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EFFECTS OF SOLVENT BLENDING ON THE CHARACTERISTICS OF OILS EXTRACTED FROM THE SEEDS OF *CHRYSOPHYLLUM ALBIDUM*

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ABSTRACT
In this study, oils were extracted from the seeds of *Chrysophyllum albidum* using different solvent/solvent mixtures. The effects of the different solvents on the physicochemical properties of the extracted oils were also investigated. The proximate composition and phytochemical screening of the seed flour were similarly studied to ascertain their nutritive value as well as the presence or absence of secondary metabolites. The results reveal that the highest oil yield (12.23%) was obtained when the oil was extracted with ethanol, followed by hexane (10.55%) and petroleum ether (9.23%). Ethanol/Hexane blend also gave the highest oil yield of 13.43% while Hexane/petroleum ether blend gave the lowest oil yield of 8.40%. The acid value, free fatty acids, saponification values and iodine values also differ depending on the solvent/solvent blends used for extraction. The acid values and free fatty acids in all the oils were low confirming the stability and edibility of the oil. The results of the proximate analysis show that the seeds have ash content of 1.25%, moisture content of 5.55%, carbohydrate and protein contents of 50.98% and 13.13%, respectively. The seed is a good source crude fibre (7.0%) and phosphorus (16.34%). Phytochemical screening of the seeds meal shows that it is rich in alkaloids, flavonoids, tannins and terpenes, but contains no saponins. The presence of these phytochemicals indicates potentiality to provide preventive and curative property against ailments. The oil exhibited good physico-chemical properties and could be useful for industrial purposes while the seed meal could serve as a source of animal feed.

KEYWORDS: Oil yield, physico-chemical properties, solvency power, proximate composition, *Chrysophyllum albidum*.

INTRODUCTION

Plant seeds have been used since antiquity as sources of vegetable oils. Examples of some plant seeds which have been conventionally exploited commercially for this purpose include, soybean, cottonseed, groundnut, corn, palm seeds and sunflower. Vegetable oils derived from plant seeds have been playing vital roles to provide comforts in human lives in various aspects. For instance, they have been used for illumination and lubricating purposes, production of detergents and cosmetics and for coatings and paints for many centuries before an abundant and cheap supply of mineral oil became available (Ohlson, 1993; Ibemesi, 1992). In the last few decades, there have been growing concerns over vegetable oils as source of raw material in preference to petroleum or mineral oil. The main factor for these concerns is due to environmental issues that regard mineral oil as major contributor of volatile organic compounds (VOCs) which themselves are responsible for most of the present recalcitrant pollution problems threatening the ecology. 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 become 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; Bishop *et al.,* 1983). Moreover, developments in organic chemistry and fundamental knowledge of Physics and Chemistry have provided solutions to some problems which were previously encountered in vegetable oil-based products. Unlike fossil fuels which are limited in supply, seed oils are renewable (Derksen *et al.,* 1996); they can be produced on the farm by the producer to satisfy his demand. Consequently, the latter are being investigated as potential replacement for fossil fuels. Thus, there are present incentives for continuous interest in the production of seed oils.

Production of oils from plant seeds is carried out by either of two processes, namely mechanical pressing and solvent extraction (Iyayi *et al.,* 2008). The principle of the presser is very similar to that of a kitchen blender. The oil produced by this method can be of very high quality after further refining. However, the method does not guarantee total extraction of the oil, leaving behind usually residue of 10-15% in the seeds. Solvent extraction provides the best means of removing oil from the plant seeds, leaving a residue of less than 1% oil typically (Moore, 1968). Solvent extraction consists of washing previously grounded/powdered form of the oilseed in an organic solvent, like n-hexane, until practically all the oil have dissolved out from its tissues. The procedure of oil extraction by the solvent relies on counter-current principle. By this, seed moving in one direction or packed stationary in a cylindrical column (cold process) is washed by the solvent moving (in the opposite direction) through the seeds inside the column (Moore, 1968). The principle behind solvent extraction process is that solvent-oil interaction, which is a measure of solvency power, prevails over either solvent-solvent or oil-oil interactions. In this investigation, solvent extraction process is applied for the extraction of oil from the seeds of *Chrysophyllum albidum* (G. Don.) using different solvents/solvent mixtures. The aim of this work is to determine whether or not the type of solvents used in extraction of oil has any significant effect on physicochemical properties of the oil.

The plant, *Chrysophyllum albidum* (G. Don.) belongs to the family *Sapotaceae.* It is primarily a forest tree species indigenous to diverse ecozones in Nigeria, Uganda, Niger Republic, Cameroon and Cote d'Ivoire (Bada, 1997). The use of the plant bark for the treatment of yellow fever and malaria and its leaves for various ailments has been reported (Adisa, 2000). The seeds of *Chrysophyllum albidum* have rarely been exploited for production of oils for commercial purposes, despite its great potentials to help in reducing competition for existing edible oils due to high oil content of the seeds, approximately 13 wt. % (Bada, 1997). Very often the seeds are thrown away after the juicy pulps enclosing the seeds have been consumed. Due to ever-increasing competition between the food-based and industrial chemicals-based industries for dependence on conventional edible oils as raw materials, the need to encourage the production of less-dependent vegetable oils from seeds of *Chrysophyllum albidum* is compelling.

Solvents that naturally have very good solvency power relative to others will extract oils from plant seeds the most. However, it is believed that blending two or more solvents which individually might be poor solvent intrinsically can produce a solvent mixture that becomes very good solvent. This reasoning is based on the benefits of hindsight that have shown blending as a suitable technique for provoking synergism (Argent, 1985; Kulshrestha *et al.*, 1988; Asaletha *et al.*, 1999; Essawy and El-Nasar, 2004; Corte and Leibler, 2005). Hence, the objectives of this investigation include the extraction of oils from the seeds of *Chrysophyllum albidum* using solvent blends, and determination of the effect of the solvent blending on the characteristics of the extracted oils, proximate analysis of the seeds to determine their nutritive components as well as phytochemical screening of the defatted seeds to determine the presence or absence of secondary metabolites in order to ascertain the justification for history of use of some parts of the plants for medicinal purposes. The goal of this study is to stimulate further interests on the commercial exploitation of this plant seeds.

MATERIALS AND METHODS

Collection of the Plant Seeds and their Pretreatments

The fruits of *Chrysophyllum albidum* were purchased from Minna Central Market, Niger State, Nigeria, by random selection between March and April, 2010. The outer spongy coats of the fruits which representes the edible portion were first removed and the seeds were collected and dried. Afterwards, they were decorticated and the resulting kernels dried under ambient conditions for one week. Oven drying was avoided so as to prevent loss of any constituents by thermal degradation. The dried kernels were then blended into powdered form using a laboratory blender (WARRING COMMERCIAL BLENDOR, USA; Model No.: 35BL64).

Solvent Extraction of Oil from the Plant Seeds

Cold process solvent extraction method was used. This involved introducing pre-weighed (40.00g) ground meal into a glass column (burette) into which the solvent was added until the meal was soaked through with a solvent head above. The end of the column was equipped with a tap to control the passage of the oil/solvent mixture into a collecting container pass via cotton wool placed as filtering device by the mouth of the tap. The column with the content was left for a minimum of five days to allow the dissolution of the oil in the solvent. Thereafter, the tap was opened to release the oil/solvent mixture. The procedure was repeated until the solvent/oil mixture became more or less colourless indicating complete extraction of the oil from the meal inside the column. The oil was extracted using three solvents namely hexane, ethanol, petroleum ether, and their blends as follows: hexane/petroleum (50/50), hexane/ ethanol (50/50); petroleum ether/ethanol (50/50). The oil/solvent mixture was subjected to evaporation process at ambient conditions to recover the volatile solvent leaving behind the crude oil.

Characterization of Oils

The crude oil samples obtained from the various solvent extraction fractions were characterized for refractive index (RI), acid value (AV), saponification value (SV), iodine value (IV), and free fatty acid (FFA) value, respectively based on AOAC official methods (2000).

Phytochemical Screening and Proximate Analysis of Plant Seeds

Phytochemical screening was carried out using standard procedures (Njoku and Obi, 2009) which consists of screening the meal for the presence of secondary metabolites namely, carbohydrates, tannins, saponins, resins, balsams, alkaloids, flavoniods, steroids, terpenes and cardiac glycosides. Proximate analysis was carried out in order to determine the percentage composition of some essential nutrients namely carbohydrate, protein, phosphorus, crude fiber, fat, moisture and ash contents, respectively. All determinations were done according to AOAC (2000) standards.

RESULTS AND DISCUSSION

The yields of extracted crude oils based on the individual and blended solvents are shown in Figure 1. It is significant to note that the yield of the oil is dependent upon the type as well as combination of the extracting solvents. Among the pure (unblended) solvents, ethanol produced the highest oil yield followed by hexane and then petroleum ether. Ethanol is a polar organic solvent while hexane and petroleum ether are non-polar organic solvents. It is suggested that the chemical structure of ethanol allows for specific interactions to take place between solvent and oil molecules which might be the reason this solvent extracted more than either of the other two pure solvents. Among the solvent blends, hexane/ethanol gave the highest oil yield followed by petroleum ether/ethanol and then hexane/petroleum ether. Looking at the pattern of the result, it seems that the presence or absence of ethanol is a critical factor in the solvency power and hence, the yield of the oil. This is not unexpected to observe that the solvent blend made up of ethanol and hexane gave the highest oil; as earlier noted, hexane is second among the pure solvents in order of increasing oil yield. Also, this solvent blend gave the highest oil yield among the whole range of pure/ blended solvents used in the study. This phenomenon of a blend showing enhanced activity relative to pure components is commonly reported (Argent, 1985; Asaletha *et al.,* 1999) and is known as "synergism". Normally, blending combines the advantages of individual components while at the same time mitigating their disadvantages in a composite formulation. The use of solvent blend could also in addition imply financial (cost) advantage, especially in circumstances where the blend would involve both costly and cheap solvents simultaneously. In the case of the above blend, it could be assumed that the good solvency powers of both the ethanol and hexane have combined to produce the synergism.

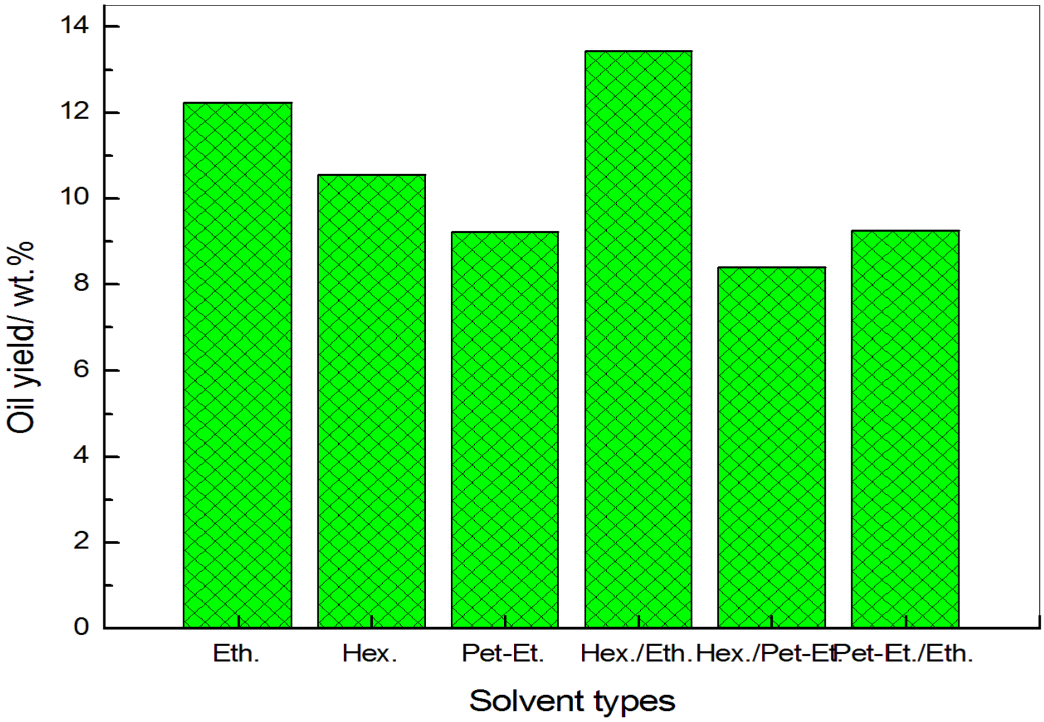

FIGURE 1. Oil yield versus types of solvents used for extraction

Table 1: Some physico-chemical properties of Chryophyllum albidum seed oil in different solvent/blends.

Extracting solvents	Acid value/ mgKOH/ g	FFA/ wt.%	Saponification value/ mgKOH/g	Wij's iodine value	Refractive index
Ethanol	2.81	1.41	246.84	60.91	1.45
Hexane	5.05	2.54	210.38	60.91	1.46
Petroleum ether	5.05	2.54	266.48	19.54	1.43
Hexane/Ethanol	5.61	2.82	193.55	90.72	1.48
Hexane/Pet.ether	6.17	3.10	238.48	30.74	1.49
Pet.ether/Ethanol	5.05	2.54	199.16	85.93	1.47

The results of some determined physico-chemical properties of the crude oil samples extracted based on individual solvents and their blends are shown in Table 1.

The acid value is a direct measure of the percent content of FFAs in a given amount of oil. It is a measure of the extent to which the tryglycerides in the oil have been decomposed by lipase action into FFAs. Acid value depends on the degree of rancidity which is used as an index of freshness (Khan *et al.*, 2006). There is a corresponding variation of each of these two properties against solvents of oil extraction. This is clearly illustrated as shown in Figure 2.

The low-level acid values and FFAs are viewed as testimony to the freshness of the crude oil and that show that the oil is not degraded from processing stage. However, these acid values are slightly higher compared to some oil types and this may be due to the method of drying which was done under shade, a condition which could have resulted in dampness of the seeds and, therefore, led to slow fermentation, which hydrolysed the triglycerides in the seeds liberating free fatty acids. It is a 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 (Onyeike and Oguike, 2003). The acid value obtained in this work are however lower than 11.5mgKOH/g obtained by Akintayo and Bayer (2003) for *Plukenetia corophora.*

The iodine values (Table 1), which are generally below 100, indicate the saturated nature of the oils extracted. The iodine values mark the extracted oils as non-drying oils, which though unsuitable for oil paints, could be employed for manufacture of soaps, lubricating oils and lighting candles which traditionally requires fats or saturated oils. This 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. While the saponification value measures the free as well as chain-bounded fatty acids, the refractive indexes indicate the level of optical clarity of the crude oil samples relative to water. The variation of the refractive indices falls within the range common for vegetable oils; same goes for the saponification values obtained.

In order to evaluate the effect of solvents of extraction on the physico-chemical properties of the extracted crude oil samples, a decision has to be made whether or not there is a significant difference among the data obtained for each of the physico-chemical properties. Consequently, standard deviation using MS Excel program was calculated for all data obtained over an entire solvent range under a given property. The results which are shown in Table 2 below show slight differences, particularly in iodine and saponification values. Nevertheless, the deviation is still accommodated within the range of values of these parameters common with the type of oil (i.e. non-drying) indicated.

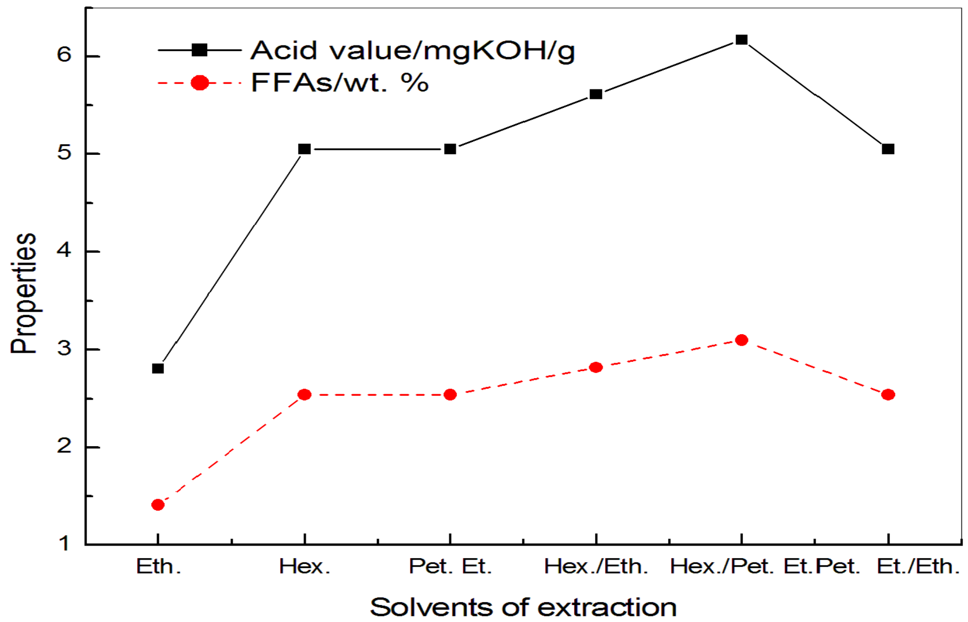

FIGURE 2. Comparison between the variation of acid and FFAs values against solvents of extraction.

TABLE 2. Standard deviation of determined parameters of oil samples for all solvents

Parameters	Standard deviation, σ
Acid values	1.1431
% Free fatty acids	0.5753
Saponification values	29.1405
Wij's iodine values	28.6000
Refractive index	0.0216

The results of the phytochemical screening of the seed meal are presented below in Table 3, which shows the presence of secondary metabolites and suggests the medicinal value of seed meal as similar to extracts of the plant bark which earlier studies (Adisa, 2000) have reported. Alkaloids are nitrogen-containing naturally occurring compound, commonly found to have antimicrobial properties due to their ability to intercalate with DNA of the microorganisms (Kasolo et al., 2010). The presence of carbohydrate provided indication to the food value of the meal. Hence, it could be processed, at least, possibly as formular for feeding animals. Cardiac glycosides are reported to modify tumorigenisis (Ueno et al., 2009), able to inhibit carbohydrate-mediated tumour growth (Nangia-Makker et al., 2002), and induce a stress response and apoptosis in human breast cancer cells. Flavonoids, which are many in number (Ramo-Tejada, 2002), are strong antioxidants that are also found to be effective antimicrobial substances *in vitro* against a wide array of microorganisms by inhibiting the membrane-bound enzymes (Cowan, 1999; Jimoh et al., 2009). They have been reported to possess substantial anti-carcinogenic and anti-mutagenic activities due to their anti-oxidant and –inflammatory properties (Li-Weber, 2009; Nandakumar et al., 2008; Hausteen, 2005). In addition, they are active in reducing high blood pressure (Ayinde et al., 2007; Dhawan and Jain, 2005). On the other hand, the absence of saponins as shown in the above result has noteworthy implications. Firstly, it suggests that not all phytochemicals can be expected in a given sample. Secondly, this sample, owing to absence of saponins, cannot be used for such applications where the presence of saponins is an underlining requirement. In some communities, substances containing saponins are used as soaps due to their surface-active and froth formation properties (Kasolo et al., 2010). Rausch et al. (2006) reported that Ginseng saponins have antioxidant, anti-inflammatory, anti-apoptosis and immunostimulant properties, which are indications in the direction that these compounds could positively affect neurodegenerative disorders and delay neural aging. However, if large quantities of saponins occur in a plant, it is difficult to successfully concentrate aqueous alcoholic extracts, even when using a rotary evaporator (Harbone, 1998). Tannins are a group of polymeric phenolic substances capable of tanning leather or precipitating gelatic from solution (Scalbert, 1991), causing local tumours (Kapadia et al., 1978), inactivating and killing microorganisms (Cowan, 1999; Hausteen, 2005). Some tannins are also known to have strong anticarcinogenic and antioxidant activities

(Perchellet et al., 1996; Riedl et al., 2002).Terpenoids (or terpenes) and steroids are active against bacteria such as *Staphylococcus aureus* (Cowan, 1999) and capable of preventing cancer (Raju et al., 2004) because of having anti-carcinogenic effects (Yun, 1996). It is also documented that phytochemicals in plant based foods can improve glucose metabolism as well as enhance the overall health of diabetic patients by improving lipid metabolism, antioxidant status, improving capillary function, and lowering blood pressure and cholesterol (Kelble, 2006; Broadhurst et al., 2000).

TABLE 3. Results of phytochemical screening

Composition	Remarks
Alkaloids	+
Carbohydrates	+
Cardiac glycosides	+
Flavonoids	+
Saponins	-
Steroids	+
Tannins	+
Terpenes	+

Key: +Present; -Absent

The results of the proximate analysis are shown in Figure 3, which indicates the presence of some of the important nutritive constituents in the meal. Furthermore, as seen in Figure 3, the low moisture content of 5.5% shows that the meal can be stored over a long period of time with minute microbial activity taking place. The low ash content value of 1.25% showed that the inorganic minerals present were trace quantity. Crude fiber with the percentage of 7% is usually made up of largely cellulose which is a polysaccharide sugar. When ingested, this would normally break to several units of monosaccharide thus serving as a source of energy to the body. The crude protein value of 13.13% is considered as moderate. This component makes significant contribution in dietary intake especially if consumed by animals during pregnancy and aids in body maintenance. The phosphorus value of 16.64% is seen as an appreciable level. Phosphorus is important for healthy bones and teeth and for the utilization of energy in the body in order to release energy in the cells. As stated earlier on, the carbohydrate value of 50.98% is significantly high which makes the meal potentially suitable as a source of fuel and energy in the body. It is important for the functioning of vital physiological systems in the body. The compositions outlined above showed the prospect for use of the meal as a source of feed for poultry and cattle; hence, it should not be wasted after extraction of the oil.

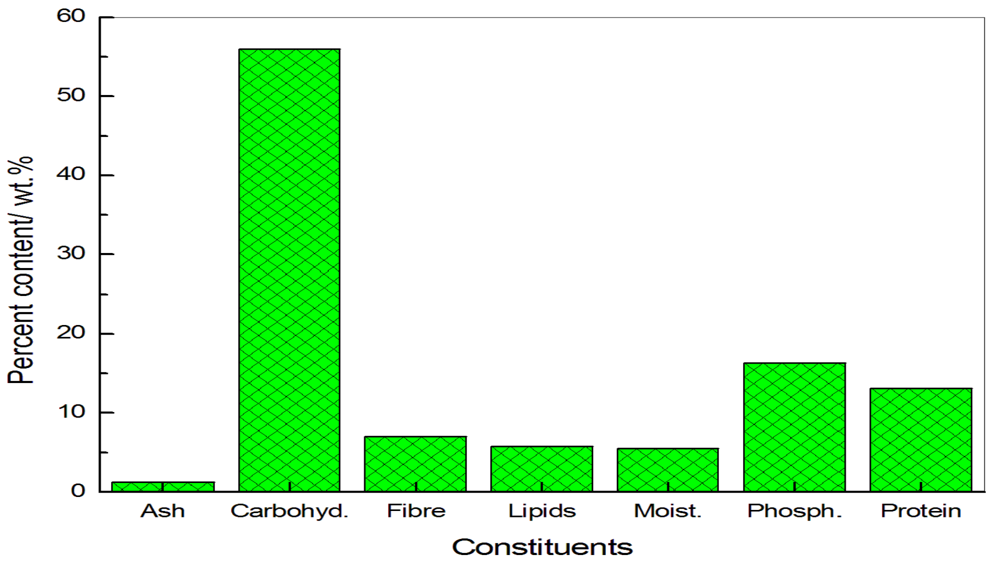

FIGURE 3. Proximate composition of the seeds of *Chrysophyllum albidum.*

CONCLUSION

The effect of solvents and their blends on the extraction of oils from seeds of *Chrysophyllum albidum* have been investigated. It is found that the yields of extracted oils are dependent on the type and composition of solvents. Solvent blend of ethanol/hexane have been found to demonstrate synergistic solvency power, as indicated by its ability to produce the highest oil yield among all the solvent/solvent blends used. The physico-chemical properties of the oils, however, show no significant dependence on the solvents of extraction. The type of oil indicates that it has good prospect for industrial purposes, especially in soap manufacture. The phytochemical screening of the meal shows the presence of secondary metabolites and suggests the medicinal value of the seed meal. Results of the proximate analysis shows that the meal could be used as a source of feed for poultry and other animals, it should not be wasted after extraction of the oil.

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