European Journal of Medicinal Plants

32(6): 22-33, 2021; Article no.EJMP.67151
ISSN: 2231-0894, NLM ID: 101583475

Comparative Studies on Phytochemicals and Physicochemical Compositions of *Chrysophyllum albidum G*: Don Seeds Oil and Edible Commercial Oil

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Authors' contributions

This work was carried out in collaboration among all authors. Author BOR designed the work, performed the statistical analysis, wrote protocols and wrote the first draft of the manuscript. Author AOTA coordinated the collection, processing and storage of plant materials. Authors BOR, YOB and IOL performed the laboratory experiments. Author YOB managed the literature searches. Author IOL supervised the plant collection and identification as well as the laboratory experiments, and made substantial contributions to revise the manuscript critically. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/EJMP/2021/v32i630397
Editor(s):
(1) Dr. Paola Angelini, University of Perugia, Italy.
(2) Dr. Patrizia Diana, University of Palermo, Italy.
(3) Prof. Marcello Iriti, University of Milan, Italy.
Reviewers:
(1) Davinson C. Anyogu, University of Nigeria, Nsukka, Nigeria.
(2) Mohamed G. Shehata, City of Scientific Research and Technological Applications, Arid Lands Cultivation Research Institute, Egypt.
Complete Peer review History: https://www.sdiarticle4.com/review-history/67151

Original Research Article

Received 05 February 2021
Accepted 09 April 2021
Published 07 August 2021

ABSTRACT

Aims: This study was designed to compare the extractable yield of *Chrysophyllum albidum* seed oil, the phytoconstituents, and physicochemical parameters with the commercially available vegetable oil, to ascertain their suitability for human consumption and industrial uses.
Place and Duration of Study: Biomedicinal Research Centre, Forestry Research Institute of Nigeria in collaboration with the Pharmaceutical Chemistry Laboratory, University of Ibadan, Oyo State, Nigeria, between October, 2018 to July, 2019.

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Methodology: The seeds were collected from two locations (a parent tree in the Forestry Research Institute of Nigeria (FRIN) and as well procured at Akesan market in Oyo town (Oyo) all in Oyo State, Nigeria. The experiments were executed adopting the standard procedures. The air-dried powdered *C. albidum* seed was cold macerated with analytical grade N-Hexane. The oils were purified using activated charcoal and qualitatively screened to ascertain the phytochemicals in them. Physico-chemical parameters were quantitatively determined following AOAC guidelines.
Results: The results revealed that *C. albidum* is a low oil yielding seed especially when cold maceration was employed. The phytochemical screening revealed the presence of alkaloids, anthraquinones, terpenoids, and cardiac glycosides in all the oils. Saponins were found only in the oil from the FRIN source. While tannins and flavonoids were absent in all the oils. The physico-chemical parameters revealed the ranges of 0.90 - 9.45 mgKOH/g (Acid value), 101.90 - 356.60 mgKOH/g (saponification value), 65.30 - 78.00 mg/g (iodine value), 101.00 - 348.50 (ester value), 2.93 - 6.21 (P^H value), 0.787 - 0.900g/cm^3 (Relative density) and 1.4590 - 1.6560 (Refractive index @28^{0}C).
Conclusion: It can be deduced that there are disparities in the yield, phytoconstituents and the physico-chemicals of the oils used for this study. Further research is needed on the *C. albidum* oil to validate its edibility and affirm its medicinal uses.

Keywords: Bioactive compounds; extraction; phytoconstituents; plant oil; purification; permissible level.

1. INTRODUCTION

Earth is endowed with numerous fruit trees that are good sources of antioxidants, vitamins, and food supplements, but people only consume little and allow the rest to waste away especially in Africa. This is the case in *Chrysophyllum albidum* G. don, where only the fleshy parts are consumed in Africa and the seeds are wasted. However, it has been documented that plant oils are used to formulate foods, cosmetics, drugs, and other industrial products [1]. *C. albidum* seeds are a good source of plant oils, which can be employed for similar activities. The availability of edible oils and fats in developing countries especially Africa is very limited. This has led to the increased level of edible oil importation, which has put more pressure on the foreign exchange rate of these countries. Hence, this occurrence calls for collaborative research to increase edible oil production in the continent [2]. This paper was designed to evaluate the extraction yield and phytochemicals present in the seed oil of *C. albidum* from the two locations of Oyo state, Nigeria compared to commercially available edible oil.

C.albidum (Sapotaceae) is a tropical perennial crop, attributed to the rain forests and the coastal region of tropical Africa [3]. It is one of the indigenous tree species of southwest Nigeria, which is usually used as an agroforestry tree that provides non-timber forest products (NTFPs) for household consumption as well as for local, regional, and international trade [4]. *C. albidum* is a small to medium tree species, having a height of 25 - 37 m with a mature girth ranging from 1.5 to 2.0 m [3] and commonly known as ‘‘white star apple’’ [5]. In Nigeria, *C. albidum* is locally known as Agbalumo (Yoruba), Udara (Igbo) and Agwaluma (Hausa-Fulani) [6]. In Nigeria, it is highly distributed in the South-West and South-East of the country, while it is rare in the savannah area of the Northern part [7]. The importance of *C. albidum* for local community livelihood improvement and its potentials in food industries have been reported in previous West African studies [8-10]. The physical, chemical, and nutritional characterization of *C. albidum* fruits had shown a high back-up for their industrial potentials [10]. The ethnobotanical usage both as medicine and food have been documented in some studies [11, 12].

Edible oils have always been a major part of the human diet in many countries and serve as good sources of protein, lipid, and fatty acids for various human physiological functions [13]. Hence, this study was designed to compare the extractable yield of *C. albidum* seed oil, the phytoconstituents, and physicochemical parameters with commercially available vegetable oil, to ascertain their suitability for human consumption and industrial uses.

2. MATERIALS AND METHODS

2.1 Methods

C. albidum fruits were collected from two different sources; the first source was from a

mother tree within Forestry Research Institute of Nigeria (FRIN), Ibadan while the second source was procured from the Akesan market in Oyo town. Also, the sample of the selected commercial vegetable oil (King's oil) was purchased from Eleyele market in Ibadan, all in Oyo State, Nigeria.

The fruits collected were depulped to obtain the seeds from the fruits after which the seeds were cracked to get the seed kernels out of them. The kernels obtained were air-dried until a constant weight was ensured and later oven-dried at 50^0C for 24 hours to avoid excess moisture and mycotoxin. The dried kernels were then milled to a fine powder sample, to have a large surface area for maximum extraction.

2.1.1 Method of oil extraction

The oil extraction method was done using the previously used procedure of Adebayo et al. [14] with little modifications. The air-dried powdered seed kernels of *C. albidum* were cold macerated with analytical grade N-Hexane (99%). An amount of each milled powder sample (130 g) was placed in a different glass container then, a five-fold excess of analytical grade N-Hexane was poured on each and stirred vigorously. The mixture was allowed to stand for 72 hours with constant agitation every 2 hours. The filtrates were concentrated to separate the N-Hexane from the extracted oil in *vacuuo* at 35^0C. Further concentration was done using a vacuum oven at a temperature of 30^0C and a pressure of 600 mmHg to ensure absolute removal of the solvent of extraction from the oils. The percentage yields of the oils were then determined.

2.1.2 Purification of the oils

Decolourization is one of the major processes in fats and oils refining, this is designed to remove a wide range of impurities as well as the pigments present therein. This is necessary because most crude fats and oils contain impurities that have to be removed for both commercial and health reasons [15]. The oils produced as well as the selected commercial vegetable oil were purified using activated charcoal through a procedure that has been previously described for the purification of edible oils [16].

The oil samples (10% v/v) were prepared using hexane to make 100 mL. A known quantity of the activated charcoal powder (30g) was packed into the column with the aid of a vacuum pump. The prepared oil solution was then run through the activated charcoal packed into the column. The effluent was collected and concentrated in *vaccuo* at 35^0C. This was further concentrated using a vacuum oven set at 40^0C with a pressure of 600mmHg. The percentage yield was then calculated.

2.1.3 Preliminary qualitative phytochemical screening

The oils were qualitatively screened using the standard procedure to ascertain the phytoconstituents present therein [17, 18]. The procedures used are briefly described below:

2.1.3.1 Anthraquinones

A known amount of the oil (0.5 mL) was boiled with 10 mL of concentrated H_2SO_4 and filtered while hot. The filtrate was shaken with 5mL of chloroform. The chloroform layer was pipette into another clean test tube and 1mL of dilute ammonia (10%) solution was added. The resulting solution was observed for colour changes at the ammoniacal phase (pink, red, or violet colourations considered present).

2.1.3.2 Terpenoids (Salkowski test)

The oil (0.5 mL) was added to 2 mL of chloroform. Concentrated H_2S0_4 (3 mL) was carefully added to form a layer. A reddish-brown colouration at the interface indicates the presence of terpenoids.

2.1.3.3 Flavonoids

Three methods were used to test for flavonoids. First, dilute ammonia (5 mL) was added to a portion of an aqueous filtrate of the sample. Concentrated H_2S0_4 (1mL) was added. A yellow colouration that disappears on standing indicates the presence of flavonoids. Second, a few drops of 1% aluminium solution were added to a portion of the filtrate. A yellow colouration indicates the presence of flavonoids. Third, a portion of the sample was heated with 10mL of ethyl acetate over a steam bath for 3 min. The mixture was filtered and 4mL of the filtrate was shaken with 1mL of dilute ammonia solution. A yellow colouration indicates the presence of flavonoids.

2.1.3.4 Saponins

The sample (5 mL) was added 5 mL of distilled water in a test tube and heated on a water bath.

The solution was shaken vigorously and observed for a stable persistent frothing. The frothing was mixed with 3 drops of olive oil and shaken vigorously after which it was observed for the formation of an emulsion.

2.1.3.5 Tannins

A known amount (0.5 mL) of the sample was boiled in 10 mL of distilled water in a test tube and then filtered. A few drops of 0.1% ferric chloride was added and observed for brownish green or a blue-black colouration

2.1.3.6 Alkaloids

The extract (0.5 mL) was diluted to 10 mL with acid alcohol, boiled, and filtered. To 5 mL of the filtrate was added 2 mL of dilute ammonia then 5mL of chloroform was added and shaken gently to extract the alkaloidal base. The chloroform layer was extracted with 10 mL of acetic acid. This was divided into two portions. Mayer's reagent was added to one portion and Draggendorff's reagent to the other. The formation of cream (with Mayer's reagent) or reddish-brown precipitate (with Draggendorff's reagent) was regarded as positive for the presence of alkaloids.

2.1.3.7 Cardiac Glycosides (Keller-Killiani test)

The extract (0.5 mL) was diluted to 5 mL in water and glacial acetic acid (2 mL) containing one drop of ferric chloride solution was added. This was under laid with1mL of concentrated H_2S0_4. A brown ring at the interface indicated the presence of a deoxy sugar characteristic of cardenolides. A violet ring may appear below the brown ring, while in the acetic acid layer a greenish ring may form just above the brown ring and gradually spread throughout this layer.

2.1.4 Determination of the physico-chemical parameters

The physico-chemical parameters of the oils (such as; acid values, saponification values, refractive index among others) were determined using standard procedure of AOAC (2000) guidelines as described by Adebayo [14].

2.1.4.1 Determination of Acid value (A.V)

Twenty five milliliters (25 mL) of alcohol (95%), 25mL ether and 1mL phenolphthalein solution were mixed and neutralized by adding dilute alkali drop wisely until a pale pink was obtained. The oils were accurately weighed (10.0g) into different conical flask (250mL) and the prepared solvent was added. When the oil is completely dissolved, it was then titrated against the prepared 0.1M aqueous KOH, shaking constantly until the pink colour that persists for 15sec is obtained. The number of mL required was noted. The determination was duplicated and the acid value was calculated using the relation:

$$\text{Acid value} = 56.1\ V\ x\ N\ \div W \qquad \text{equation (i)}$$

Where,

V = Volume in mL of standard potassium hydroxide or sodium hydroxide used
N = Normality of the potassium hydroxide solution or Sodium hydroxide solution; and
W = Weight in gm of the sample
56.1= mg of KOH contained in 1mL of a 0.1M solution

2.1.4.2 Determination of Saponification value (SV)

The oils were accurately weighed (2.0g) into a 250 mL Quick fit flask and exactly 25.0 mL of approximately 1M alcoholic KOH was added from a burette. A reflux condenser was attached and the mixture was refluxed for 1hour on a water-bath, swirling the contents frequently. The flask was then removed from the water-bath, 5 mL of phenolphthalein solution was poured down the condenser (in order to wash the latter without diluting the contents of the flask) and the flask was allowed to cool for 5 minutes under the tap. The mixture was then titrated against 0.5MHCl. A blank was prepared under similar conditions. The number of mL of 0.5M HCl required ("b" mL) was noted. The test was replicated and the SV was calculated using the following relation:

$$SV = (A\ -\ B)x\ N\ x\ 56.1 \div W \qquad \text{equation (ii)}$$

Where;

A = 0.5M HCl for blank, mL
B = 0.5M HCl for sample, mL
W = weight of sample (dry basis), g
N = normality HCl solution
56.1 = equivalent weight of potassium hydroxide

2.1.4.3 Determination of Iodine value (IV)

The IV of the oil was determined using Wijs method as described by Das and Dash [19]. The

different oil samples (0.17g) were weighed into a dry 500 mL iodine flask and 10 mL of carbon tetrachloride was added. When the oil is dissolved, 20.0mL of 0.2M iodine monochloride solution was added from a burette, and a stopper moistened with KI solution was previously inserted, the mixture was allowed to stand in the dark for 30 min at a temperature between 15 and 25^{o}C. The stopper was partly removed and 15 mL of 10% w/v KI solution was poured over the stopper into the flask. The water (100mL) was also added in the same way. The stopper was re-inserted and shook vigorously. It is essential that no iodine monochloride vapour is allowed to escape while the liquids are being added. The content of the flask was then titrated with 0.1M sodium thiosulphate solution, using starch mucilage as the indicator added towards the end-point. The number of mL required ("a" mL) was noted. At the same time, the procedure was carried out in the same manner but without the oil for the blank, and the number of mL of 0.1M $Na_2S_2O_3$ required ("b" mL) was noted. The experiment was done in duplicate and the iodine values were calculated using this formula:

$$IV = (B - S)x\ Nx12.69/W \quad \text{equation (iii)}$$

Where;

B = the volume of sodium thiosulphate required for the blank, in mL
S = the volume of sodium thiosulphate required for the sample, in mL
N = Normality of sodium thiosulphate solution in Eq/ L;
12.69 = conversion factor from mEq sodium thiosulphate to grams of iodine
W = weight of the sample in grams.

2.1.4.4 Ester value (EV)

This is the number of mg of KOH required to neutralize the fatty acid obtained solely by hydrolysis of the glycerides contained in 1g of the substance. It is, therefore, the difference between saponification value (SV) and the acid value (AV) obtained for each of the oils;

That is: $EV = SV - AV$ equation (IV)

2.1.4.5 Determination of PH value

P^H is the value characteristics of an aqueous solution, which represents conventionally its acidity or alkalinity. P^H meter was used to determine the values of the different oils by immersing the electrode into the oils and the potential differences between the electrodes immersed in standard as well as the oils were taken accurately as the P^H values.

2.1.4.6 Determination of relative density

In determining the relative density of the oil, a 10 mL relative density bottle was used. The weight of the dried clean empty relative density bottle (10mL) was taken (W_0), the bottle was then filed with distilled water to the graduated mark and the weight recorded (W_1). The bottle was dried using acetone and then filled with the oil to the graduated mark and the weight taken (W_2). The relative density of the different oils was calculated using the formula:

Relative density = $W2 - W0 \div W1 - W$ equation (V)

Where

W_0= weight of empty relative density bottle
W_1=weight of water + relative density bottle
W_2= weight of test sample + relative density bottle

2.1.4.7 Determination of refractive index

In the determination of the refractive indexes of the different oils, standard instrument (Abbey refractometer) was used. In doing this, three (3) drops of the oil was dropped on the prism of the refractometer, closed, adjusted and viewed through the eye-piece of the instrument and the refractive index taken.

3. RESULTS AND DISCUSSION

3.1 Results

The yield of the oils extracted from *C. albidum* seeds from the two sources is shown in Table 1. It is shown that the FRIN source yielded more oil than the Oyo source. This may be allotted to the fact that the fruits from the Oyo source have been harvested days before being purchased while the FRIN source was freshly harvested from the parent tree and was extracted almost immediately. This corroborates previous work on olive oil that time of harvesting to the time of processing greatly affects the yield [20]. The oils obtained from *C. albidum* seeds are dark brown in colour with pleasant odour.

The oils extracted as well as the selected commercial vegetable oil were subjected to further purification using an activated charcoal reagent. The percentage yields of the purified

oils are presented in Table 2. The result revealed that impurities are much in the commercial vegetable oil compared to *C. albidum* seeds oils, while the level of impurity is less in the oil from FRIN source than other sources. The purified oils were all colourless in appearance.

The oils (both the crude and the purified) were subjected to qualitative phytochemical screening to determine the secondary metabolite present in them. The result revealed that terpenoids, anthraquinones, alkaloids, and cardiac glycosides are present in all the sample oils (Table 3). Saponins present in the *C. albidum* crude oil from the two sources while tannins and flavonoids are absent in all the sample oils.

Besides, the sample oils were subjected to the analysis of the physicochemical parameters (Table 4). The parameters tested are; the acid value (AV), saponification value (SV), iodine value (IV), ester value (EV), $_P$H value, Relative density, and the Refractive index.

The results of the acid values (AV) established that high AV (9.45 mgKOH/g) was observed in crude *C. albidum* oil (Oyo), followed by the crude oil from the FRIN source, while the lowest AV was obtained in the commercial edible oil (Table 4). The Saponification value (SV) of the different categories of oils was calculated (Table 4). The highest value of 356.60 was obtained in the crude oil of *C. albidum* (FRIN), while the lowest value was recorded in the purified commercial oil. This means that FRIN crude *C. albidum* oil may be most suitable for soap making since, the higher the saponification value, the lower the fatty acids average length, and the lighter the mean molecular weight of triglycerides [14]. The Iodine value (IV) of the oils was also determined, the highest IV (78.00) was recorded in the purified commercial oil while the lowest (65.30) was obtained in the crude *C. albidum* oil (FRIN) (Table 4).

Similarly, the ester value (EV) of the sample oils was measured to determine the amount of alkali required to hydrolyze the ester present in one gram of the oil sample. The greatest EV (348.50) was recorded in the *C. albidum* oil (FRIN) while the lowest (101.00) was gotten from the purified commercial oil (Table 4). The results of the $_P$H value obtained revealed that all the oils produced are acidic but the acidity varies from most acidic to slightly acidic except the purified market oil that is slightly acidic (Table 4). Crude *C. albidum* oil (Oyo) is more acidic than other oils, followed by crude *C. albidum* oil (FRIN) while the crude market oil was slightly acidic. The relative density (Table 4) of the individual sample oils was measured. The result obtained revealed that the highest value was recorded in the crude market oil (0.913 g/cm^3) while the lowest relative density was acquired in the crude *C. albidum* oil (Oyo) (0.787 g/cm^3). Although, the refractive index (28^{0}C) of the sample oils was determined and is shown in Table 4. The result exposed that the refractive index of the oils was in the range of 1.4590 (purified FRIN *C. albidum* oil) to 1.6560 (market crude oil) throughout the experimental conditions.

4. DISCUSSION

The oils extracted from *C. albidum* seeds are dark brown with a pleasantly sweet odour, which aligns with the previous work done by Umaru et al. [21]. The colour of the commercial oil was golden yellow before purification, while the purified oils were all colourless (Table 2). Though, the yield is generally small, which means a large quantity of *C. albidum* seeds will be required to get an appreciable amount of oil yield using the cold maceration method adopted in this study. The percentage yield (Table 1) of the oils from this study is quite low compared to the literature values of the previous works for the same seeds [2, 14, 21-23]. This may be ascribed to the soxhlet extraction method employed by them as against the cold maceration method adopted in this study. Besides, the particle size may also affect the percentage yield of the *C. albidum* seeds oil because it has been previously confirmed that the larger particle sizes (500 µm) of the powdered seed kernel are more suitable for solid-liquid extraction of *C. albidum* seeds oil [21] and the powder sample used for this study was finely blended. The variations in the percentage yield of the *C. albidum* seeds oils from different locations (both crude and purified) may be accredited to the duration between the time of harvesting and the time of processing; because the Oyo source has been harvested days before they purchase from the market, while FRIN source was processed almost immediately after the collection, climate, and the soil condition of the locations could also be the determinants. This is in correlation with the previous studies reported in the literature [20, 24]. Furthermore, the oils were purified to ensure that all the impurities herein were removed to increase their acceptability and marketability. The result exposed that the FRIN source produced the purest oil compared to others since

Table 1. The percentage yields and the appearance of the crude oils of *C. albidum* seeds from two sources

Sample	Source	Weight of plant sample used (g)	Weight of oil obtained (g)	% yield (w/w)	Appearance
C. albidum oil	FRIN	1130.00	16.95	1.50	Dark brown
C. albidum oil	Oyo	1130.00	12. 43	1.10	Dark brown

Table 2. The percentage yields and the appearance of the purified *C. albidum* seed oils as compared to the purified market vegetable oil

Sample	Source	The volume of sample oil used (mL)	The volume of oil obtained (mL)	% yield (w/w)	Appearance
C. albidum oil	FRIN	10.00	9.00	90.00	Colourless
C. albidum oil	Oyo	10.00	8.85	88.50	Colourless
Market oil	Eleyele	10.00	7.50	75.00	Colourless

Table 3. Phytochemical composition of the crude and purified *C. albidum* oil and commercial edible oil

Sample	Source	Terpenoids	Flavonoids	Anthraquinones	Saponins	Tannins	Alkaloids	Cardiac glycosides
C. albidum crude oil	FRIN	++	-	+	+	-	+	+
C. albidum crude oil	Oyo	++	-	+	-	-	+	+
C. albidum purified oil	FRIN	++	-	+	+	-	+	+
C. albidum purified oil	Oyo	++	-	+	-	-	+	+
Market crude oil	Eleyele	+	-	++	-	-	+	+
Market purified oil	Eleyele	+	-	++	-	-	+	+

Interpretation: ++ = Abundant, + = Present, - = Absent

Table 4. The results of the physicochemical parameters of the sample oils

Sample	Source	AV(mg KOH/g)	SV (mg KOH/g of oil)	IV (mg/g)	EV	P^H value	Relative density g/cm^3	Refractive index @28^{0}C
C. albidum crude oil	FRIN	8.10	356.60	65.30	348.50	3.91	0.874	1.4596
C. albidum crude oil	Oyo	9.45	339.70	65.50	330.25	2.93	0.787	1.4597
C. albidum purified oil	FRIN	6.31	288.70	66.80	282.39	4.76	0.882	1.4590
C. albidum purified oil	Oyo	7.20	254.70	68.30	247.50	4.04	0.826	1.4591
Market crude oil	Eleyele	2.25	152.80	74.30	150.55	5.09	0.913	1.6560
Market purified oil	Eleyele	0.90	101.90	78.00	101.00	6.21	0.900	1.6522

Key: AV – Acid value, SV – Saponification value, IV – Iodine value, EV – Ester value

it has the highest percentage yield of oil, followed by the Oyo source while the commercial oil had the lowest purification yield. The implication is that the impurities in the commercial oil are more than the *C. albidum* seeds oil.

Similarly, the presence of phytochemicals such as terpenoids, alkaloids, anthraquinones, cardiac glycosides, and saponins in the seed cotyledon of *C. albidum* oil legitimize its use as a potential medicinal oil for alleviating health issues. This confirms that the seed oil can be used against some ailments the same way the seed cotyledon itself can be used. Since there was a study [25] that noticed the positive antimicrobial activity of the aqueous seed extract of *C. albidum* on some strains of bacteria and a fungus. And the secondary metabolites detected in the oils are similar to the phytochemicals found in the leaf [26], the fruit skin and pulp [27-28], and the seed shell pericarp [26]. The seeds and the fruits of *C. albidum* had been reported to have various pharmacological and folkloric uses. Pharmacologically, the seed cotyledon has been reported to possess hypoglycemic and hypolipidemic activities [23], the fruit has been said to have antioxidants properties at a concentration of 1mg/mL [29]. Traditionally, the seed cotyledons are used as unguents for the treatment of vaginal infections [30], the ground seed cotyledon mixed with palm oils is used to treat Haemorrhoids, and alcohol is added to the immature fruit to treat dental decay [31]. Besides, it has been reported that the plants whose phytochemicals are alkaloids, anthraquinones, and saponins may have anti-malarial activities [32]. These aforementioned phytochemicals are detected from the oils produced in this study. Saponins have been reported to have antiprotozoal activities as well as possible defaunation agents in the rumen [33-34]. The indication of this is that the oil from the FRIN source may have anthelminthic properties so far it contains saponins in its phytoconstituents. These oils may also have antimicrobial properties dueto the presence of phytochemicals such as alkaloids and saponins, which exhibit stronger antimicrobial properties [35]. However, the results so far from the oil extract of *C. albidum* seeds support the traditional claims of the seeds and affirmed that the phytoconstituents present in the seeds were not denatured during the oil production processes and were able to be transferred into the oils.

The physicochemical parameters of the sample oils were measured to determine the present conditions and the quality of the oils. The AV is used to determine the freshness and edibility of the oils. The permissible level of AV for all edible oils should be below 0.6 mgKOH/g (measured in potassium hydroxide per gram) from FAO/WHO recommendation (AOCS Official Method Cd 8-53) [36]. The AV observed in the sample oils are greatly above the permissible level of edible oil; this means that even the commercial vegetable oil used for this study needs to be purified before consumption since it is above the permissible level of AV. The results obtained revealed that the AV of the *C. albidum* oil recorded in this study was higher than the previously reported AV for the same species [21,23] but lower than the AV reported for *Landolphia owariensis*(15.33mg KOH/g) and Palm kernel oil (14.04mg KOH/g) among others [23]. The disparities observed could be accredited to the geographical location where the seeds were obtained, the age of the seed, or the storage conditions as well as the extraction method. The high AV observed in this study could limit the consumption of the *C. albidum* oil produced. Moreover, the saponification value (SV) in combination with the AV is essential to provide details on the quantity, glycerides type, and the mean weight of acid in a given sample. Besides, SV is used to check the oil adulteration [37]. The determination of the SV in this study disclosed the soap-making ability of the sample oils produced. The results obtained divulged that the *C. albidum* oil from the two sources had a higher saponification value but low molecular weight of fatty acids in the oil fractions compared to the commercial edible oil. Since saponification value is inversely connected to the average molecular weight of fatty acids in the oil fractions [38]. The high SV of the crude *C. albidum* oil (FRIN and Oyo) connotes a high content of triacylglycerol congruous with the high ester value, which confirmed their better soap-making ability [39]. Consequently, the SV of the crude *C. albidum* oil (FRIN and Oyo) as well as the purified *C. albidum* oil (FRIN), was higher than the permissible SV limits of the oils stipulated by the Codex Alimentarius (250-260 mg KOH/g of oil) [40]. The SV of the purified *C. albidum* oil (Oyo) was within the permissible limits while the commercial edible oil (crude and purified) was below the limits of Codex. The high SV recorded (crude *C. albidum* oil (FRIN and Oyo) and the purified *C. albidum* oil (FRIN) in comparison with Codex standard could be attributed to the low level of impurities present in them, while the low SV observed in commercial edible oil might be due to the existence of a high level of impurities in it. This is in line with the

earliest assertion of Kirschenbauer [41]. The IV indicates the degree of unsaturation in fats or oils. However, the highest IV observed affirmed that the purified commercial oil is unsaturated, thereby making it a drying oil and suitable for paint making. While the lowest IV obtained from the crude *C. albidum* oil (FRIN) makes it more saturated and well suited for soap making [42]. The result obtained from the IV correlates with the result of the SV of the sample oils. However, the standard limit of IV specified by Codex [40] ranges from 6.3 - 10.6 mg/g but the range (65.30 – 78.00 mg/g) of IV obtained in this study was greater than the Codex specified standard. This indicates that there may be a greater degree of unsaturation in the sample oils. Furthermore, the sample oils can be classified as non-drying since they are below 100 mg/g [43] and thus, well suited for industrial uses (soap making, lubricating oils, and lighting candles) [14]. The high ester value correlates with the high amount of ester present and the low molecular weight of the fatty acid content [44]. This indicated that the amount of aromatic compound present in the crude *C. albidum* oil (FRIN) was higher with a low molecular weight of the fatty acid content compared to others.

The $_{P}$H value of the sample oils was measured to determine their relative acidity and alkalinity. The $_{P}$H value is one of the major parameters to detect the quality and shelf life of different types of oil. The result revealed that the sample oils are acidic except the purified commercial oil. This means that the *C. albidum* oil can be stored for a long period because of its acidity. Whereas, commercial edible oil has a low shelf life due to its weak acid content before purification and weak alkaline content after purification. Because, weakly acidic or weakly alkaline oil permits the proliferation of microorganisms, thereby supports the progression of the decay [45]. Moreover, the lower the $_{P}$H value, the more the degradation progresses. Also, the *C. albidum* oil produced in this study may be suitable for skin because of its acidic nature. Alkaline oils are not suitable for the skin as they tend to cause dermatitis [45]. The relative density of all the oils was less than 1g/cm3, which is the relative density of the reference (water). This means that the oils would be less dense than water and can easily float on water. However, the relative density obtained from this study greatly compares with the specific gravity of the oils from *Landolphia owariensis* seed, *Napoleana imperidis* seed [23] as well as the pulp and seed oil of *Dacryodes edulis* [46]. The indication of the refractive index of oil showed the possible chances of oil rancidity. Furthermore, the higher the refractive index of oil, the higher the chances of spoilage due to oxidation [47]. This means that purified *C. albidum* oil (FRIN) may have less chance of spoilage as a result of oxidation than the other sample oils. While the market edible crude oil is more susceptible to oxidation rancidity because of its higher refractive index. Additionally, all the oils from the seeds of *C. albidum* are within the permissible refractive index level of 1.4620–1.4640 [48], while the acclaimed edible commercial vegetable oil (Both crude and purified) was above this permissible level.

5. CONCLUSION

The phytochemicals present indicate that the oil obtained from C. *albidum* seed indicated the potentiality of the oil as a good therapeutic agent for the treatment of some ailments. The physicochemical parameters observed in this study revealed that *C. albidum* is a non-drying oil and can be used in the manufacturing firms such cosmeceuticals companies based on the compositions of the *C. albidum* oil it is recommended as not suitable for vanishes. However, the seeds of *C. albidum* are within the permissible refractive index level compared to edible oils. The research on the *C. albidum* oil is a continuum.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

ACKNOWLEDGEMENTS

The authors are grateful to those who enormously subscribed to the success of this study. The efforts of Mr. Ale Oluwatosin of the department of Pharmaceutical Chemistry, University of Ibadan, Mrs. Martha Osunlaja, and the Federal College of Forestry for their massive contribution towards the successful completion of this study are highly appreciated.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/67151