International Journal of Sciences & Applied Research

www.ijsar.in

Mycoflora and nutritional composition of *Chrysophyllum albidum* fruits/ seed oil

*[1]Akpe, Azuka Romanus, [2]Okwu, Grace Ifeoma, [3]Abu, Dirisumedinat, [4]Femi Imah Justus

[1, 2, 3, 4]Department of Microbiology, Ambrose Alli University, Ekpoma, Edo State

Corresponding author: *Akpe, Department of Microbiology, Ambrose Alli University, Ekpoma, Edo State.

Abstract

Chrysophyllum albidum is primarily cultivated for their sweet fleshy fruit and has been reported as an excellent source of vitamin C, iron and other nutrients. Nevertheless, it is deteriorated by different species of fungi. This present study examined the nutritional, proximate and physicochemical composition and fungi species associated with the deterioration of *Chrysophyllum albidum*fruits. Standard procedures were used for the analysis. Results showed that the fungi associated with *Chrysophyllum albidum*fruit were *Aspergillus flavus, Aspergillus fumigatus, Rhizopus stolonifer, Fusarium oxysporium*, *Sacharomyces cerevisiae*and *Candida albican.* Of these, *Rhizopus stolonifer* was the most predominant.The range of values for the proximate composition were; crude protein (5.74±0.64 – 9.75±0.43), carbohydrate (15.17±0.65 – 37.37±2.16), crude fibre (10.13±0.75 – 92.11±2.54), crude fat (2.67±0.23 – 8.35±1.01), ash (4.25±0.29 – 7.20±0.44), moisture content (26.74±2.72 – 65.80±2.39) and energy value (123.71±0.24 – 247.59±0.62).The range of the vitamins and mineral contents of the pulp were vitamin C (25.26±0.58 – 54.37±2.20), vitamin A (0.07±0.01 – 1.11±0.14), calcium (29.04±1.16 – 40.80±0.95), magnesium (20.58±0.39 – 24.95±0.32), phosphorus (3.53±0.12 – 9.06±0.63), sodium (4.53±0.39 – 6.30±0.59), iron (0.78±0.24 – 1.39±0.06) and zinc (4.84±0.26 – 7.92±0.54).The pH, titrable acidity and viscosity of the fruits pulp ranged from 5.46±0.12 – 6.83±0.38, 0.97±0.08 – 1.69±0.02 and 12.67±3.393 – 35.37±2.12 respectively. The seed oil yield is 8.75% and is liquid room temperature with brownish-red colour and a sweet smelling flavour. It has an acid value of 4.30±0.31mgkOH/g, free fatty acid (FFA) of 2.19±0.15mgkOH/g, saponification value of 198.90±0.10mgkOH/g, iodine value of 33.8±0.52mg/100mg, peroxide value of 1.54±0.08mgeq/kg, specific gravity value of 0.91±0.02 and refractive index of 1.459±0.30. The microbiological and nutritional implications of these findings are hereby discussed.

Keywords: *Chrysophyllum albidum* fruit, Mycoflora, Nutritional and physicochemical composition, Seed oil

INTRODUCTION

Fruits are essential food components that contain vitamins, minerals, fibres and antioxidant. Antioxidant helps to mop up free radicals that are capable of damaging the body cells. Fruits provide a wide range of health benefits such as reducing the risk of heart disease, cancer, inflammation and diabetes.

Chrysophyllum albidum (African Star Apple) produces large berry that contains up to five seeds that are flat in shape. The leaves of the plant are alternate and nearly evergreen elliptic, slightly leathery. The fruit could be ellipsoid, round or pear shaped. It has a milky sweet pulp that houses the seeds. When the fruit is cut transversely it appears like asterisks in the central core or like the pointed stars (Edem and Miranda, 2011). The plant recently became a crop of commercial value and its fruits are gaining wide acceptance due to its nutritional and medicinal benefits. The fleshy pulp is eaten by humans and some wild animals. The fruits are attacked by pests while on the tree when it is fully ripened (just about to drop), and on the ground after dropping because of its aromatic nature. The fruits get contaminated from the air while on the tree and on the ground. As pests perch on them, they also inflict contamination and some lay eggs on the fruits in a region close to the fruit point of attachment to the parent plant.

The African star apple fruit/seed could serve as alternative carbohydrate or energy foodstuff. Preliminary investigations showed *Chrysophyllum albidum* seed contains valuable nutrients such as crude protein, carbohydrate, crude fat, crude fibre, mineral matter in concentrations of 8.75, 83.38, 3.45, 2.45 and 2.00% respectively warranting the potentials of the seed as a good novel food stuff for animals. In addition to these qualities, it has an acceptable composition of moisture, ash, protein, starch and sugar as cited in Adindu, *et al*., (2003). Mineral analysis also revealed the presence of phosphorus (P), and aluminum (Al), (Chukwuemeka, 2006). The seed is also known to be an important source of oil for diverse purposes (Amusa *et al*., 2003). This oil acts as insulator to the body, reduces chances of stroke and serves as antioxidant (Odigbo and Paiko, 2011).

Beside its nutritional properties, some species of fungi are implicated in the deteriorationof *Chrysophyllum albidum*fruits. Some of the fungal species include: *Aspergillus fumigatus, Aspergillus flavor, Fusarium oxysporium, Rhizopus stolonifer, Mucor mucedo, Aspergillusrepens* etc. These organisms utilize the nutrients in the fruit to overcome the antimicrobial properties of the exudates (Adindu *et al*., 2003). This research is geared towards the nutritional composition of *C. albidum* and knowing the possible fungi that could wreak havoc on the fruit in the environ of Ekpoma, Edo State, Nigeria.

MATERIALS AND METODS

Sources and collection of Samples

Samples were collected from different trees located at Opoji village, Esan West Local Government Area, Edo State, Nigeria. The samples that dropped from trees over the night were the ones collected in the morning. Samples were immediately transported to Ambrose Alli University laboratory for analysis.

Sample Treatment and Isolation Associated Fungi

The samples were surface sterilized in 2% aqueous solution of commercial bleach (sodium hypochlorite) for 2mins, followed by further treatment in 75% ethanol for another 2mins and then rinsed in two sequence of changed autoclaved distilled water. Samples were then separated into four groups (A, B, C and D) of 10 fruits each in triplicates. Group A was without

any substance rubbed on it (control), group B was with *C. albidum* oil, group C with coconut oil rubbed on it and group D had 0.5% Sodium carbonate (a chemical preservative) rubbed on it. This was achieved by first reconstituting the Sodium carbonate from its solid state to liquid by weighing 1g of Sodium carbonate and dissolving in 100ml of sterile distilled water. With the aid of a sterile syringe, 0.5ml was measured and sprayed on group D in a sterile bowl and agitated for even circulation. This was done to group B and C using 0.5ml of C. *albidum* oil and coconut oil respectively. Representative fruits from each group at day 1 were dissected into pieces with sterile cutting blades and 20g each was transferred into 180ml of sterile quarter strength Ringer's solution. The solution and its content was periodically agitated to homogenize and left to stand for 2 hours after which the content was serially diluted. In the process, an aliquot of 0.1 ml was plated on Sabouraud Dextrose Agar (SDA) and incubated at ambient temperature ($28\pm2^{o}C$) for 48 hours. All experiments were done in triplicates. Fungal identification was done by observing colonial characteristics, followed by lactophenol blue staining and microscopy. Details of observed characteristics were compared to features outlined in district laboratory manual of fungal identification (Cheesebrough, 2006).

Procedure for Seed Oil Extraction

Approximately 200g of the milled (pulverized) cotyledon was extracted with 2000 ml of solvent (n-Hexane) using the Soxhlet apparatus. In the process, the reflux condenser was fitted to the top of the extractor and the water flow was turned on. The round bottom flask was placed in the heating mantle and the temperature of the mantle adjusted to $65^{o}C$ so that the solvent is brought to the vaporization point. The extraction process was allowed to continue over a period of time for complete extraction after which the extractor was turned off with the condenser detached, thimble removed and filtrate collected in the round bottom flask. The filtrate was heated at $65^{o}C$ using a thermostatically controlled water bath to remove residual solvent. The oil was then decanted from the evaporating dishes and the yield was weighed. The oil was introduced into sterilized sample bottle and stored in the refrigerator at $4^{o}C$ for subsequent investigations Association of Official Analytical Chemists, (2000).

Preparation and determination of physicochemical, nutrient and Proximate Composition of the Fleshy Pulp of *C. albidum*

Samples collected from each group (A, B, C and D) at day 1 and at day 11 were cut open using sterile blade, de-seeded and the fleshy pulp were oven dried at $65^{o}C$. The dried pulp was pulverized (milled into fine powder) using laboratory sterilized mortar and pestle. The pulverized powder was subsequently analysed for protein, crude fibre, crude fat, carbohydrate, ash, moisture content, vitamin-A, vitamin-C, calcium, magnesium, phosphorus, potassium, sodium, zinc and iron. The analysis of the proximate composition was carried out using the modified official methods of analysis of the (AOAC 2000).

i. Moisture content

The moisture content was determined using weight difference method (AOAC, 2000). The powdered sample (2g) was weighed into a clean dry crucible of known weight. The crucible with its content was oven dried at $105^{0}C$ for 3-6hrs. It was then removed after the first 3hours and weighed at 30 minutes interval until a constant weight is achieved. The moisture content was calculated as loss in weight in percentage. It is given by the formular:

$$MOISTURE = \frac{W_1 - W_2}{W_1}$$

Where: W_1 = original weight of sample before drying and W_2 = Weight of sample after drying.

ii. Total ash

The total ash value was determined using the dry ashing method (AOAC, 2000). Six clean crucibles were labeled 1- 6 and 2g of the powdered samples were weighed into each crucible. Three of the crucibles with its contents were heated in the muffle furnace at 600^{o}C for 3hrs until white (light grey) residue was obtained. The muffle furnace was switched off allowed to cool and all the crucibles were removed, cooled in a desiccator and reweighed. The percentage ash was calculated for the three replicates with reference to the air dried content of the other three crucibles. The ash percentage was calculated as follows:

Weight of ash/weight of sample x 100/1

iii. Crude protein

The amount of protein in the powdered sample was measured as total nitrogen using Kjeldahl method described by AOAC (1990) involving digestion, distillation and finally titration of the sample. The powdered sample (1g) was weighed into the digestion tube and digested with 10ml of concentrated sulphuric acid and 2.5g of catalyst [K_4SO_4/Na_2SO_4 and CU (9:1)] and heated to give a transparent green solution. The solution was allowed to cool and 10ml of 40% NaOH was added to the digest to give a blackish solution. The resultant solution was distilled and the distillates were collected in 10ml of 2% Boric acid indicator. The resultant Boric acid distillate solution (25ml) was titrated with 0.1N HCl in triplicates until the dark green colour of the indicator changed to red at the endpoint. The same procedure was used for blank without the sample. The total nitrogen content was calculated from the equation below;

CP% = Va x Na x 14/1000 x 100/V_2 x 100/W x 6.25

Where Na = Concentration of HCl used for titration (0.1N)

Va = Volume of HCl used for titration

1000 = Constant

14 = Atomic number of Nitrogen

V_1 = Final volume of digest (100ml)

V_2 = Volume of aliquot (10ml)

W = Weight of sample used

6.25 = conversion factor from nitrogen to crude protein

iv. Crude fat

The method described by AOAC (2000) was adopted. A neatly folded filter paper containing the sample was placed into a Soxhlet apparatus filled with petroleum ether. The apparatus was heated and set on 5-6 drops per second for four hours. Following Soxhlet extraction the filter paper and it content was removed from the apparatus and kept at room temperature to air dry, before keeping it overnight in the oven at 100^{0}C. After 12hours of drying the filter paper and its content were removed from the oven cooled in a desiccator and the weight was recorded. The ether extract was expressed as a percentage of the sample weight.

v. Crude fibre

Crude fibre was equally analysed according to AOAC (2000).A known weight of the powdered sample (2g) was weighed into a clean dry beaker. About 10ml of acetone was added to the sample and the sample was allowed to air dry for 10mins. To the air driedsample 200ml of 1.25% sulphuric acid was added; the mixture was heated over a hot plate and allowed to reflux for 30mins. After reflux the mixture was filtered through a muslin cloth rinsing with hot water to neutrality. To the filtrate 200ml of 1.25% of NaOH was

added; the mixture was allowed to reflux again for 30mins.The resultant mixture was filtered and the residue was washed with dilute HCl followed by hot water till it is free from alkali. The residue was dried in a crucible of known weight at 80^oC for 20mins. The dried residue was ashed for 2hours at 300^0C in a muffle furnace. The loss of weight due to ignition was recorded as the weight of crude fiber. It can be shown as: Ash wt./wt. of sample x 100/1

vi. Nitrogen free extract (Total carbohydrate)

Nitrogen free extract which represent the digestible carbohydrate was determined by difference between the total value of moisture, crude fibre, crude protein, crude fat, and ash from 100 percentage.

N. F.E. = 100 - Crude protein + Moisture content + Ash + Lipid + Crude fibre

vii. Energy value

The energy values (Kcal/100g) were determined by multiplying the values of carbohydrate, lipid and protein by factors of 4, 9 and 4 respectively and the total sum expressed in kilocalories (Onyeike and Ikru, 1998; Imran, Talpur, Jan, Khan and Khan, 2007). All proximate values were carried out in triplicates and expressed in percentage.

viii. Vitamin C: Ascorbic acid (Vit. C) was determined according to the method of Ranganna of analysis of quality control for fruits and vegetable product (Prasad and Bisht, 2011). 10 to 20 ml of sample was extracted with 100 ml of 3% HPO_3 at room temperature. Then filtered the sample with a glass wool funnel. After that, (2-10 ml) aliquot was taken and titrated against dye solution (0.1% solution of 2, 6-Dichlorophenol indophenol dye). Titration point was indicated by pink colour. Ascorbic acid content of the sample was calculated by following formula:

$$\% \text{ Ascorbic acid} = \frac{\text{Titre} \times [\text{Dye factor}] \times \text{Vol. made up} \times 100}{\text{Wt. of Aliquot}}$$

ix. Vitamin A: It was determined by the rapid Carr-price method, in which the blue colour formed with antimony trichloride was measured using the ultra-violet absorbance in an organic solvent.

x. Mineral contents: The mineral composition (calcium, magnesium, phosphorus, potassium, sodium, iron and zinc) were determined using, analytical methods of atomic absorption spectrophotometer after ashing and dissolving the samples in 10% hydrochloric acid (AOAC, 2000).

xi. Determination of the viscosity

The viscometer was used in this assay. In the process, distilled water (10 ml) was added to the viscometer at 20^oC. Using suction to draw water above the upper mark the liquid level was allowed to fall and the timing started with a stop watch as meniscus passes the upper mark until it got to the lower mark. The viscometer was then rinsed and the samples applied and the time required for its passage between meniscuses was determined which was used to calculate the viscosity with the formula:

$$\text{Viscosity} = \frac{\text{flow time of solution at } 20^oC \times \text{specific gravity of the sample solution} \times 1.002 \times 100}{\text{Flow rate of water at } 20^oC.}$$

xii. Determination of the titratable acidity (TTA)

The pulverized pulp was homogenized with 100 ml of water and the homogenates centrifuged to obtain the supernatant. About 50 ml of the clear liquid (supernatant) was

measured out into a beaker and titrated with 0.1N NaOH. The solution which was considerably clear with phenolphthalein turns pink momentarily but disappears with swirling and the first permanent pink indicates the end point. The titratable acidity is calculated by the formular:

$$\% \text{ acid} = \frac{\text{mls NaOH used} \times [0.1 \text{ N NaOH}] \times [100]}{\text{Grams of aliquot}}$$

xiii. Determination of the pH

The pH of the African star apple fruit was determined using the pH meter. The pieces of the fruit were homogenized for 30 minutes at 5 minutes interval inside a clean glass beaker with sterile distilled water. The electrode of the standardized pH meter was inserted into the homogenates and reading were taken and recorded.

All experiments were carried out in triplicates and their mean values were calculated and recorded.

RESULTS AND DISCUSSION

This study was carried out to determine the possible fungal species associated with the fresh and preserved *C. albidum* fruits and also their nutritional/ physicochemical composition. The results of this study are shown in Tables 1 – 5.

Table 1 showed the cultural, morphological and biochemical characteristics of fungi isolated from *Chrysophyllum albidum* fruits. The isolated fungi included - *Aspergillus flavus, Aspergillus fumigatus, Rhizopus stolonifer, Fusarium oxysporium, Sacharomyces cerevisiae, Candida albican.* Of these, *Rhizopus stolonifer* was the most predominant. This result, differs slightly from those reported by Arotupin *et al*. (2016) on deteriorated *C. albidum* pulp. The presence of these organisms may be due to the nutrient rich nature of the fruit which supports the growth and proliferation of the organisms. Microorganisms are ubiquitous and could contaminate or find their way into fruits from the air, water (during rainfall), soil (especially due to the accompanying impactful pressure that dropping fruits exert as they hit the ground from trees) and animals including insects and birds that hovers over fruits before or after dropping (Adindu *et al*., 2003; Ureigho and Ekeke, 2010; Mohammed and Ali, 2015).

The range of values for the proximate composition were; crude protein (5.74±0.64 – 9.75±0.43), carbohydrate (15.17±0.65 – 37.37±2.16), crude fibre (10.13±0.75 – 92.11±2.54), crude fat (2.67±0.23 – 8.35±1.01), ash (4.25±0.29 – 7.20±0.44), moisture content (26.74±2.72 – 65.80±2.39) and energy value (123.71±0.24 – 247.59±0.62). The nutrient rich nature of the fruit as growth medium for proliferation of vast array of microorganism is supported by the results of proximate, mineral and vitamins analyses (Tables 2 and 3) which show that the fresh fruit is rich in carbohydrate, crude fat, moisture, protein, fiber, vitamins (C and A) and some vital minerals all of which are necessary for the balance growth and proliferation of cells. Higher carbohydrate, fibre, fat, moisture and energy values were recorded for the fresh fruit pulps on day 1 than those recorded for the various experimental groups (A to D) whereas among the groups, the reference values were higher in group B, C and D than the control group A. Similar pattern was recorded for the vitamin C, vitamin A, calcium, phosphorus, potassium, sodium, iron and zinc content. These results clearly indicate the richness of the healthy pulp over the deteriorated counterpart. It further reveals that even upon deterioration, the groups treated with preservatives managed to maintain the original richness of the fruits but could not absolutely maintain the original quality and hence had higher values due to the action of the preservatives when compared with the control group A which had no preservatives. Similar results

were reported by Ureigho and Ekeke (2010) who recorded higher values of carbohydrates, fibre, energy, moisture, vitamin C, vitamin A, calcium, phosphorus, potassium and sodium content for the healthy pulp of *C. albidum* than the deteriorated pulp which had corresponding lower values. In contrast, the crude protein, ash, and magnesium values were lower in the healthy pulps than the deteriorated pulps in the various groups. Also, the experimental group B, C and D had lower crude protein, ash, and magnesium values than the group A (control) which had the corresponding highest values of crude protein, ash, and magnesium. In a related research, Arotupin *et al.*, (2016) reported 9.83% crude protein, 6.67% ash and 38.34% magnesium values for the fresh pulp of *C. albidum* which had lower values than the corresponding 12.28%, 10.28% and 46.35% for the spoilt fruits. The more of these carbohydrates, proteins, fat, moisture, minerals, etc in the healthy fruits as opposed to the deteriorated experimental groups and vice versa could have resulted from the concomitant uptake and release of these minerals in the course of the metabolic activities of the associated microorganisms. The higher values of the magnesium, ash and crude protein in the deteriorated fruits may be attributed to higher microbial biomass contributing their cytofibrils, magnesium and protein content to the deteriorated fruits (Amusa *et al.,* 2003; Ajala and Adeleke, 2014; Damilola, *et al*., 2016).

The vitamins and mineral contents of the pulp of *C. albidum* are shown in Table 3. The range of values were vitamin C (25.26±0.58 – 54.37±2.20), vitamin A (0.07±0.01 – 1.11±0.14), calcium (29.04±1.16 – 40.80±0.95), magnesium (20.58±0.39 – 24.95±0.32), phosphorus (3.53±0.12 – 9.06±0.63), sodium (4.53±0.39 – 6.30±0.59), iron (0.78±0.24 – 1.39±0.06) and zinc (4.84±0.26 – 7.92±0.54) respectively.

The pH, titrable acidity and viscosity of the fruits pulp ranged from 5.46±0.12 – 6.83±0.38, 0.97±0.08 – 1.69±0.02 and 12.67±3.393 – 35.37±2.12 respectively as shown in Table 4. The physicochemical properties revealed the average pH (5.46±0.12) and titratable acidity (TA) (1.69±0.02) of the healthy fruits as moderately acidic, whereas the deteriorated fruits the pH ranged from 6.18±0.07 to 7.30±0.22. These in no small measure indicate that the fruits could permit and tolerate the growth of microorganisms (Amusa *et al*., 2003; Jayani *et al*., 2005). The viscosity showed a higher value (35.37±2.12%) for the healthy fruits than the deteriorated fruits in each of the groups - A (11.81±0.33%), B (16.67±3.93%), C (16.32±1.01) and D (16.87±0.27). Groups B, C and D had very similar values of intermediate viscosity when compared to group A (control) which had the least viscosity. The healthy pulps had the highest viscosity value. The viscosity values are indicative of the degradative activity of the associated microorganisms and their ability to breakdown carbohydrate and other structural polymers which serve as carbon source for their nourishment and growth. The intermediate viscosity values of groups B, C and D is a pointer to the restrictive effect of the applied preservatives

Table 5 showed the physicochemical properties of the seed oil of *C. albidum*. The oil is in liquid state at room temperature with brownish-red colour and a sweet smelling odour. It has an acid value of 4.30±0.31mgkOH/g, free fatty acid (FFA) of 2.19±0.15mgkOH/g, saponification value of 198.90±0.10mgkOH/g, iodine value of 33.8±0.52mg/100mg, peroxide value of 1.54±0.08mgeq/kg, specific gravity value of 0.91±0.02 and refractive index of 1.459±0.30. Its specific gravity of 0.91 ± 0.02 means that it is less dense than water.

This value is consistent with those obtained by Belewu *et al.,* (2010) for *Jatropha curcas* seed oil. The refractive index indicates the level of optical clarity of the oil sample relative to water. A refractive index of 1.459± 0.30 which is in agreement with the value of 1.46 obtained for the African star apple seed oil by Ochigbo and Paiko (2011) shows that the oil is not as thick as most drying oils whose refractive indices fall between 1.475 and 1.485 (Akinhanmi and Akintokun, 2008). The oil yield which is 8.75%is low compared to the values reported in seeds of neem 46%, cotton 24% and groundnut 46% (Tint and Mya 2009; Adebayo *et al*., 2012). This indicates that the seed may not be a good source of abundant oil. However, genetically modified breeds may be developed which could produce seeds with more oil yield. The iodine value 33.8 ± 0.52 mg/100g of African star apple seed is in close agreement with the value 31.06±0.80 mg/100g from previous work on African star apple seed by Akubugwo and Ugbogwu (2007). However, the iodine value is lower than that obtained for shea butter nuts by Enweremadu and Alamu (2009). Oils are classified into drying, semi-drying and non-drying according to their iodine values. Since the iodine value of *C. albidum* seed oil is lower than 100, it could only be classified as a non-drying oil. The low iodine value indicates that the oil has a low content of unsaturated fatty acids thus resembles olive oil and groundnut oil. It could be employed for manufacture of soaps, lubricating oils and lighting candles which traditionally requires fats or saturated oils (Enweremadu and Alamu, 2009). The oil will not attract high interest in the paint and coatings industry unless it undergoes dehydration before use. Its suitability for the manufacture of soaps, lubricating oil, candles etc is an attractive option because this oil, being not known yet commercially for consumption, can help to minimize dependence on use of known edible oils for making such products (Ochigbo and Paiko, 2011). The acid and free fatty acid values obtained are 4.30 ± 0.31 and 2.19 ± 0.15 mg/KOH/g. These agrees with those obtained by Eka and Chidi (2009) for butternut oil and Akubugwo and Ugbogwu (2007) who reported acid and free fatty acid value of 4.50 and 2.25 mg/KOH/g respectively for *C. albidum* seed oil. Acid value is a direct measure of the percentage content of free fatty acids in a given amount of oil. It is a measure of the extent to which the triglycerides in the oil have been decomposed by lipase action into free fatty acids. It depends on the degree of rancidity which is used as an index of freshness (Aremu *et al.,* 2015; Ochigbo and Paiko, 2011). Hence, the low values obtained in the results are indicative of the freshness and edibility of the oil. More so, the peroxide values obtained for the oil is 1.54±0.08mgEq/kg which is below the maximum acceptable value of 10mgEq/kg set by the Codex Alimentarius Commission for such oils as groundnut seed oils (Akubugwo and Ugbogu, 2007). Peroxide value is an index of rancidity, thus the high peroxide value of oil indicates a poor resistance of the oil to peroxidation during storage (Mohammed and Hamza, 2008). Peroxide value is an indication of the level of deterioration of oil. The low peroxide value further confirms the stability of the oil. Fresh oils have values less than 10meq/kg. Higher values between 20 and 40meq/kg results to a rancid taste (Akubugwo and Ugbogu, 2007). The low acid and peroxide values are indicators of the ability of the oil to resist lipolytic hydrolysis and oxidative deterioration (Akanni *et al.,* 2005). Saponification value obtained was 198.90±0.10mgKOH/g. This compared favourably with values obtained for sesame seeds (189 to 190 mgKOH/g) by Mohammed and Hamza, (2008) and some common oils like palm oil (196 – 205

mgKOH/g), groundnut oil (188 – 196 mgKOH/g), corn oil (187 – 196 mgKOH/g) and lower than that of coconut oil (253mgKOH/g) and palm kernel oil (247 mgKOH/g) as reported by Akanni*et al*. (2005). According to Mohammed and Hamza, (2008) a saponification value of 200mgKOH/g indicates high proportion of fatty acids of low molecular weight. This shows that the oil may have a potential for use in soap making and cosmetics industry and for the thermal stabilization of poly vinyl chloride (PVC); These properties make them useful as sources of essential fatty acids required in the body (Akanni *et al.*, 2005). However, this saponification value is within the range for edible as oils reported by Ochigbo and Paiko, (2011).

Table 1: Cultural, Morphological and Biochemical Characteristics of the Fungal Isolates

Colonial morphology	1	2	3	4	5	6	7
a) Elevation	Low convex	Low convex	Raised	Raised	Low convex	Convex	Low convex
b) Margin	Smooth	Rough	Rough	Rough	Rough	Smooth	Smooth
c) Shape	Irregular	Circular	Irregular	Irregular	Irregular	Circular	Irregular
d) Colour	White Grey on SDA but greenish on CHRAgar	Greenish Yellow on SDA	Brownish Black on SDA	Wooly Brown on SDA	White Yellow on SDA	Creamy on SDA	Creamy on SDA and greenish on CHRAgar
Cell Characteristics							
a) Conidia	-	-	+	-	+	-	+
b) Sporangiospores	+	-	-	+	+	-	-
c) Rhizoids	-	-	+	+	-	-	-
d) Cell type	Round buds	F. mycelia	F.mycelia	F.mycelia	F.mycelia	Round buds	Round buds
e) C.A.	Overlapping buds	Overlapping	Elongated septate filament	Elongated septate filament	Fluffy white mycelia	Overlapping	Overlapping
Isolated fungi	***Muco mucedo***	***Aspergillus flavus***	***Aspergillus fumigatus***	***Rhizopus stolonifer***	***Fusarium oxysporum***	***Saccharomyces cerevisiae***	***Candida albican***

Keys:C.A = Cell arrangement and F.mycelia = Filamentous mycelia

Table 2: Proximate composition of *C. albidum* pulp ($^{w}/_{w}$ dry mass Mean ± S.E. %)

Parameters	Day 0-1	Day 11			
	(Fresh pulp)	Group A (control)	Group B	Group C	Group D
Crude protein	5.74^{a} ± 0.64	9.75^{b} ± 0.43	6.48^{a} ± 0.31	7.05^{a} ± 0.15	6.59^{a} ± 0.43
Carbohydrate	37.37^{a}±2.16	15.17^{b}±0.65	27.10^{c}±1.72	24.03^{c}±1.76	25.23^{c}±0.61
Crude fibre	25.11^{a}±2.54	10.13^{b}±0.75	20.00^{a}±0.87	14.56^{b}±1.85	19.30^{c}±0.49
Crude fat	8.35^{a} ± 1.01	2.67^{b} ± 0.23	4.53^{b} ± 0.29	3.60^{b} ± 0.36	3.91^{b} ± 0.42
Ash	4.25^{a} ± 0.29	7.20^{b} ± 0.44	5.13^{a} ± 0.01	6.07^{c} ± 0.42	6.13^{c} ± 0.24
Moisture content	65.80^{a}±2.39	26.74^{b}±2.72	47.05^{c}±2.86	42.28^{c}±1.59	42.95^{c}± 0.77
Energy value (Kcal/100 g)	247.59^{a}±0.62	123.71^{b}±0.24	175.09^{c}±0.32	156.72^{c}±0.42	162.47^{c}±0.32

Results are the mean ± SE value of triplicate determinations. Means followed by different alphabet within the row are significantly (P<0.05) different while those with the same alphabet within the row are not significantly (P>0.05) different.

Keys:SE = Standard Error
Group A = Fruit only; Group B = Fruit + *C. albidum*oil; Group C = Fruit + Coconut oil;
Group D = Fruit + 0.5% Sodium carbonate

Table 3: Mineral and vitamins composition of *C. albidum* pulp ($^{w}/_{w}$ dry mass Mean±S.E%)

Parameters	Day 0-1	Day 11			
	(Fresh pulp)	Group A (control)	Group B	Group C	Group D
Vitamin C	54.37^{a}±2.20	10.71^{a}±0.31	29.35^{b}±1.33	25.26^{b}±0.58	26.83^{b}±0.58
Vitamin A	1.11^{a} ± 0.14	0.05^{b} ± 0.00	0.08^{b} ± 0.00	0.07^{b} ± 0.01	0.08^{b} ± 0.01
Calcium (Ca)	40.80^{a}±0.95	20.09^{b}±0.87	30.41^{c}±1.15	29.04^{c}±1.16	29.61^{c}±1.11
Magnesium(Mg)	20.58^{a}±0.39	28.54^{b}±0.62	23.97^{c}±0.84	24.95^{c}±0.32	24.05^{c}±0.85
Phosphorus (P)	5.14^{a} ± 0.61	2.52^{b} ± 0.30	4.03^{a} ± 0.14	3.53^{b} ± 0.21	3.57^{b} ± 0.29
Potassium (K)	9.06^{a} ± 0.63	3.12^{b} ± 0.17	4.69^{c} ± 0.42	4.16^{c} ± 0.12	4.40^{c} ± 0.65
Sodium (Na)	6.25^{a} ± 0.21	3.20^{b} ± 0.53	4.49^{c} ± 0.12	4.53^{c} ± 0.39	6.30^{a} ± 0.59
Iron (Fe)	1.39^{a} ± 0.06	0.06^{b} ± 0.02	0.80^{c} ± 0.19	0.79^{c} ± 0.18	0.78^{c} ± 0.24
Zinc (Zn)	7.92^{a} ± 0.54	3.85^{a} ± 0.32	5.52^{a} ± 0.86	4.84^{a} ± 0.26	5.82^{a} ± 0.22

Results are the mean ± SE value of triplicate determinations. Means followed by different alphabet within the row are significantly (P<0.05) different while those with the same alphabet within the row are not significantly (P>0.05) different.

Key:SE = Standard Error
Group A = Fruit only; Group B = Fruit + *C. albidum*oil; Group C = Fruit + Coconut oil;
Group D = Fruit + 0.5% Sodium carbonate

Table 4: Physicochemical properties of *C. albidum* pulp ($^{w}/_{w}$ dry mass Mean ± S.E. %)

Parameters	Day 0-1	Day 11			
	(Fresh pulp)	Group A (control)	Group B	Group C	Group D
Ph	5.46^{a}±0.12	7.30^{b}±0.22	6.18^{c}±0.07	6.57^{c}±0.16	6.83^{b}±0.38
TTA	1.69^{a}±0.02	0.88^{b}±0.07	1.15^{c}±0.13	1.04^{b}±0.01	0.97^{b}±0.08
Viscosity	35.37^{a}±2.12	15.81^{b}±0.33	12.67^{c}±3.93	16.32^{c}±1.01	16.87^{c}±0.27

Results are the mean ± SE value of triplicate determinations. Means followed by different alphabet within the row are significantly ($P<0.05$) different while those with the same alphabet within the row are not significantly ($P>0.05$) different.

Key:TTA= Titratable acidity
SE = Standard Error
Group A = Fruit only
Group B = Fruit + *C. albidum* oil
Group C = Fruit + Coconut oil
Group D = Fruit + 0.5% Sodium carbonate

Table 5: Physicochemical properties of the seed oil of *C. albidum*

Parameters	Values (Mean ± S.E)
Acid value (mgKOH/g)	4.30 ± 0.31
Free fatty acids (mgKOH/g)	2.19 ± 0.15
Iodine value (mg/ 100g)	33.8 ± 0.52
Saponification value (mgKOH/g)	198.90±0.10
Peroxide value (mgEq/kg)	1.54 ± 0.08
Specific gravity	0.91 ± 0.02
Refractive index	1.459± 0.30
Colour	Brownish red
Odour	Agreeable (sweet smell)
State at 25±2^{o}C	Liquid

Key: S.E = Standard error of mean

CONCLUSION

Chrysophyllum albidum has been relished by man, wild animals and microorganisms because of its nutritive, sensory and tasty nature. Findings in this study revealed that the fruit is rich in essential nutrients such as vitamins, minerals, fibre, iron etc. It also contains some amount of carbohydrate required for body building. The nutritive nature of *C. albidum* makes it a suitable growth medium for diverse fungal species such as *Aspergillus fumigatus, Aspergillus flavus, Fusarium oxysporium, Rhizopus stolonifer, Mucor mucedo* etc. All these facilitate the spoilage of the premium fruit when ripened. Poor handling and injury inflicted on the fruit during harvesting is among the predisposing factors that results in its early microbial deterioration. Understanding the complexity of food-microbial interaction will go a long way in eliminating the spoilage microbes and their possible prevention. Awareness should be made to the public regarding the nutritional

composition of African star apple and its health benefit. This will help to widen its scope of consumption and increase its economic values.

REFERENCES

Adebayo, S.E., Orhevba, B.A., Adeoye, P.A., Musa, J.J. and Fase, O.J. (2012) Solvent extraction and characterization of oil from African star apple (*Chrysophyllum albidum*) seeds. *Academic Research International,* **3**(2): 178 -183.

Adewusi, H.A. (1997). The African star apple (*Chrysophyllum albidum*) indigenous knowledge from Ibadan, South Western Nigeria. In: *Proceedings of a National Workshop on Potentials of the Star Apple in Nigeria.*

Adindu, M.N.; Williams J.O. and Adiele E.C. (2003). Preliminary storage study on African star apple (*Chrysophllumalbidum*). *Plant Food and Human Nutrition*, 58:1-9.

Ajala, A.S. and Adeleke, S.A. (2014). Effect of drying temperatures on physicochemical properties and oil yield of African star apple (*Chrysophyllumalbidum*) seeds *Global Journal of Engineering, Design and* Technology, 3(3):12-16.

Ajayi, A.O. (2011). Sustainable dietary suppliments: An analytical study of African yam bean-*Sphenostylissternocarpa* and corn-*Zeamays.European Journal of Experimental* Biology, 1(4):189-201.

Akanni, M.S.; Adekunle, A.S. and Oluyemi, E.A. (2005). Physico-chemical Properties of Some Nonconvetional Oilseeds. *Journal of Food Technology,* 3(2):177–181.

Akinhanmi, T.F. and Akintokun, P.O. (2008). Chemical Composition and Physico-chemical Properties of Cashew Nut *(AnacardiumOccidentale)* oil and Cashew Nut Shell Liquid. *Journal of Agricultural, Food and Environmental Sciences,* 2(1): 5.

Akpan, I. (2004). Screening for novel fungal biocatalysts. *Nigerian Journal of Microbiology*, 18:288-292.

Akubugwo, I.E. and Ugbogwu, A.E. (2007). Physicochemical studies on oils from five selected Nigerian plant seeds. *Pakistan Journal of Nutrition,* 6(1): 75 – 78.

Amusa, N.A.; Ashaye, O.A. and Oladapo, M.O. (2003). Biodeterioration of the African star apple (*Chrysophyllumalbidum*) in storage and the effect on its food value. *African Journal of Biotechnology*, 2(3):56-59.

AOAC. (1990). Offical Methods of Analysis. Association of official Chemists. 15th ed. Washington DC. Association of official and Analytical Chemists. 234 pp.

Aremu, M.O., Ibrahim, H. and Bamidele, T.O. (2015). Physicochemical Characteristics of the Oils Extracted from Some Nigerian Plant Foods, *Chemical and Process Engineering Research*, 32: 36 – 52.

Arotupin, D.J., Awojobi, K.O., Owolabi, T. R. and Eze, C. (2016). Microorganisms associated with African star apple (*Chrysophyllumalbidum*) and their hydrolases. *African Journal of Microbiology Research*, 10(7): 225-230.

Belewu, M.A., Adekola, F.A., Adebayo, G.B., Ameen, O.M., Muhammed, N.O., Olaniyan, A.M., Adekola, O.F. and Musa, A.K. (2010). Physico-chemical Characteristics of Oil and Bio-dieselfrom Nigerian and Indian *Jatropha curcas*seeds. *International Journal of Biological andChemical Science,* 4(2): 524 – 529.

Buchannan, R.E. and Gibbon, N.E. (2000). Bergeys Manual of Determinative

Bacteriology. Williams and Wilkens Co. Baltimore, USA, 15–43pp.

Cheesbrough, M. (2006) District Laboratory Practice in Tropical Countries part 2. Cambridge University Press, London, 290-320pp.

Chukwuemeka, A.N. (2006). Nutritional value and mineral content of *Chrysophyllum albidum*. *Journal of Science, Food and Agriculture*.33: 283-286.

Cowan, S.T. and Steel, K.J. (1990). Manual for the Identification of Medical Bacteria. 6th edition. Cambridge University Press, London. pp.483-945.

Damilola, A.O.; Ugochukwu B.A. and Oti, A.A. (2016). Comparative evaluation of chemical profile of *Chrysophyllum albidum* seed cotyledon and leaf. *Journal of Medicinal Plants*, 4(4): 203-207.

Dauda, A.O. (2014). Physico-chemical properties of Nigerian typed African star apple fruit. *International Journal of Research in Agriculture and Food Sciences* 2: 2311-2476.

Eka, B.E. and Chidi, E.A. (2009). Physico-chemical characterisation of Butternut *(JugulansCinerea)* oil. *Global Journal of Pure and Applied* Sciences, 15(3): 340.

Enweremadu, C.C. and Alamu, O.J. (2009). Development and Characterization of Biodiesel from Shea Nut Butter. *International Journal of Agrophysics*, 24:29-34.

Holt, J.G.; Krieg, N.R.; Sneath, A.; Staley, J.T. and Williams, S.T. (1994). Bergy's Mannual of Determinative Bacteriology. 9th ed. William and Wilkins, Baltimore, Maryland, USA, 23-35pp.

Imran, M.; Talpur, F.N.; Jan, M.S.; Khan, A and Khan, I. (2007). Analysis of nutritional components of some wild edible plants, *Journal of chemical society Pakistan*, 29(5): 500-508.

Jayani, R.S.; Savena, S. and Gupta, R. (2005). Microbial pectinolytic enzymes. *Review Process* Biochemmistry, 40:2931-2944.

Mohammed, M.I. and Hamza, Z.U. (2008). Physicochemical Properties of Oil Extracts from *Sesamum Indicum*L. Seeds Grown in Jigawa State – Nigeria. *Journal of Applied Science and Environmental Management*, 12(2): 99 –101.

Nwodo, S.C.; Anela, O.E.; Adebayo, I.A. and Janet, A.A. (2010). Assessment of growth and cellulase production of wild-type microfungi isolated from Ota, Nigeria. *Asian Journal of Plant Science*,9(3):118-125.

Ochigbo, S.S. and Paiko, Y.B. (2011). Effects of Solvent Blending on the Characteristics of Oils Extracted from the Seeds of *Chrysophyllum albidium. International Journal of Science andNature* 2(2): 352-358.

Onyeike, E.N. and Ikru, P.R. (1998). Preliminary investigation of proximate composition of heat processed cashew nut seed (*Anacardiumoccidentale*) flours. *Journal of Applied Science and Environmental Management*, 1(1): 27-30.

Oranusi, S.U.; Braide, W. and Umeze, R.U. (2015). Antimicrobial activities and chemical compositions of *Chrysophyllumcainito* (star apple) fruit.*Microbiology Research International*, 3(3): 41- 50.

Pepper, I.L. and Gerba, C.P. (2005). Environmentalmicrobiology: A laboratory manual. 2nd edition.Elsevier academic press. London, 175-189pp.

Prasad, K. and Bisht, G. (2011). Evaluation of nutritive, antioxidant and mineral composition of *Pavettaindica* Linn. Leaves, *Research Journal of Phytochemistry*, 5: 54-59.

Tint, T.K. and Mya, M. (2009). Production of Biodiesel from Jatropha oil *(Jatropha*

curcas) in Pilot Plant. *World Academy of Science, Engineering and Technology*, 4(2):477 – 480.

Ureigho, U.N. and Ekeke, B.A. (2010). Nutrient values of *Chrysophyllumalbidum*Linn Africanstar apple as a domestic income plantation species. *African Research Review*,4(2):50-56.