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SOLVENT EXTRACTION AND CHARACTERIZATION OF OIL FROM AFRICAN STAR APPLE (CHRYSOPHYLLUM ALBIDUM) SEEDS*

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ABSTRACT

African Star Apple (Chrysophyllum albidum) is one fruit of great economic value in tropical Africa due to its diverse industrial, medicinal and food uses. Its seeds have also been found to have a number of beneficial uses. In this study, oil was extracted from the seeds of Chrysophyllum albidum using normal hexane as extracting solvent. The extraction was carried out at a temperature of 65^0C at 3 – 4 hours extraction time. Solvent extraction is known to be the best method of extracting oil from low oil bearing seeds. The method used is aimed at determining the percentage oil yield. At a range of 3 - 4 hours extraction time and a temperature of 65^0C, the average oil yield obtained was 10.71%. The characterization was conducted to determine the physical and chemical properties of the extracted oil shows that the oil was deep red in colour, liquid at 28^0C with a characteristics smell, density of 0.89 kg/m^3, solidification temperature of -2^0C, boiling point of 62^0C, saponification value of 177.30 mg/KOH/gram, acid value of 5.20% free fatty acid value of 2.60%, peroxide value of 1.65 meq/kg, refractive index of 1.4672 at 31.2^0C. These results suggest that Chrysophyllum albidum seeds may be a viable source of oil going by its oil yield. Furthermore, the studied characteristics of the oil extracted shows that it may be used for many domestic and industrial purposes in Nigeria.

Keywords: African star apple, solvent extraction, refractive index, oil yield.

INTRODUCTION

Plant seeds have been used since antiquity as sources of vegetable oil. Examples of some plant seeds which have been conventionally exploited commercially for this purpose includes soyabeans, cotton seed, groundnut, corn, palm seeds and sunflower (Ochigbo & Paiko, 2011).

Seeds of plants are a good source of food for animals, including humans, because they contain nutrients necessary for plant's initial growth, including many healthy fats, such as omega fats. In fact, the majority of foods consumed by human beings are seed-based foods. Edible seeds include cereals, legumes and nuts. Oilseeds are often pressed to produce rich oils – sunflower, flaxseed, rapeseed, sesame. Seeds are typically high in unsaturated fats and, in moderation, are considered a healthy food, although not all seeds are edible (Wikipedia, 2011).

Vegetable fats and oils are lipid materials derived from plants. Physically, oils are liquids while fats are solids at room temperature. Chemically, both fats and oils are composed of triglycerides, as contrasted with waxes which lack glycerin in their structure. Fats are made up of saturated fatty acids while oils are up of mostly unsaturated fatty acids. Although many different parts of plants may yield oil, in commercial practice, oil is extracted primarily from seeds of plants which grow in many different parts of the world. The chief importance of vegetable oils lies in their food value. Oils and

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fats are vital ingredients of a balanced diet because they supply body warmth and build physical energy, and in recent years, vegetable sources have accounted for about three – fifths of the world's consumption of fats and oil, the rest coming from animal and marine fats.

These edible oils are consumed in various ways; the liquid form are used for cooking in warmer climate, in the western world, they are eaten in spreadable form, they are applicable in food industry in the preparation of fats and oils for cooking, salad dressings and ice cream. In addition to their value as a source of oil, the seeds of several of these plants have high protein content, the residue (cake) after the oil has been extracted in many cases provides animal fodder (Elaine, 1975).

There are wide varieties of seeds and nuts that can produce oils for food, nutraceuticals, skincare products, aromatherapies, fuels and industrial lubricants. Also, some of these plant derived oils can be used to make soap, body and hair oils, detergents and paint. A wide range of oilseeds and other oil producing plants are high quality feedstock for biodiesel. Oilseed processing expands the use of crops and also brings value to waste products. Vegetable oils derived from plant seeds have been playing vital roles to provide comfort in human lives in various aspects. Outside the realm of food manufacture, vegetable oils feature in a variety of industrial uses ranging from the manufacture of soap to the production of paints, varnishes, lubricants and plastics. For instance, they have been used for illumination and lubricating purpose, production of detergents and cosmetics and for coatings and paint for many centuries before an abundant and cheap supply of mineral oil became available (Ohison, 1993; Ibemesi, 1992). In the last few decades, there have been growing concerns over vegetable oils as source of material in preference to petroleum or mineral oil. The main factor for this concern is due to environmental issues that regard mineral oil as major contributor of volatile organic compounds (VOCs) which themselves are responsible for most of our present recalcitrant pollution problems threatening the ecology.

The African Star Apple (*Agbalumo* in Yoruba, *Udara* in Igbo) is a native of many parts of tropical Africa. It features prominently in the compound agroforestry system for fruit, food, cash income and other auxiliary uses including environmental uses (Kang, 1992). The tree grows as a wild plant and belongs to the family of Sapotaceae which has up to 800 species and make up almost half of the order (Ehiagbonare *et al.*, 2008). The plant has in recent times become a crop of commercial value in Nigeria (Oboh *et al.,* 2009). It is an evergreen tree and can grow up to 40 metres high and about 2 metres in girth. It has a straight and long fluted bole with small buttress at the base. The bark is thin and light brown and when incised exudes a gummy latex (Jayeoba *et al.*, 2007). The fruit when ripe is ovoid to sub-globose, pointed at the apex, up to 6 cm long and 5 cm in diameter. The skin or peel is orange to golden yellow when ripe and the pulp within the peel may be orange, pinkish or light yellow. Within the pulp are three to five seeds which are not usually eaten. The seeds are dark brown or blackish, obliquely ellipsoid to obovoid, up to 2.8 cm long and 1.2 cm wide; its coat are hard, bony, shiny and dark brown and when broken reveals white coloured cotyledons. Its leaves are elliptic to oblong (Emmanuel & Francis, 2010).

Additionally, it has become known that virtually every type of raw material derived from petroleum and coal can also be obtained from seed oils. Scientists have shown that vegetable oils can be substituted for diesel fuel as a backup power source. It is strongly opined that if fossil fuel should suddenly becomes unavailable, there is no question that vegetable oil could be used to run tractors, turbines and other agricultural implements (Derksen *et al.*, 1996; Ahmad *et al.*, 1996). Thus, it is possible to add value to seeds and nuts by extracting the oils. In this way, waste is converted to wealth. The research work is to study the domestic and industrial applications of *Chrysophyllum albidum* seeds by extracting oil from African Star Apple *(Chrysophyllum albidium)* seeds and to determine the physico-chemical properties of the oil extracted from the seed.

MATERIALS AND METHODS

Sample Collection and Preparation

Fresh fruits of *Chrysophyllum albidum* were purchased from some local markets at Oyo, Oyo State, South Western Nigeria (Latitude 10 00^0N 8 00^0E). The climate off Oyo is equatorial, notably with wet and dry seasons with relatively high humidity. The dry season lasts from November to March while the wet season starts from April and ends in October. Average daily temperature ranges between 25^{0}C (77.0^{0}F) and 35^{0}C (95.0^{0}F), and almost throughout the year. The seeds were removed from the fruit, decorticated and the resulting cotyledons were dried under ambient conditions for one week. Oven drying was avoided so as to prevent loss of constituents due to thermal degradation.

Procedure for Oil Extraction

The extraction method used for this research is soxhlet extraction. 10 g by weight of the milled sample was filled in a thimble was weighed and recorded as W_1 and then filled with the milled sample, reweighed and recorded as W_2. The round bottom flask was weighed and recorded as W_3 and then filled with the solvent (normal hexane) up to two-third of the flask. 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^{0}C so the solvent is brought to the vaporization point. Each extraction occurs over a period of 3 to 4 hours. When the solvent has just siphoned over the barrel, the condenser is detached and the thimble removed. The filtrate is exposed to the atmosphere and the residual solvent is allowed to evaporate.

Characterization of the Extracted Oil

In evaluating the quality of the extracted oil, the refractive index, viscosity, saponification values, acid value, iodine value, free fatty acid value, peroxide value, specific gravity, boiling point and solidification temperatures of the oil were determined using AOAC (2000).

RESULTS AND DISCUSSION

Results

The results obtained from the experimental work of this project are presented in Tables 1, 2 and 3. The tables include results of the oil yield from the extraction process as well as the physical and chemical properties of the extracted oil.

Results of Extraction of Oil from *Chrysophyllum albidum* seeds

Table 1. Oil Extracted at a temperature of 65^{0}C

S/N	Weight of thimble (g)	Weight of sample (g)	Weight of thimble + sample before extraction (g)	Weight of sample + thimble after extraction	% oil yield
1	2.43	9.59	12.02	10.746	10.6
2	2.43	10.943	13.373	11.926	10.82

Table 2. Physical Properties of the Extracted Oil

S/N	Characteristics	Analyzed
1	Refractive index	1.4672 at 31.2^{o}C
2	Odour	Agreeable
3	Colour	Deep red
4	Solidification point	-2^{o}C
5	State at 28^{0}C	Liquid
6	Specific gravity	0.89

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Table 3. Chemical Properties of the Extracted Oil

S/N	Characteristics	Analyzed
1	Saponification value	199.50meq/KOH/gram
2	Acid value	4.50mg/KOH/g
3	Free Fatty Acid value	2.25mg/KOH/g
4	Peroxide value	1.57meq/kg
5	Iodine value	35mg/100g of sample

DISCUSSION

Tables 4.2 and 4.3 present the physico-chemical properties of oil extracted from *Chrysophyllum albidum* seeds. The oil extracted is deep red in colour, the odour is sweet smelling and not offensive. It has a specific gravity of 0.89 which shows that it is less dense than water. This value is consistent with those obtained by Belewu *et al.,* (2010) and Tint & Mya (2009) for J*atropha curcas* seed oil. The refractive index indicates the level of optical clarity of the crude oil sample relative to water. A refractive index of 1.4672 which is in agreement with the value of 1.46 obtained for the African star apple seed oil by Ochigbo and Paiko (2011) and shows that the oil is not as thick as most drying oils whose refractive indices fall between 1.475 and 1.485 (Akinhanmi & Akintokun, 2008).

The oil yield which is less than 12% is low compared to the values reported in seeds of neem seed 46%, cotton seed 24% and groundnut 46% (Abdullahi *et al.,* 1991). 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 35 mg/100g of African star apple seed is in close agreement with the value 31.06$\pm$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 nut butter by Enweremadu & Alamu (2009). Oils are classified into drying, semi-drying and non-drying according to their iodine values. Since the iodine value of *Chrysophyllum 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, could be employed for manufacture of soaps, lubricating oils and lighting candles which traditionally requires fats or saturated oils (Dosunmu & Ochu, 1995). Thus, the oil will not attract high interest in the paint and coatings industry unless it undergoes dehydration before use (Abayeh *et al.,* 1998). 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 & Paiko, 2011).

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; Acid value depends on the degree of rancidity which is used as an index of freshness (Ochigbo & Paiko, 2011). The acid and free fatty acid values obtained are 4.50 and 2.25 mg/KOH/g and this agrees with those obtained by Eka & Chidi (2009) for butternut oil and Akubugwo & Ugbogu (2007) for African star apple oil and also with Pearson (1976) who reported acid values of 4 for sesame, soybean, sunflower and rape seed and 7 for olive oil. It is common knowledge that these parameters are a measure of the level of spoilage of oil, hence we conclude that the fact that they are of low magnitude is a reflection of the freshness and edibility of the crude oil.

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 & Hamza, 2008). The peroxide values of African star apple seeds are 1.57 meq/KOH/g which is below the maximum acceptable value of 10 meq/KOH/g set by the Codex Alimentarius Commission for such oils as groundnut seed oils (Abayeh *et al.,* 1998). Peroxide value is an indication of 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 40 results to a rancid taste (Akubugwo & Ugbogu, 2007). The low acid and peroxide values are indicators of the ability of the oil to resist lypolitic hydrolysis and oxidative deterioration (Akanni *et al.,* 2005)

Saponification value obtained was 199.50 mg/KOH/g. This compared favourably with values obtained for sesame seeds (189 to 190 mg/KOH/g) Mohammed & Hamza, (2008) and some common oils like palm oil (196 – 205 mg/KOH/g), groundnut oil (188 – 196 mg/KOH/g), corn oil (187 – 196 mg/KOH/g) and lower than that of coconut oil (253mg/KOH/g) and palm kernel oil (247 mg/KOH/g) as reported by Pearson (1976). According to Ezeagu *et al.,* (1998) a saponification value of 200 mg KOH/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 makes 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 oils reported by Eromosele *et al.,* (1994).

The results of the iodine value, specific gravity determinations and other physico-chemical analysis of the oil extracted from the African star apple seeds compared favourably with those of other conventional seed oils such as groundnut, soybean and palm kernel oil as well as those reported by other researchers (Abayeh *et al.,* 1998; Ezeagu *et al.,* 1998; Fernando & Akujobi, 1987; Klein, 1994). The oil yield is low compared to some oil seeds. Therefore the seeds should not be subjected to heat as this could destroy the oils. The physico-chemical properties of the African star apple seed oil indicated that it is non-drying and may be used for production of soap, lubricating oil and lighting candles. However, it may not be suitable for oil paint, varnishes and surface coatings due to its non-drying attribute. The low level of unsaturation could possibly be that the oil sample contains linoleic and oleic acids which are typically unsaturated fatty acids.

Conclusively, the seed oils have potential for use as domestic and industrial oil.

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2.5 Characterization of Chrysophyllum albidum oil Characterization of the oil samples obtained from the various solvent extraction fractions were characterized for acid value (AV), saponification value (SV), iodine value (IV),peroxide value and free fatty acid (FFA) value, respectively based on the methods reported by Akpan et al.,(2006). 3. Result and Discussion. Table 1 Chrysophyllum albidum Seed Oil Yield Using 23 Factorial Design. Trial Particle Size(Âµm). Time (hr).Â Characterization of Oil From African Star Apple (Chrysophyllum Albidum) Seeds. Academic. Research International, Vol.3(2), 178-183. This research work was undertaken to determine the physicochemical parameters of oil from the seeds of African Star Apple (Chrysophyllum albidum) and further evaluate the adsorptive properties of the fruit shell. The oil was extracted using hexane with the soxhlet apparatus at a temperature of 65Â°C for 4 hours. The results showed an average oil yield obtained of 11.6%, specific gravity of 0.92kg/m3, the refractive index of 1.464 at 30Â°C, an acid value of 7.72 mg KOH/g, a free fatty acid value of 3.16 g/100g, saponification value of 200.56 mg KOH/g, and an iodine value. of 70.64 g/100g. A Fouri The proximate composition of Chrysophyllum albidum seeds wascarried out using standard analytical methods. The results of the proximate composition was shown to be moisture (14.00Â±0.22%), ash (4.00Â±0.10%), fat (25.58Â±0.51%), fibre (16.00Â±0.13%), protein (25.76Â±0.45%) and carbohydrate (14.64Â±0.01%).The production and characterization. of biodiesel from the seeds was done using Standard procedures. Solvent extraction was employed with the yield of 22.70% oil. The extracted oil was characterized and subsequently used for biodiesel production. On characterization of the oil, saponification value w modified oils of chrysophyllum albidum (African star apple) seeds to reduce the effects of environmental impact. of waste generated from drilling operations. DOI: 10.9790/264X-0602012732 www.iosrjournals.org. 27 | Page.Â Dried chrysophyllum albidum seed kernels were ground and milled to about 2.5mm mesh size prior to extraction.Solvent extraction was carried out using50 g of powdered chrysophyllum albidum seed packed in a muslin cloth and placed in a thimble of the Soxhlet extractor as described in Awolu & Layokun16. The extraction was carried out at 60 oC using n-hexane charged in round bottomed flask. The mixture was thereafter concentrated at 65 oC using a model N-1110S rotary evaporator, to recover the extracted oil as described elsewhere17. Oil was extracted from Chrysophyllum albidum seed using petroleum ether as solvent. The yield of the oil was found to be 4.98%. The result of charact..Â The result of characterization of the oil extract showed that it has iodine value of 163.3 mg, saponification value of 90.71 mg, acid value of 19.70 mg, percentage free fatty acid was 9.90% and dirt content was 0.23%. The specific gravity of the oil at 25ÂºC and its content was found to be 0.8269 and 10.00%, respectively. The color analysis gave red, yellow, blue and neutral to be 1.1, 2.2, 2.1 and 0.0, respectively. Thus, the oil was found to be a drying oil.