the other three crucibles (Dauda et al., 2014). The ash % was calculated using these formulas:

$$\%\ \text{Ash} = \frac{\text{Weight of Ash}}{\text{Weight of original sample}} \times 100$$

Crude protein determination: The Kjeldahl method, which involves digestion, distillation, and ultimately titration of the sample, was used to measure the amount of protein in the powdered sample as total nitrogen. This method was described by AOAC (2010). The powdered sample was weighed into the digestion tube (1g) and digested with 10ml of concentrated sulfuric acid and 2.5g of catalyst (K_4SO_4/Na_2SO_4 and CU (9:1)) before being heated to produce a transparent green solution. The blank without the sample was treated in the same way. The following equation was used to compute the total nitrogen content;

$$\% \text{ Crude protein} = \frac{(V_s - V_b) \times 0.001401 \times \text{Ca acid } (6.25)}{\text{Weight of original sample}} \times 100$$

Where Vs = Volume (cm^3) of acid required to titrate sample,V_b = Volume (cm^3) of acid required to titrate blank and Ca acid = concentration in $moldm^3$ of the acid. 1000 is the same as constant; Nitrogen has the atomic number 14, so 100ml is the digest's final volume, or V1; V2 is the volume of the aliquot (10 ml), W is the sample's weight, the nitrogen to crude protein conversion factor is 6.25 (Paiko et al., 2016).

Crude fat determination: The procedure outlined by AOAC (2010) was used. A Soxhlet apparatus with petroleum ether inside was filled with a filter paper that had been properly folded and contained the sample. For four hours, the device was heated and adjusted to produce 5–6 droplets per second. After Soxhlet extraction, the filter paper and its contents were taken out of the device and left to air dry at ambient temperature before being maintained overnight in an oven at 1000C. The filter paper and its contents were removed from the oven, cooled in a desiccator, and the weight was noted after 12 hours of drying. A percentage of the sample weight was used to represent the ether extract (Shaba et al. 2017b).

Crude fiber determination: According to AOAC (2010), crude fiber was analyzed similarly. The powdered material was weighed into a dry, clean beaker at a known weight (2g). The sample received 10ml of acetone, which was added, and was then left to air dry for 10 minutes. 200ml of 1.25% sulphuric acid was added to the air-dried sample, and the mixture was then heated over a hot plate and allowed to reflux for 30 minutes. Following reflux, the mixture was filtered through a cotton cloth and brought to pH neutrality by rinsing with hot water. 200ml of 1.25% NaOH was added to the filter, and the mixture was allowed to reflux once more for 30 minutes. The filtered mixture was then rinsed with hot water and diluted HCl until the residue was free of alkali. The residue was dried for 20 minutes at 80°C in a crucible with a specified weight. The dried residue was heated in a muffle furnace to 3000C for two hours. As the weight of crude fiber, the weight lost as a result of ignition was calculated. It may be represented as: Ash wt. /wt. 100/1 times the sample.

Total carbohydrate determination: The nitrogen free extract, which is a representation of the digestible carbohydrate, was calculated using the difference between the total value of moisture, crude fiber, crude protein, crude fat, and ash from 100 percentage (Ndamitso et al., 2019)

Total carbohydrate. = 100 - Crude protein + Moisture content + Ash + Lipid + Crude fiber

Mineral analysis: The method described by Association of Official analytical Chemists' AOAC, 2010) was used for mineral analysis.

Determination of Amino Acid profile: About 200 mg of the ground seed sample was defatted using methanol/chloroform mixture in a ratio of 1:1. From the defatted sample, 30 mg was weighed into a glass ampoule, 7 cm3 of 6 M HCl was added and oxygen expelled by passing nitrogen into the ampoule. The sealed ampoule was placed in the oven at 105 oC for 22 h, this was allowed to cool and filtered. The filtrate was then evaporated to dryness at 40ºC under vacuum in a rotary evaporator. The residue was dissolved in 5 cm^3 acetate buffer (pH 2.0) and loaded into the amino acid analyzer where the amino acid compositions of the seed samples were determined by Ion Exchange Chromatographic method using the Technicon Sequential Multisample Amino Acid Analyzer (AOAC, 2010; Mathew et al., 2018a).

RESULTS AND DISCUSSION

Table 1. Showed the proximate composition of African star apple seed (*Chrysophyllum albidum)*. The sample seed contained 6.45% moisture, 2.25% ash, 5.65% fats, 0.82% crude fiber, 10.50% crude protein, and 74.29% carbohydrate.

Table 1: Proximate Composition of African Star apple seed (mg/100g)

Parameters	**Content (%)**
Moisture	6.45
Ash	2.23
Crude fat	5.65
Crude Fiber	0.82
Crude protein	10.50
Carbohydrate	74.29

The analysis revealed that the sample had an average percentage moisture content of 6.45%. The small variance could be attributable to seed storage management procedures. AKubor *et al*. (2013) and Damilola *et al*. (2016) reported 9.0% and 9.39%, respectively, but this figure is substantially lower. The number is considerably less than the 24.17% that Florence *et al.* (2015) reported. By preventing mold growth and reducing moisture-dependent metabolic reactions, the seed's low moisture content improves its storage stability (Onimawo and Akubor 2012). However, the moisture level of both samples is low. This suggests that there is no risk of microbiological degradation or decomposition and that they can all be stored for a suitable amount of time. Compared to other protein sources like beef, eggs, and fish, which are more easily prone to deterioration if sufficient care is not given to them, the lengthy shelf-life promised here is an extra benefit. According to Onimawo *et al.*, (2003), any seed that has a moisture level of over 15% is susceptible to deterioration from mold growth, heat, insect damage, and sprouting. (Onimawo *et al.*, 2003). According to the proximate analysis, the average percentage ash content for the sample was 2.23%. This is more than the 1.40% reported by Florence *et al*. (2015), but a little less than the 2.62 and 3.80 percent reported, respectively, by Damilola *et al*. (2016) and Akubor *et al*. (2013). Thus, the amount of minerals contained in the samples is indicated by the ash content. The crude fat of the studied seeds averagely ranged 5.65% between the two duplicates, however, the seed cannot be regarded as oil seeds as their crude fat contents were below 30%. From the analysis, the sample's crude fiber content was found to be 0.82%. The figures are lesser than the 1.36% recorded by Florence *et al.* (2015) and the 2.80% and 2.96% reported by Akubor *et al.* (2013) and Damilola *et al.* (2016) for both samples, respectively. Colon cancer, diabetes, and heart disorders have all been linked to fiber. Constipation and diverticulosis are two more conditions that are helped by fiber (Soliman 2019). High fiber intake simultaneously limits the bioavailability of minerals, proteins, and carbohydrates by preventing their hydrolytic breakdown (Mustapha et al., 2015; Ioniță-Mîndrican *et al*., 2022). The protein proportions of the seed samples on an average between two duplicates is 10.50%. These figures is significantly higher than the 4.50 percent and 2.45 percent that Akubor *et al.* (2013) and Florence *et al.* (2015) previously reported, respectively. The 13.14% recorded by Damilola *et al*. (2016) is still significantly higher in the samples. Protein is an essential component for maintaining cells and repairing tissues that have been damaged. The average percentage of carbohydrates observed from the proximate analysis of the samples was 74.29%. This value is significantly higher than the 60.39% previously reported by Florence *et al.* (2015). And significantly higher than 70.60% and 71.40% respectively reported by Akubor *et al.* (2013) and Damilola *et al.* (2016). Carbohydrate is an excellent source of energy. This high percentage of carbohydrates makes the seed to be a good source of energy. The African star seed (*Chrysophyllum albidum)* sample contained minerals content namely calcium 92.36 mg 100g-1; magnesium 38.64 mg 100g-1; sodium 29.10 mg 100g-1; potassium 63.44 mg 100g-1; and phosphorous 108.50 mg 100g-1; as shown in Table 2. The results of the mineral-processed African star apple seed (*Chrysophyllum albidum)* are shown in Table 2. There were significant differences in all the minerals analyzed in which phosphorus has the highest mineral content from the samples (108.50mg/100g) respectively. The potassium content of the sample was significantly higher than the reported ones. The magnesium content of the seed was 38.64mg/100g while phosphorous and calcium is 92.36 mg/100 g.

Table 2: Mineral Composition of African Star apple seed (mg/100g)

Parameters	Content
Ca	92.36
Mg	38.64
Na	29.10
K	63.44
P	108.50

The most abundant minerals in the samples were phosphorous (108 mg/100 g) and calcium (92.36 mg/100 g), while the least concentrated mineral was sodium (29.10 mg/100 g) in the sample. The samples were also rich sources of the following nutritional valuable minerals: potassium (63.44 mg/100g). For the sample, the concentrated values of phosphorus (108.50 mg/100g), calcium (92.36 mg/100mg), and potassium (63.44 mg/100g) correspondingly would make African star apple seed suitable for bone formation in livestock.

Table 3: Amino Acid compositions of African Star apples seed (g/100g protein)

Amino Acid	Concentration: g/100g protein
Leucine	9.57
Lysine	4.70
Isoleucine	4.21
Phenylalanine	4.72
Norleucine	____
Tryptophan	1.90
Valine	4.68
Methionine	1.23
Proline	3.19
Arginine	4.68
Tyrosine	3.53
Histidine	2.20
Cystine	1.39
Alanine	4.70
Glutamic acid	11.96
Glycine	4.00
Threonine	3.33
Serine	2.53
Aspartic acid	9.80

Thus, the potassium (63.44, 65.20 mg/100g) and calcium (92.36 mg/100g) content were all comparatively higher than 17 mg/100 g and 12 mg/100 g respectively for *F. flavicarpa* (Corrêa., 2016). The fact that C. albidum seeds contain a variety of mineral elements, such as phosphorus, sodium, potassium, calcium, and magnesium, further attests to their nutritional significance and raises the possibility that they may help maintain body electrolytes and muscle tone.(Olusanya., 2008). Furthermore, the results of this study confirm the report of Agbabiaka *et al.* (2013). Phosphorus was however found to be the highest concentrated. Phosphorus is always found with calcium in the body, both contributing to blood formation and supportive structure of the body (Goretti and Alon, 2012). Modern foods rich in animal protein and phosphorus can promote the loss of calcium in urine (Worku and Sahu., 2017; Mathew et al., 2018b). 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 (Worku and Sahu., 2017). However, potassium is one of the most abundant minerals in African star apple seeds. Despite the fact that Na and K are necessary for the maintenance of body fluid (Omole, 2003), the high concentration of Na and K in this fruit makes it unfit for eating by those with hypertension (Oloafe *et al.*, 2004). When compared to the values published in Chrysophyllum Roxburgh by Barthakur and Arnold (1991), other elements including Ca, Mg, and K generally contribute little to the daily intake guidelines. Generally, from Table 2, it was observed that both were rich in Phosphorous, calcium, potassium, and Magnesium contents while Sodium was not as much as the other four in both of the samples. The data on the amino acid composition of the examined seed samples is shown above. Both non-essential and essential amino acids are present in abundance in the seeds. The quantities of a few essential amino acids are similar to those recommended by the FAO/WHO (National Research Council 1989). In the seed, leucine was the essential amino acid with the highest content (9.57 mg/100 g crude protein), aspartic acid had the highest concentration (9.8 g/100 g), and norleucine was either absent or had a very low concentration (Lopez et al., 2023). Thus, the findings indicate that these seed proteins would pair well with protein sources that are low in lysine, value, methionine, threonine, leucine, and isoleucine. According to Adewumi et al. (2023), the sample's isoleucine concentration was 4.11g/100g, which is higher than the 1.2g/100g value found in C. nudiflora. The complete sample is an excellent supply of isoleucine based on the FAO/WHO criterion of 2.50g/100g. Hemoglobin serves as an energy regulator, and isoleucine aids in the growth and repair of muscles (Adeboye et al. 2007). The amount of threonine (3.33g/100g) in the sample that was examined is higher than the FAO/WHO-recommended value of 1.5g/100g and is consistent with the amounts found in the seeds of B. monandra, D. microcarpum, and M. oleifera. Valine content was 4.68g/100g, which is lower than the values reported by Onwuka (2005) in C. nudiflora, D. micorcarpum, and Balanite seeds but within the range of the 7.5g/100g, 8.3g/100g, and 8.12g/100g in V. calvoana, V. amydalina, and V. Colorata. Reported by Ijarotimi, et al (2013).

Valine is said to support cerebral vigor, physical coordination, and calm emotions, according to FAO/WHO (National Center for Biotechnology Information, 2023). Leucine was 9.57 g/100 g in value. This figure is high when compared to the raw, boiled, fermented, and roasted kernels of the African star apple, which Makinde et al. (2019) observed to contain 5.37g/100g, 4.17g/100g, 3.71g/100g, 5.28g/100g, respectively. Anisophyllea laurina R. Br. ex Sabine) seed experiments were conducted and the results were reported by Gbago et al. (2014) as 5.17 mg/100g. According to Onwuka (2005), D. micorcarptum has 2.25g/100g and B. monandra contains 2.13g/100g. According to Yang et al. (2010), leucine aids insulin in its ability to control blood sugar levels as well as the growth and repair of muscles and tissue. Phenylalanine is an essential amino acid that produces norepinephrine, a chemical that transmits signals between nerve cells in the brain (Dalangin et al., 2020). The seed sample under investigation has a phenylalanine level of 4.72g/100g. This finding is slightly less than the 5.32g/100g in C. nudiflora seeds that Onwuka (2005) reported. The findings are comparable to the FAO/WHO standard limit of 2.5g/100g. The resulting lysine content was 4.70g/100g. When compared to D. microcarpum's value of 2.12g/100g and B. monandra's value of 2.53g/100g (Mathew et al., 2014a), this figure is high. The figures match Olaefe's (2009) findings on the amino acid composition of Balanite seeds. Lysine maintains proper calcium absorption and aids in collagen production (Bihuniak and Insogna, 2015; Ndamitso et al., 2014). The most prevalent non-essential amino acids in the African star apple seed are glutamic and aspartic acids (11.96g/100g and 9.80g/100g, respectively). This supports studies from several researchers that the most prevalent amino acids in various Nigerian plants are glutamic and aspartic acids (Adeyeye 2004; Aremu et al., 2006). However, the findings of the amino acid composition imply that the seed sample examined is a rich source of both essential and non-essential amino acids.

Conclusions: The proximate study revealed that the cotyledons of *Chrysophyllum albidum* seeds are a good source of nutrients. The results of proximate composition showed high level of carbohydrate in both of the samples. The samples are not prone to microbial deterioration and spoilage as a result of low moisture content of the seed, this indicates that they can all be preserved for a reasonable period of time.

The long shelf-life promised here is an added advantage over other sources of protein like beef, egg and fish which are easily prone to spoilage if proper care is not given to them. It also contains appreciable number of mineral elements, and it is good for animal feed since the ash value is below 2.5%. The seed also has healthy mineral content, with high concentrations of phosphorous, calcium, potassium, magnesium, and sodium. The findings imply that, if consumed in sufficient quantities, the sample would significantly help to meet human nutritional needs for normal growth and adequate defense against diseases brought on by malnutrition.

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