



## Proximate, Mineral Contents and Physicochemical Properties of *Chrysophyllum Albidum* (African Star Apple) Kernel Flour and Oil

<sup>1\*</sup>AUDU, SS; <sup>2</sup>BEETSEH, CI; <sup>1</sup>EDWARD-EKPU, DU; <sup>1</sup>EWUGA, AA

<sup>1</sup>Department of Chemistry, Nasarawa State University, Keffi, Nigeria

<sup>2</sup>Department of Chemistry, Federal University of Agriculture, Markudi, Nigeria

\*Corresponding Author Email: [saratusteve1@gmail.com](mailto:saratusteve1@gmail.com)

**ABSTRACT:** The flour and oil of the kernel of African Star Apple (*Chrysophyllum Albidum* Linn.) sourced from Maraba Gurku township of Nasarawa state was analysed to determine their potentials for industrial and human consumption. Standards methods were used to determine the proximate and mineral contents of the flour and physico-chemical properties of the oil. The results obtained from the Proximate Analysis shows the kernel has a moisture content of 10.06±0.08 %, Ash content of 2.72±0.07 %, Crude lipid of 13.31±0.08 %, Crude Protein of 7.92±0.00 %, Crude Fibre of 1.59±0.00 % and Carbohydrate of 65.41±0.05 %. This suggests that the flour can be used as an alternative to cereals in compounding animal feed. The results from the Mineral Analysis showed the kernel has 0.01 mg/g of copper, 0.01 mg/g of Iron, 37.50 mg/g of phosphorus, 57.37 mg/g of calcium and 0.44 mg/g magnesium. The Calcium-Potassium Ratio indicates the flour is a good source of calcium for bone formation. The Physicochemical analysis showed the oil has an Acid Value of 33.12±0.25 mgKOH/g, a Saponification Value of 184.90±0.29 mgKOH/g, an Iodine Value of 60.05±0.02 mgKOH/g, a Free Fatty Acid Value of 16.05±0.14 mgKOH/g, Peroxide Value of 2.10±0.10 m Eq/kg, Moisture of 3.36±0.08 %, Unsaponifiable Matter of 5.26±0.05 g/kg and an Ester Value of 151.78±0.15 mgKOH/g. The quality of the kernel oil falls below the standard for edible oil but the oil may be useful in the paint and cosmetic industry.

DOI: <https://dx.doi.org/10.4314/jasem.v23i7.9>

**Copyright:** Copyright © 2019 Audu *et al.* This is an open access article distributed under the Creative Commons Attribution License (CC BY), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

**Dates:** Received: 03 May 2019; Revised: 01 June 2019; Accepted 04 July 2019

**Keywords:** *Chrysophyllum Albidum*, Kernel, Oil, Flour

Seeds of plants are normally known to be a good source of food for animals, including humans because they contain many nutrients. Plant seeds from soybeans, groundnut, corn, cotton, sunflower palm nuts etc. have been sources of food, cooking oil and industrial oil since ancient times. Most of the foods consumed by humans such as cereals, legumes and nuts are seed-based. Seeds are often rich in oil and unsaturated fats are considered as healthy however not all seeds are edible. As the demand for edible vegetable oil and vegetable oil for industrial uses increases, there have been search for alternative and cheaper seeds for these purposes. Seed from the African star apple (*Chrysophyllum Albidum* Linn.) is been investigated as a potential source of nutritional oils, industrial raw materials and nutraceuticals in this study. The plant commonly known as “*Agbalumo*” (Yoruba) or “*Udala*” (Igbo) in local languages of Nigeria is classified as a wild plant and often grows to a height of about 36.5 m (Bada, 1997). *C. Albidum* is a forest tree species belonging to the *Sapotaceae* family and is naturally found in many tropical countries of Africa such as Nigeria, Uganda, Niger, Cameroon and Cote d’Ivoire (Bada, 1997). *C. Albidum* fruit is a berry orange to yellow in colour, about 6 cm in length

and 5 cm in diameter when ripe. The fruit usually contains 3 – 5 dark coffee-coloured hard shiny ellipsoid seeds that are about 2.8 cm long and 1.2 cm wide. The seed contains a white coloured kernel. Several studies have been done on the plant but most have been on the edible parts especially the pulp. The fleshy pulp of the fruit of *C. Albidum* which is commonly eaten as snacks has been attributed numerous health benefits such as vitamins (C, B & E) and Iron (Adepoju and Adenij, 2012; Oguntoyinbo *et al.*, 2015; Adebayo, 2012; Bada, 1997). Adubiaro and Olaleye (2016) reported that the kernel of the seed has high level of fat and carbohydrate. Azor *et al.* (2017) reported that though the kernel has high carbohydrate which is a source of energy, it contains high levels of anti-nutritional or toxic factors. Ajayi and Ifedi (2015) reported that the flour of *C. Albidum* kernel could be a good source of potassium, magnesium and calcium, and has a higher quantity of mineral when compared to those reported for some African oil bean seeds in studies. In recent time studies have been done on the kernel as a source of domestic and industrial oil and there have been varying reports. However, the kernel of the seed has been reported to be a viable source of oil for several domestic and industrial purposes in

\*Corresponding Author Email: [saratusteve1@gmail.com](mailto:saratusteve1@gmail.com)

Nigeria going by its oil yield (Adebayo, 2012; Chukwumalume *et al.*, 2010). Less research has been done on the kernel of *C. Albidum* seed compared to the pulp and peel of the fruit. The seed of the fruit if not used for local games are usually thrown away as waste which can become an environmental nuisance. In the context of creating wealth from environment waste, this study is aimed at assess the kernel of *C. Albidum* seed as viable source of vegetable and industrial oil, and therefor add to the body of knowledge on the potential of the seed.

## MATERIALS AND METHODS

**Procurement and processing of seeds:** *C. Albidum* seeds were bought from Orange market within the vicinity of Maraba Gurku township of Nasarawa state. The shells were separated manually from the kernel and dried for 5 days at ambient temperature. After the kernel were separated from the shell, they were re-dried in the oven for oil 180 minutes at 60 °C to reduce moisture before grinding to flour to increase the surface area for oil extraction. The flour was further oven-dried to constant weight and then put aside for analysis.

**Proximate Analysis of *C. Albidum* kernel flour:** The moisture content was determined using AOAC method (2010). Ash content was determined using AOAC method (2010); the crude fibre and lipid contents were determined the methods described by Pearson (1976); the crude protein content was determined according to the method of AOAC (2010) using the Keldahl method; The method of James (1995) was used to determine the carbohydrate content of the sample.

**Mineral Analysis of *C. Albidum* kernel flour:** Sample for mineral analysis were prepared using the method described by AOAC (2010). Samples were digested at about 60 °C in 10 cm<sup>3</sup> of Nitric Acid and allowed to cool. The digested sample was filtered into a 100 ml flask and marked up to deionized water. The metals were determined using Atomic Absorption Spectrophotometry (ICE 300 aa02134104 v1.30).

**Oil Extraction:** The oil was extracted from 640 g of the grounded sample and conducted in a Soxhlet extractor using 500 ml n-hexane at a temperature 55–60 °C) for eight hours. The oils sample obtained was transferred into a beaker and heated at 40 °C to evaporate the solvent collected alongside the oil was properly stored for subsequent physicochemical analysis.

**Physicochemical Analysis of *C. Albidum* kernel oil:** The analyses of Saponification Value, Unsaponifiable Matter, Peroxide Value, Acid Number/Value, Iodine

Value, Density (Specific Gravity), were carried out using the methods of AOAC (2010). Ester Value (mgKOH/g) = Saponification Value - Acid Number/Value ± DSV of duplicate value. Free Fatty Acid value (mgKOH/g) = 0.503 x Acid Number/Value ± DSV of duplicate value (Aremu *et al.*, 2015).

## RESULTS AND DISCUSSION

**Proximate Composition of *C. Albidum* kernel flour:** The result for the proximate analysis of *C. Albidum* kernel oil is presented in Table 1. The result shows the kernel have a moisture content that fall within the 7 – 11 % moisture content range of legumes reported by Arkroyed and Doughty (1964). This mean it can be stored as long as legumes before spoiling. The result for ash content, crude protein, carbohydrate content and crude lipid are similar to those reported (2.32 ± 0.02, 8.14 ± 0.13%, 63.94±0.12% and 12.82 ± 0.04% respectively) by Ajayi and Ifedi (2015) for ash content, crude protein and crude lipid respectively in their study. The ash content gives the amount of mineral element and inorganic matter present in a food sample. Ash content observed is high when compared with ash value (1.6% to 2.9%) of cereals as reviewed by Edward-Ekpu *et al.* (2016) but lower than 4.28 of Bambara nut as reported by Aremu *et al.* (2006). The crude fibre content result is 1.59±0.00 %. This is similar to the value (1.50±0.07) reported by Damilola *et al.* (2016) and higher than the values (1.22 ± 0.02 and 1.19 ± 0.01 %) reported by Agbabiaka *et al.* (2013) for raw and fermented kernel. The crude fibre in the kernel appears to be less than that of cereal which ranges from 2.0 - 8.1 %. A total carbohydrate content was observed to be within the range (48.6 – 81.6 %) reported for cereals by Edward-Ekpu *et al.* (2016). This suggests that the kernel flour can be a useful as an alternative to cereals in compounding animal feed.

**Table 1.** Proximate composition of *C. Albidum* kernel flour

Parameter	Value %
Moisture content	10.06±0.08
Ash content	2.72±007
Crude lipid	13.31±008
Crude protein	7.92±0.00
Crude fibre	1.59±0.00
Carbohydrate	65.41±0.05

±DSV of triplicate value

**Mineral Composition of *C. Albidum* kernel flour:** The result from the mineral analysis of *C. Albidum* kernel flour is presented in Table 2. The kernel was found to be a good source of phosphorus (37.50 mg/g), calcium (57.37 mg/g) and magnesium (0.44 mg/g). The result showed that of the minerals tested for phosphorus and calcium were the most abundant. All the values observed for mineral content (copper, iron, phosphorus, calcium and magnesium) were higher

than the values of these element reported by Agbabiaka *et al.* (2013) in their mineral analysis of both the raw and fermented kernel of the fruit. Copper by and iron, and a value of 0.44 mg/g for magnesium. However, Ajayi and Ifedi (2015) reported higher values for copper, iron and magnesium but lower values for phosphorus and calcium. The calcium content observed in this study is higher than those in cereals (Edward-Ekpu *et al.*, 2016). It was so observed that the Calcium-Potassium Ratio (C:P Ratio) is greater than one (1) indicating that can serve as a good source of calcium for bone formation as a ratio is less than 0.5 is considered a poor source (Nieman *et al.*, 1992). This is based on fact that diets rich in phosphorus may promote the loss of Calcium in the urine (Shills and Young, 1988). Cadmium was not detected in the kernel sample.

Table 2 Mineral composition (mg/g) of *C. Albidum* kernel flour

Parameter	Sample Concentration(mg/g)
Copper	0.01
Iron	0.01
Phosphorus	37.50
Calcium	57.37
Magnesium	0.44
Cadmium	ND

ND = Not Detected

#### Physicochemical properties of *C. Albidum* kernel oil:

The result of the Physicochemical analysis of *C. Albidum* kernel oil is presented in Table 3. The physicochemical properties of the oil extracted from the seed of *C. Albidum* were assessed to determine its qualities. As shown in the table 3, a Free Fatty Acid value of 16.05±0.14 mgKOH/g and an Acid value of 33.12±0.25 mgKOH/g was detected for oil. The values are higher than those (4.50 mgKOH/g and 2.25 mgKOH/g) reported by Adebayo *et al.* (2012) for raw sample of *C. Albidum* oil and similar to the value reported by Aladekoyi *et al.* (2016) for the oil from fermented *C. Albidum* seed. The acid value of the oil was found to be higher than the Codex standard for virgin vegetable and the range recommended for cooking oil which is 0.00 -3.00 mgKOH/g (Oderinde *et al.*, 2009). According to Demian (1990), acid content (which is an index of free fatty acid content) shows the degree to which the glycerides in the oil has been decomposed due to enzymatic activity such as lipase action and other physical factors such as light and heat. The high acid value of the oil under investigation suggest that the oil susceptible to lipase activity, other hydrolytic action or oxidation and is not suitable for cooking. The saponification value (184.90±0.29 mgKOH/g) of the oil is less 199.50±0.29 mgKOH/g that reported by Aladekoyi *et al.* (2016) for the oil from fermented *C. Albidum* seed and similar to 180.92±0.02 mgKOH/g reported by Adebayo *et al.*

(2012) for raw sample of *C. Albidum* oil. Saponification value is an index of the average molecular mass of the fatty acids in an oil sample (Oladiji *et al.*, 2010). A high saponification value indicates a high proportion of fatty acids of low molecular weight or short-chain acids required for the production of soap that is soluble soap (Akbar *et al.*, 2009) and the thermal stabilization of poly vinyl chloride (PVC) (Mohammed and Hamza, 2008). The Saponification Value of the oil from this study was observed to be less than the standard *Codex Alimentarius* (2005) values range of 250-260 mg KOH/g.

Table 3 Physicochemical properties of *C. Albidum* kernel oil

Parameter	Value
Acid Number/Value (mgKOH/g)	33.12±0.25
Saponification Value (mgKOH/g)	184.90±0.29
Iodine Value (mgKOH/g)	60.05±0.02
Free Fatty Acid value (mgKOH/g)	16.05±0.14
Peroxide Value (m Eq/kg)	2.10±0.10
Moisture (%)	3.36±0.08
Unsaponifiable Matter (g/kg)	5.26±0.05
Ester Value (mgKOH/g)	151.78±0.15

The Peroxide Value of 2.10±0.10 m Eq/kg is higher than 1.80±0.28 mEq/kg and 1.51±0.42 m Eq/kg reported by Akubugwo *et al.* (2007) and Aladekoyi *et al.* (2016) respectively for raw oil from *C. Albidum* seed. All these values are far below the maximum acceptable value of 10 mEq /kg set by the Codex Alimentarius Commission (2015). Peroxide value is an index of rancidity. It is an indicator of the deterioration of lipids due to oxidation at the double bond of an unsaturated fatty acid which causes rancidity (Inekwe *et al.*, 2012).

The Iodine Value (60.05±0.02) mgKOH/g obtained for the oil sample is higher than 33.18±0.08 mgKOH/g reported by Audu *et al.* (2013) and lower than 7.1064±0.01 mgKOH/g report by Aladekoyi *et al.* (2016) for crude seed oil of *C. Albidum*. The value from the oil in this study is higher that the *Codex Alimentarius* (2005) Standard range 6.3-10.6 mgKOH/g. The iodine value is used to quantify the amount of double bonds in an oil which reflects its susceptibility to oxidation. The high iodine value observed from the test is an indication of the presence of high a fraction of unsaturated fatty acids in the seed oil of *C. Albidum*. The Unsaponifiable Matter value obtained was 5.26±0.05 g/kg which lower than the standard value of 10 g / kg. The Unsaponifiable Matter is oily matter that cannot be converted into soap during saponification by alkali hydroxides. The Ester value of mgKOH/g 151.78±0.15 obtained in the study means 151.78±0.15 mg of KOH required to hydrolyse the fatty acids present in the glyceride form in 1 g of oils

or fat, indicating the actual amount of glyceride present in the sample of oil, which is saponifiable. High ester value indicates the presence of high amount of ester and low molecular weight fatty acid content (Belsare and Badne, 2007). The value observed for the oil of *C. Albidum* in this study is below the range of values (169.18 – 251.639 mgKOH/g) reported for several edible oils such as groundnut oil, sesame oil, soybeans and cotton oil.

**Conclusion:** The study showed that *C. Albidum* kernel flour has a high carbohydrate content, good calcium-potassium content ratio and good level of nutrients that makes it an attractive and possible option for compounding animal feed. The quality of oil from the kernel falls below the standard for edible oil and good quality solid soap but the oil may be useful in the paint and cosmetic industry. The viability of the oil been used as a biodiesel should be further researched.

## REFERENCE

- Adebayo, SE; Orhevba, BA; Adeoye, PA; Musa, JJ; Fase, OJ (2012). Solvent Extraction and Characterization of Oil from African Star Apple (*Chrysophyllum Albidum*) Seeds. *Acad. Res. Int.* 3(2):178- 183.
- Adepoju, OT; Adeniji, PO (2012). Nutrient composition and micronutrient potential of three wildly grown varieties of African star apple (*Chrysophyllum Albidum*) from Nigeria. *Afri. J. Food Sci.* 6 (12):344-351.
- Adubiaro, HO; Olaleye, AA (2016). Proximate, Minerals and Fatty Acids Composition of African Star Apple Seed (*Chrysophyllum Albidum*). Proceedings of The 2016 Faculty of Science International Conference.
- Agbabiaka, LA; Eke LO; Nwankwo, CF (2013). Nutrients and Phyto-Chemical Assay of African Star Apple Kernel (*Chrysophyllum africanum*) as Potential Feedstuff in Fish and Livestock Production. *Brit. J. of Appl. Sci. & Tech.* 3(4):1215-1219.
- Ajayi, IA; Ifedi, EN (2015). Chemical and Preliminary Toxicological Evaluation of *Chrysophyllum Albidum* Seed Flour in Dietary Formulation of Albino Rats. *IOSR J. Env. Sci. Toxic. Food Tech.* 9(6):59-67.
- Akbar, E; Yaakob, Z; Kamarudin, SK; Ismail, M; Salimon, J (2009). Characteristic and composition of *Jatropha Curcas* oil seed from Malaysia and its potential as biodiesel feedstock. *Euro. J. Sci. Res.* 29:396-403.
- Akubugwo, IE; Yusuf, D; Obiegunam, JE (2007). Physicochemical Studies on Oils from Five Nigerian Plant seeds. *Pak. J. Nutr.* 6:75-78
- Aladekoyi, G; Shakpo, I.O; Omosuli, SV; Jide, AO (2016). The Effect of Fermentation on the Physicochemical and the Fatty Acid Composition of Oil of African Star Apple Endosperm (*Chrysophyllum Albidum*). *Int. J. Sci. Res. Eng. Studies* 3(1):49-62
- AOAC (2010). Official Methods of Analysis. 18<sup>th</sup> Ed., Rev. 3, Association of Official Analytical Chemists, Washington DC.
- Aremu, MO; Ibrahim, H; Bamidele TO (2015). Physicochemical Characteristics of the Oil Extracted from Some Nigerian Plant Foods – A Review. *Chem. Process Eng. Res.* 32:222-228.
- Aremu, MO; Olaofe, O; Akintayo, ET (2006). Chemical Composition and Physicochemical Characteristics of Two Varieties of Bambara Groundnut (*Vigna subterrenea*) Flours. *J. Appl. Sci.* 6:1900-1903.
- Arkroyed, WR; Doughty, J (1964). Legumes in human Nutrition. Food and Agricultural Organisation Nutrition Studies Publication 19.
- Audu, TOK; Aluyor, EO; Edualeona, S; Momoh, SS (2013). Extraction and Characterization of and *Luffa* cylindrical seed Oils. Petroleum Technology Journal: *An Int. J.* 3 (1):1-7.
- Azor, A; Kolade, J; Adebisi, A; Sola-Ojo, F; Edoh, J; Ajide, S (2017). Utilization of African Star Apple (*Chrysophyllum Albidum*) Kernel Meal in Broiler Diets. *J. Agri. Sci.* 62(2):143-154.
- Bada, SO (1997). Preliminary Information on the Ecology of *Chrysophyllum albidum* in West and Central Africa. In proceedings of National Workshop on the potential of the star apple in Nigeria pp. 16-25.
- Belsare, GW; Badne, SG (2007). Study On Physico-Chemical Characterization of Edible Oils from Agencies of Buldhana District. *Int. J. Res Pharm. Chem.* 7(4):525-529.
- CODEX *Alimentarius* Commission, 2005 Codex standard for named vegetable oils- 'Codex stan

- 210-1999'. Food and Agricultural Organisation of the United Nations and the World Health Organisation.
- Damilola, AO; Ugochukwu, BA; Oti, AA (2016). Comparative Evaluation of Chemical Profile of *chrysophyllum Albidum* Seed Cotyledon and Leaf. *J. Med. Plants Studies* 4(4):203-207
- Demian, MJ (1990) Principles of Food Chemistry. 2nd Ed. Van Nostrand Reinhold International Company Limited, London, England, pp: 37-38.
- Edward-Ekpu, DU; Audu, SS; Odiba, VA; Okopi. OS; Affiku, ML (2016). African Cereals and Non-African Cereals: A Comparative Review of Their Nutritional Composition. *World J. Appl. Chem.* 1(2):30-37
- Inekwe, UV; Odey, MO; Gauje, B; Dakare, AM; Ugwumma, CD; Adegbe, ES (2012). Fatty Acid Composition and Physicochemical properties of *Jatropha Curcus* oils from Edo and Kaduna State of Nigeria and India. *Annals Bio. Res.* 3:4860-4864
- James, CS (1995). Analytical Chemistry of Food. Champion and Hall, London, PP: 64-65.
- Mohammed, MI; Hamza, ZU (2008). Physicochemical Properties of Oil Extracts from *Sesamum Indicum* L. Seeds Grown in Jigawa State – Nigeria. *J. Appl. Sci. Environ. Manage.* June, 12(2) 99-101
- Nieman, DC; Butterworth, DE; Nieman, CN (1992). Nutrition. Winc Brow Publishers. Dubugne, USA. Pp 237-312.
- Oderinde, RA; Ajayi, IA; Adewuyi, A (2009). Characterisation of seed and seed oil of *Hura crepitans* and the Kinetic of Degradation of the oil during Heating. *Electr. J. Environ. Agri. Food Chem.* 8 (3):201- 208
- Oguntoyinbo. OO; Abdus-Salaam RB; Bello WA; Ifesan BOT (2015). Evaluation of Phytochemical, antioxidant and antimicrobial properties of the extract from *chrysophyllum Albidum* (African Star Apple) leaf. *J. Food Tech. Res.* 2(1):1-10
- Oladiji, AT; Yakubu, MT; Idoko, AS; Adeyemi, O; Silva, MO (2010). Studies on the Physicochemical Properties and Fatty Acid Composition of the Oil from Ripe Plantain Peel (*Musa Paradisiaca*). *Afri. Scient.* 11 (1):73-78
- Pearson, DA (1976). Chemical Analysis of food (7<sup>th</sup> Edition). Edinburgh, Churchill, Livingstone, Pp. 4222- 511.
- Shills, ME; Young, VR (1988). Modern nutrition in health and disease. In: Nieman DC; Butterworth DE; Nieman CN (ed) Nutrition, Winc Brow Publishers. Dubugne, USA. Pp 276-282.