Extraction of Chrysophyllum albidum Seed Oil: Optimization and Characterization

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Abstract
This work presents the result of the optimization of extraction of oil from *Chrysophyllum albidum* seed using ethanol as solvent. A 2^3 factorial designs with replication was employed to study the effect particle size, time, and temperature of extraction. The oil yield from extraction was 12.70 – 16.85 % with the optimal yield of 16.85 % at particle size of 500 µm, temperature of 55 ^{0}C, and a time of 6 hours. Characterizations of the oil reveal a Saponification value of 228.4mgKOH/g, iodine value of 30 gI_2 /100g, peroxide value of 1.45 meq/kg, acid value of 2.52 mgKOH/g. The oil extracted from this seed can be effectively used for variety of domestic and industrial application such as the making of paint, candles, soap and biodiesel.
Keywords: Optimization, Characterization, *Chrysophyllum albidum*, Oil

1. Introduction

The industrialization of oil seeds is one of the most important agro industrial activities in the world today. Oil from plant and animal are employed in the formulation of foods, cosmetics, and drugs in many industrial activities (Nimet *et al.,* 2011). These oils act as insulators to the body protective layer or internal organ such as heart and lung, energy source to the body in absence of carbohydrate. Vegetable oil is also used as viable feedstock biodiesel production (Ochigbo and Paiko, 2011). There is a serious shortage of edible oils and fats in the developing countries of the world especially in Africa. This short fall is being largely met by increased importation of edible oils from the developed countries of the world which is putting a heavy strain on the foreign exchange position of these African countries. This situation, therefore, calls for concerted research effort to increase edible oil production in Africa. In order to overcome this challenge, new sources of oil bearing crops are been exploited (Sam *et al*., 2008).

African Star Apple *(Chrysophyllum albidum)* is one fruit of great economic value in tropical Africa due to its diverse industrial, medicinal and food uses. 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 Ebernales (Oboh *et al*., 2009). It is primarily a forest tree species, its natural occurrences have been reported in diverse ecozones in Nigeria, Uganda, Niger Republic, Cameroon, and Cote d'Ivoire (Ewansiha *et al*., 2011). The plant has become a crop of commercial value in Nigeria (Bada, 1997). The seed of this plant have been rarely exploited for the production of oil for commercial purposes, despite the fact it contain about 13 wt % of edible oil. Most often the seed are thrown away after the consumption of its juicy pulp (Ochigbo and Paiko, 2011).

Solvent extraction provides the best means of removing oil from the plant seeds, leaving a residue of less than 1% oil (Ochigbo and Paiko, 2011). Studies of effect of process variables on extraction of oil from Nigeria *C.albidum* are rarely reported in literature. Only few attempts are documented with limitation. Ochigbo and Paiko (2011) reported the study of effect of solvent blending on the characteristics of oils extracted from the seeds of *C.albidum.* In another study Sam *et al.,* 2008 reported the extraction and classification of lipids from seeds of *Chrysophyllum albidum.* The work was limited to phytochemical screening and determination of fatty acid composition. Adebayo *et al.* (2012) reported the extraction and characterization at 65 ^{0}C for 3-4 hours; the author did not provide any explanation on his choice of process condition.

The aim of the present study is to study the effect of process variables (Particle size, temperature and time) on extraction of oil from Nigeria *C. Albidum*, determine the optimum conditions for the extraction of the oil and also to characterize of oil extracted to determine its physico- chemical properties.

2. Material and Method

2.1 Materials

The fruits of *Chrysophyllum albidum* were collected from a local farm at Agbaha in Otukpa, Benue State, Nigeria. Ethanol used was 99 % pure and all other reagent used were of analytical grade.

2.2 Raw Material Preparation

The *C. Albidum*, seeds undergo various processing in the course of its preparation for extraction. The unit operations involved are:

- Clearing: The seeds had some foreign materials and dirt which was separated by hand picking.
- Drying: The cleaned seeds were sun dried in the open, until the casing splits and sheds the seeds. The seeds were further dried in the oven at 60°C for 7 hrs to a constant weight in order to reduce its moisture content, which was initially at about 5 to 7%.
- Winnowing: The separation of the shell from the nibs (cotyledon) was carried out using tray to blow away the cover in order to achieve very high yield.
- Grinding (*size reduction*): Mortar and pestle were used to crush the seeds to obtain a size of 1.18 mm sieve size, in order to weaken or rupture the cell walls to release castor fat for extraction (Akpan *et al*.,2006; Sayyar *et al.,* 2009).

2.3 Experimental Design

A 2^3 factorial experimental design was used to determine the optimum conditions, three variables were studied at both high and low levels. The upper and lower limits were chosen considering the range commonly employed in literature. The low level of particle size chosen was 0.5 mm and the high level was 0.7 mm. The low level of temperature was chosen as 55 °C and the high level was chosen at 65 °C. The reaction time chosen for the lower level was 6 hours and 8 hours for the higher level. The choice of level was based on some preliminary investigation. The experiment was performed with replication and the average oil yield was recorded.

2.4 Soxhlet Extraction of the seed to determine percentage oil content

About 300 ml of Ethanol was poured into a round bottom flask. 10 g of the powdered seed sample was placed in the thimble and was inserted in the centre of the soxhlet extractor. The extractor was then heated to and held constant at 65°C. As the solvent begins boiling; the vapor rose through the vertical tube of the extractor into the condenser at the top of extractor. The liquid condensate then dripped into the filter paper thimble in the centre which contained the solid sample from which oil is extracted. The extract seeped through the pores of the thimble and filled the siphon tube, where it flowed back down into the round bottom flask. This was allowed to continue for 6 hrs. It was then removed from the tube, dried in the oven, cooled in the desiccators and weighed again to determine the amount of oil extracted. Further extraction was carried out at 30 min intervals until the sample weight at further extraction and the previous weight became equal. At the end of the extraction, the resulting mixture containing the *Chrysophyllium albidum* oil was heated to recover solvent from the oil.

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 2^3 Factorial Design

Trial	Particle Size(μm)	Time (hr)	Temp. (^{O}C)	Oil Yield 1	Oil Yield 2	Average
1	300	8	65	14.7	14.3	14.50
2	300	8	55	15.8	16.9	15.90
3	500	8	65	16.6	16.7	16.65
4	500	8	55	16.7	17.0	16.85
5	300	6	65	12.5	12.9	12.70
6	300	6	55	14.3	14.2	14.25
7	500	6	65	13.2	13.2	13.25
8	500	6	55	15.1	14.9	15.00

3.1 Effects of Particle Size

The Particle sizes of a material greatly determine the rate of extraction (Sayyar *et al*., 2009). The smaller, the particle size the greater the interfacial area of contact between the solid and the solvent which implies higher rate of extraction (Ogbogolo, 2004). From Table 1 it can be seen that extraction was carried using two different particle size namely 300μm and 500 μm.

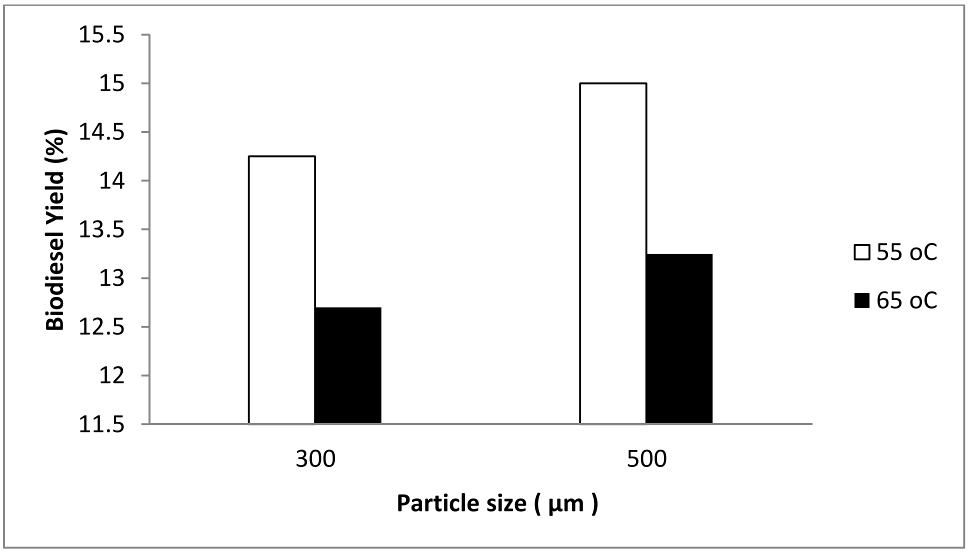

Figure 1 Effect of particle size at different temperature at an extraction time of 6 hr

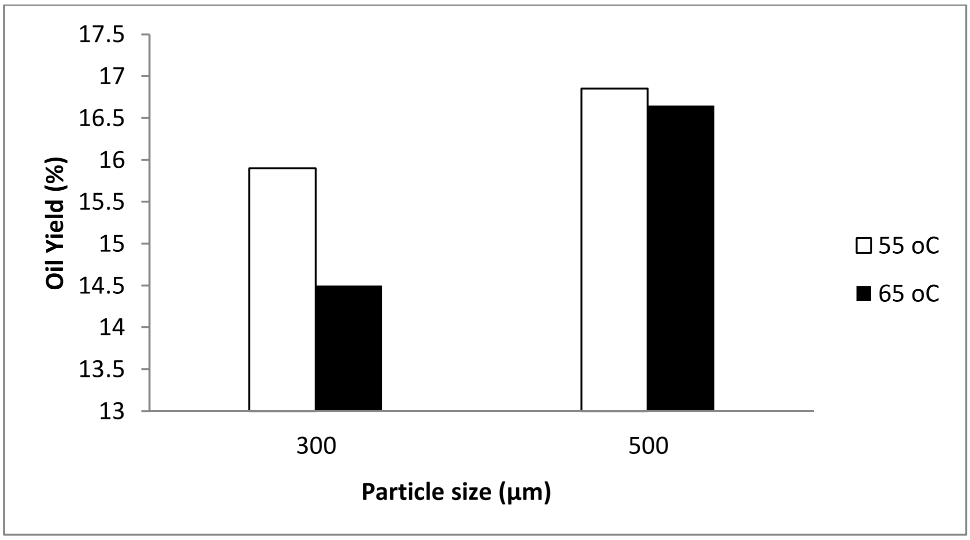

Figure 2 Effect of particle size at different temperature at an extraction time of 8 hr

Figure 1 and 2 show that the highest oil was extracted from the larger particles size of 500 µm than at 300 µm for all experimental runs carried out, although the contact surface area for small particle is expected to be significantly higher than that of the larger particles. However when the particles size are to fine is will probably result into agglomeration which will definitely reduces the effective surface area between the solute and solvent (Sayyar *et al.*, 2009). It was deduced that the medium particle size of 500 µm are more suitable for solid-liquid extraction of *C. albidum* seeds oil.

3.2 Effects of Time

Time is plays an important role in the extraction of oil from its seed. The quantity of extract from seed increases as the extraction time increases (Ogbogolo, 2004).

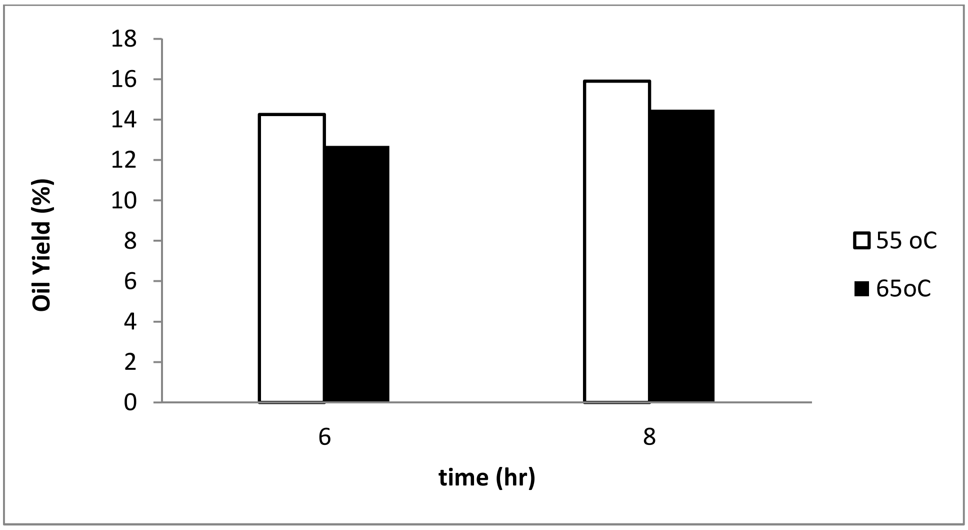

Figure 3 Effect of time on oil yield at different temperature at particle size of 300 µm

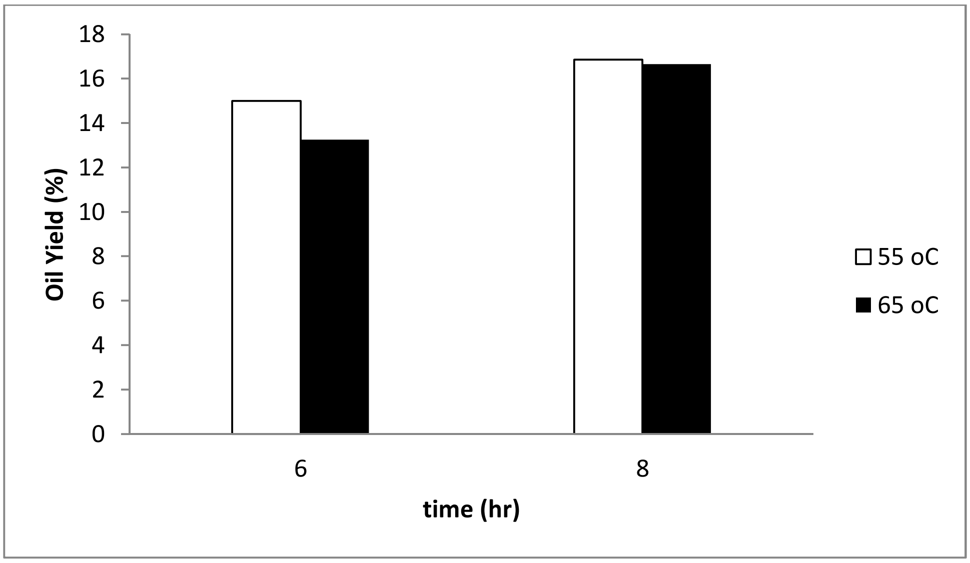

Figure 4 Effect of time on oil yield at different temperature at particle size of 500 µm

The result depicted on Figure 3.0 and 4.0 shows that the percentage oil yield increased as extraction time increased in from 6 – 8 hours. The highest oil yield was 16.85 % at time 8 hrs and at particle size 500 µm. This result was quite consistent with the work of Sayyar *et al.,* 2009 who reported that the extraction rate increases with time for *Jatropha* seed oil extraction. The finding also agrees well with literature of Richardson and Harker (2002).

3.3 Effects of Temperature

Temperature is an important factor in the determination of extraction efficiency. However, it should not be too high as active component fade with temperature (Hojnik*et al*., 2007).

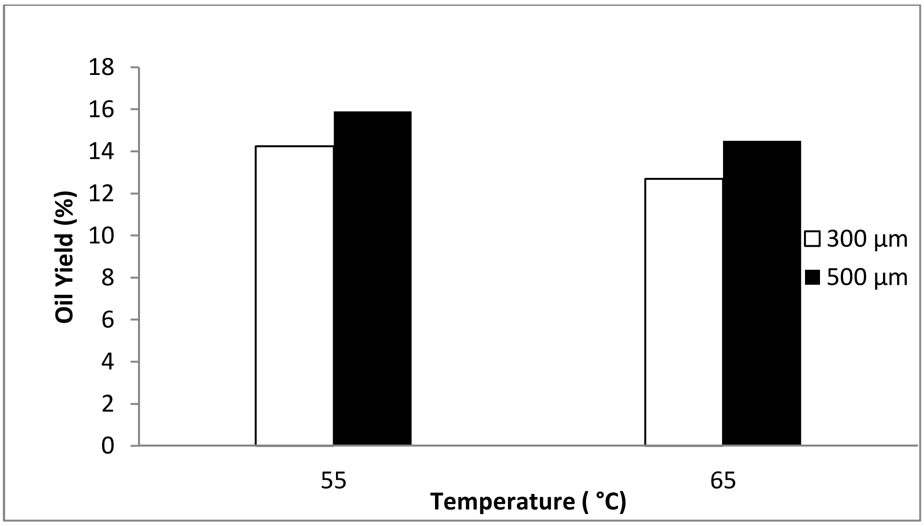

Figure 5 Effect of temperature on oil yield at different particle size at extraction time of 6 hrs

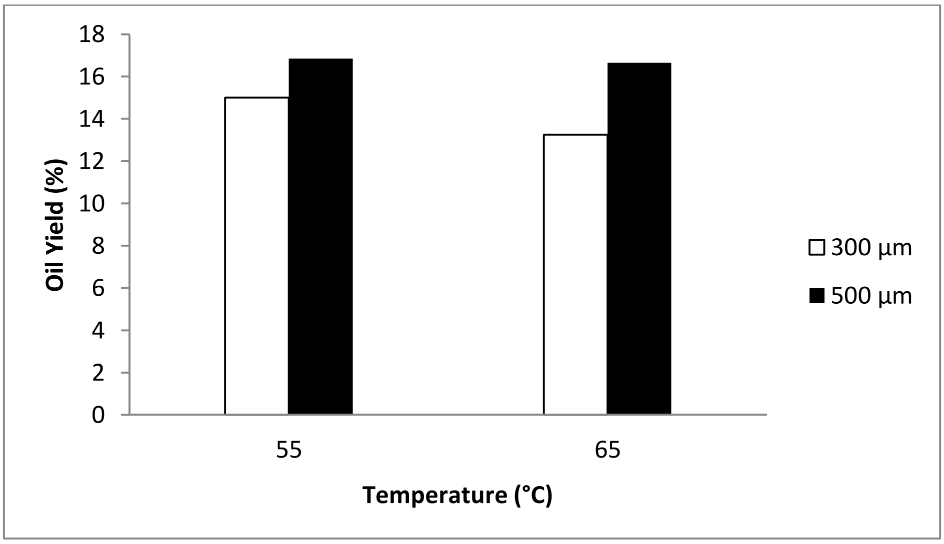

Figure 6 Effect of temperature on oil yield at different particle size at extraction time of 8hrs

The result obtained from Figure 4.0 and 5.0 shows a decrease in percentage oil as the temperature increases from 55^0 C - 65 ^{o} C. The highest oil yield was obtained at 16.85 % at 55 ^{0}C. The optimum extraction temperature of oil from *C. Albidum* was near the boiling point of solvent used as this ensure the maximum recovery of the oil from the seed in which it was contained.

The colour of oil extracted was deep brown; it has a pleasant and sweet smelling odour. The oil content of the seed was 16.85 % which was greater than the literature value of 7.7 %, 10.82 % and 13.43 % reported by Sam *et al.,* (2008), Adebayo *et al*.(2012) and Ochigbo and Paiko,(2011) for the same seed respectively. The difference in oil yield could be attributed to variation in genes, climate, plant species, soil condition and improper processing techniques such as prolong exposure of harvested seeds to sunlight which is capable of impairing the oil yield considerably (Raja *et al.,*2011). It can also be attributed to factors such as the extraction process employed (Mahale and Goswami-Giri, 2012). Comparing the oil yield with known vegetable oil of plant origin like cotton seed (24%) and groundnut (46%) (Adebayo et al., 2012), Shea butter (34 %)(Kyari, 2008), soybean seed (18 %) and palm kernel oil (44.6 %) (Akbar *et al.,* 2009) the oil yield seems quite low. But the result compares favourably with some under ultilised plant seed oil such as pearsea americana which has an yield of 10.8% (Sam *et al.,* 2008), *Detarium microcarpum* with percentage oil content of 7.42 % and 13 % for mango seed (Nzikou *et al.,* 2009).

Table 2 Physico- chemical Properties of *C. albidum* seed oil

Properties	Composition			
		Reported Values		
	This work	1	2	3
Oil yield	16.85	10.82	13.43	12.00
Odour	Agreeable	ND		Agreeable
Specific gravity		ND	ND	0.92
Acid value (mgKOH/g)	2.52	2.81	4.5	3.56
Colour	Dark brown	ND	Deep red	Pale yellow
FFA (%)	1.26	1.41	2.25	1.76
Saponification value(mgKOH/g)	228.40	246.84	199.50	191
Peroxide value(mg/kg)	1.45	ND	1.57	1.80
Iodine value	30	ND	ND	31.06

Source: (Ochigbo and Paiko, 2011;Adebayo *et al.,* 2012; Akubugwo and Ugbogu, 2007)

Table 2 shows the results of some chemical properties of the seed oil. The chemical properties of oil are amongst the most important properties that determines the present condition of the oil.

Acid values provide an indication of age and quality of the oil or fat. It depends on the degree of rancidity thus; a measure of freshness of the oil. The acid value was determined to be 2.52 mgKOH/g with a corresponding Free Fatty Acid value of 1.26 mgKOH/g. This result shows close proximity to the literature value of 1 mgKOH/g reported for mango seed oil (Mahale and Goswami-Giri, 2011). However the result was quite lower than 2.81 mgKOH/ and 4.5 mgKOH/g reported by reported by Ochigbo and Paiko (2011) and Adebayo *et al.,*(2012) respectively. The difference observed could be attributed to geographical location where the seed was obtained, the age of the seed or storage conditions. Low free fatty acids content is indicative of low enzymatic hydrolysis. This could be an advantage as oil with high free fatty acids develops off flavour during storage (Mahale and Goswami-Giri, 2012). The oil from this study can be used for cooking and other industrial purposes such as the production of biodiesel and biodegradable lubricating oil.

Saponification value of oil serves as an important parameter in determining the suitability of the oil for soap making (Akpabio *et al*, 2011). Saponification value reported for this study was high (228.4 mgKOH/g). This result was higher than the reported value (199.50 mg/KOH/g) by Adebayo *et al.* (2012) but lower result than the result by Ochigbo and Paiko,(2011). Saponification value of 200 mg KOH/g indicates high proportion of fatty acids of low molecular weight. The high saponification value suggests the use of the oil in production of liquid soap, shampoos and lather shaving creams (Akbar *et al.,* 2009; Mahale and Goswami-Giri, 2012) and for the thermal stabilization of poly vinyl chloride (PVC) (Adebayo *et al.,* 2012). It is important to add that the high Saponification value obtained for C. albidium oil shows appreciable consistency with the value of 250 mgKOH/g and (253 mg/KOH/g) reported for edible oil like palm kernel oil and coconut oil by Kuwornoo and Ahiekpor, (2010) and Pearson (1976) respectively.

Peroxide value is a valuable measure of oil quality. This parameter provides information about the stability of the oil. The crude *C.albidum* oil has a peroxide value of 1.45 Meq/kg which shows quantitative consistency with the result of Abebayo *et al.* (2012) and shows close proximity to 1.60 Meq/kg reported for groundnut oil (Obasi *et al.,*2012). The value was consistent with the maximum acceptable value of 10 meq/KOH/g set by the Codex Alimentarius Commission for vegetable oils such as groundnut oils (Akubugwo and Ugbogu, 2007, Obasi *et al.,* 2012). High peroxide value in vegetable oil simply suggest absence or low levels of antioxidant (Kyari, 2008).The low value obtained in this study attest to the oxidation of stability of the oil and it ability to resist microbial degradation.

Iodine value is the measure of degree of unsaturation of the oil (Nzikou *et al.,* 2009). The iodine value of 50 gI_2/100 g for this *study* was comparable to the literature value (see Table 3). Vegetable oil with iodine value below 100 are usually classified as non drying oil (Alfa, 2010). These classes of oil are usually suitable for the production of soaps, lubricating oils and lighting candles (Adebayo *et al.,* 2012).

This is an attractive feedstock for this products because the oil have not been known commercially for consumption, and can greatly help in minimizing the dependence on the use of known edible oils for making such products(Ochigbo and Paiko,2011). The oil obtained can also be conveniently used for biodiesel production based on the low iodine value obtained. According to Akbar *et al*. (2009) higher iodine value is an indication of higher unsaturation of fats and oils. The limitation of unsaturation in biodiesel feedstock is necessary due to the fact that heating higher unsaturated fatty acid results in polymerization of glycosides. This can lead to the formation of deposits or to deterioration of the lubricating properties. However the oil cannot be use in production of alkyl resin, shoe polish, or varnishes because it low level of unsaturation do not permit the absorption atmospheric oxygen to produce soft film after prolonged exposure to air .

4. Conclusion

The optimum condition for the extraction of oil from *Chrysophyllum Albidum* Seeds was at a temperature of 55 ^{0}C, particle size of 500 µm and an extraction time of 8 hour . Oil yield (content) of the seed using sohxlet apparatus was 16.85 %. Based on the low iodine value which obtained the oil will not suitable for use in for paint industry as it contain mainly saturated fatty acids but can be used for making candles and lubricating oils. The high saponification values reported establishes the potential of the oil in soap making. The oil can be used for consumption and as a viable feedstock for biodiesel production in Nigeria.

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