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Extraction and Characterization of Oil from Watermelon Seed

Francis Emmanuel Ubi, Uwem Ekwere Inyang

Abstract: ***Extraction and characterisation of watermelon seed oil were carried out to investigate the effects of different drying methods and seed size on the quality and quantity of oil from watermelon (Citrullus lanatus) seeds. The watermelon seeds were removed from the pod and washed. The sample was weighed and divided into two equal parts; one part was subjected to sun drying, while the other part was subjected to oven drying (at a temperature of 30 °C). Drying by sun, as expected, was gradual compared to oven-drying, which was faster. The dried seeds (sun-dried and oven-dried) were dehusked and dry-milled into fine crumbs using a hand-milling machine. The powdered product from the mill was then subjected to oil extraction using hexane as solvent. Proximate and physicochemical analyses of watermelon seeds were carried out. The results showed that the seeds contained 5.15 ± 0.03 % moisture, 4.90 ± 0.14 % ash, 50.48 ± 0.05 % fat, 32.38 ± 0.02 % protein, 6.10 ± 0.02 % crude fibre, and 6.35 ± 0.12 % nitrogen-free extract. Physico-chemical characteristics showed that the pale-yellow oil had a specific gravity of 0.860 ± 0.003 and a refractive index of 1.471. The saponification value was 184.29-187.09 mg KOH/g (for both drying methods). Iodine value was 103.04–115.12 mg Iodine/g (for both drying methods). Acid value was 10.4 – 12.8 mgKOH/g and free fatty acid was 5.2 – 6.4 mgKOH/g (for both drying methods). The peroxide value was 18.74 meq peroxide/g. The watermelon seed can thus be considered a good source of protein with high nutritional value. Many of the physicochemical properties of the seed oil studied were comparable to those of other conventional seed oils, such as soybean, cowpea, and groundnut. The watermelon seed oil, therefore, has potential for use as a domestic and industrial oil.***

Keywords: ***Watermelon, Extraction, Physicochemical Properties.***

Nomenclature:
CL: Citrullus Lanatus
FFA: Free Fatty Acid

I. INTRODUCTION

The watermelon family, Cucurbitaceae, is the most popular fruit in Serbia, known as "lubenica". It is a scrambling, trailing vine–like plant and is widely cultivated worldwide. Unfortunately, there is little or no information on the domestic application or medicinal values of this seed oil for cooking and/or frying, as a valuable source of oil with good nutritional value. Thus, the composition of watermelon seed oil (physical and chemical) shall be evaluated in this study, which has not been previously investigated. The result obtained may help in the future selection of watermelon seed oil for use in the human diet. The light texture, the work's moisturising capabilities, and the stable shelf life of watermelon seed oil make it a highly suitable emollient for natural baby care formulations and light body emulsions. Unlike mineral oil, which is a common ingredient in commercial skin products, watermelon seed oil does not clog pores or prevent the body from natural elimination of toxins through the skin. The rich composition of essential fatty acids contained in watermelon seed oil nourishes and restores elasticity to the skin [1].

The edible fruit of watermelon *(Citrullus lanatus)* belongs to the family *Cucurbitaceae*. The fruit contains many obovate, smooth, compressed seeds thickened at the margin and of a black or yellowish white colour. Watermelon plays a crucial role in Africa, as it helps quench thirst during water shortages and is nourishing. The seed of watermelon *(Citrullus lanatus*) can be bruised and rubbed up with water to form an emulsion, which can be used to cure catarrhal infections, disorders of the bowels, urinary passage and fever. It is also being used as a worm expeller; in recent years, it has been used to expel tapeworm [2].

Given the importance of drying techniques, this research is designed to observe the effects of two drying methods on the physicochemical properties of the seed oil and to determine its edibility and effectiveness in soap making. Watermelon seeds could be prized for the highly nutritious oil that they contain. Traditionally, the seeds are removed from the rind and then allowed to dry outside in the sun. Once dried, the seeds are then pressed to extract the beneficial oil. Natural sourcing provides the most superior watermelon seed oil available. It is carefully processed and packaged to maintain the purity, freshness and beneficial properties of this exceptional watermelon seed oil. The fatty acid profile of edible oils plays a vital role in their stability and nutritional value. Monounsaturated (18:1) and polyunsaturated (18:2) fatty acids have been shown to be adequate replacements for saturated fats in cholesterol-lowering diets [3][44].

However, it is also known that oils with substantial unsaturation, particularly 18:2 fatty acids, are susceptible to oxidation and may produce products that contribute to arteriosclerosis and carcinogenesis. Some studies in experimental animals indicate that excessive linoleic acid promotes carcinogenesis [4]. Watermelon seed oil, rich in linoleic acid (~64.5 %), is used for frying and cooking in some

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*Correspondence Author(s)
Francis Emmanuel Ubi, Department of Chemical Engineering, Faculty of Engineering, University of Uyo, Akwa Ibom, Nigeria. Email ID: frankoaklyn@gmail.com
Uwem Ekwere Inyang*, Department of Chemical Engineering, Faculty of Engineering, University of Uyo, Akwa Ibom, Nigeria. Email ID: uweminyang@uniuyo.edu.ng , OCRID ID: 0000-0003-0731-3694

African and Middle Eastern American countries owing to its unique flavour [1]. Much research has been published on the oxidative stability of various vegetable oils, but little has been reported on watermelon seed oil. The modification of the fatty acid composition of watermelon seed oil by incorporating oleic acid (18:1) has been explored [5]. The modified watermelon seed oil was produced with a better balance of monounsaturated (18:1) and essential Fatty acids (18:2), and also improved the seed oil oxidative stability and nutritional value [5]. Previous studies on watermelon seed oil have shown that it is rich in essential fatty acids [2]. It may be recommended for use in skin care formulations for all skin types, including dry, oily and maturing skin. Watermelon seed oil may also be a perfect choice for inclusion in hair care formulations as it is non-greasy yet highly moisturising. Grinding the dry seed, flaking or rolling the seeds to extract oil, and then subjecting the oil to mechanical processing to liberate it, or using a chemical solvent [1].

In Nigeria, watermelon seeds are often discarded after the juicy part has been eaten. The seeds constitute a public nuisance because the sellers of watermelon do not hygienically dispose of them. Therefore, this work focused on extraction and characterization of oil from watermelon seed, when completed will convert waste into wealth.

II. MATERIAL AND METHOD

A. Sample Preparation Analysis

The watermelon seeds were obtained from Itam market, a local market in Uyo, Akwa Ibom State, Nigeria. The collected seeds were washed and dried for easy removal of the epicarp. The watermelon seeds were then divided into two portions: one portion was sun-dried, while the other was oven-dried. Each sample of 100g was dry milled, and the oil content was extracted by Soxhlet extraction before physicochemical analyses. The chemicals used in the experiments were analytical grade and used without further purification, and the equipment/apparatus used was based on the existing literature. Proximate composition of the seed was also determined [6].

B. Crushing and grinding

Crushing is the first step in the size-reduction process. Crushing is sufficient, but in chemical processes, grinding to reduce particles and produce a fine powder usually follows. A local manual grinding machine was used in grinding watermelon seeds [7].

C. Sieving

This operation was performed after the watermelon seeds had been ground. A sieve was used to perform this operation. A sieve is a perforated or meshed apparatus for separating solids or coarse material into fine particles. For this research, a mesh of varying dimensions was used to obtain the desired particle sizes (SETHI standard set sieve sizes of 0.5, 1.0, and 2.0 mm) [7].

D. Drying

After obtaining the desired particle sizes (0.5, 1.0, and 2.0 mm), they were subjected to different drying methods. Drying is a process used to remove moisture or liquids from a sample. One hundred grams of each sample, for both particle sizes, were taken and sun-dried. In comparison, another 100 grams of the exact particle sizes were oven-dried at 30 °C. As expected, oven drying (Gallen Kamp Oven, Model OV-160, England) was faster than sun drying, which was a gradual process that took several days [7].

E. Proximate Analysis

The proximate analyses were carried out on the watermelon:

i. Oil content

The oil was extracted using the Soxhlet apparatus with petroleum ether and n-hexane as solvents. A dried thimble, which was fat-free, was weighed as w_1. 10 g of the sample was added to the thimble, and it was weighed again as w_2. The 500 ml round-bottomed flask, which was fat-free, was weighed as w_3. Petroleum ether was used to fill the 500 ml round-bottomed flask to 2/3 of its volume. The Soxhlet extractor with a reflux condenser was set up, and the heat source was adjusted to maintain gentle boiling of the solvent. This was allowed to siphon and left for several hours (5-6 hours). The condenser was detached, and the thimble removed. The petroleum ether was allowed to siphon over the barrel before the condenser was detached. The flask containing the oil was dried in an air oven at 100 °C for 5 minutes, cooled in a desiccator, and then weighed as w_4. The thimble was placed in the beaker in an oven at 50 °C, and the sample was dried to constant weight; it was cooled in a desiccator and weighed as w_5. The above procedure was also used with n-hexane as the solvent [8].

ii. Moisture Content

The determination of moisture content is one of the most important and widely used measurements in samples that absorb and retain water. Moisture content determination appears very simple in concept, but in practice, accurate determination is complicated by several factors that vary considerably from one sample to another [9]. A clean, well-labelled dish that had been oven-dried was weighed as W1. Five grams (5g) of the sample was added to the dish and weighed as W2. The dish and its content were transferred to the thermosetting oven at about 105 ^{O}C for about 24 hours. The dish was transferred from the stove to the desiccators, cooled for about 1 hour, and then weighed. This was repeated to constant weight W3 [9].

iii. Crude Fibre

This is the portion of the plant material that is neither ash nor dissolved in a boiling solution of 1.25 % H2SO4 or 1.25 % NaOH. Crude fibre was initially thought to be the indigestible portion of any main food. It is known, however, that fibre consists of cellulose, which can be digested to a considerable extent by both ruminants and non-ruminants. Interest in fibre in food and feed has increased due to the growing number of serious illnesses associated with a low-fibre diet. Fibres swell and form a gelatinous mass with a high water-retention capacity in the digestive system. Findings show that fibre products can absorb cholesterol and toxic agents, and increase the excretion of bile acids and sterols [10]. Four grams (4 g) W1 of oil was transferred into a

500 ml conical flask. 200 ml of boiling 1.25 % H2SO4 was added, brought to a boil within 1 minute, and allowed to cook gently for precisely 30 minutes, using a cooling finger to maintain constant volume. Filter paper was used to filter by suction using a funnel, and the material was rinsed well with hot distilled water, then returned to the flask with a spatula. Two hundred millilitres of boiling 1.25% NaOH and a few drops of an antifoaming agent were added. This was brought to a boil in 1 minute and gently simmered for 30 minutes, using a cooling finger. Filter paper was used to filter the mixture, which was then washed with hot distilled water, once with 10 % HCl, twice with methylated spirit, and three times with petroleum ether. The residue was transferred into a crucible after drying, dried in the oven at 105 °C, cooled in a desiccator, and weighed W2. This was then placed in a muffle furnace at about 300 ^{O}C for about 30 minutes. This was removed, placed in a desiccator, cooled to room temperature, and weighed as W3 [10].

iv. Ash Content

Ash from biological materials is an analytical term for the inorganic residue left after the organic matter burns off. The ash is not usually the same as the inorganic matter present in the original material, as losses may occur through volatilisation or chemical interactions among the constituents. The importance of ash content is that it provides a quantitative measure of the mineral content of the constituents—proteins, lipids, or fats [8]. A silica dish was placed in a muffle furnace for about 15 minutes at 350 ^{O}C. The dish was removed and cooled in a desiccator for about 1 hour, then weighed as W1. Two grams (2 g) of the sample was weighed into the dish and recorded as W2. The dish was placed in the muffle furnace, and the temperature was slowly increased from 200 to 450 °C. This was done to avoid incomplete aching. The sample remained ash until it turned whitish. Within four hours (4 hours, the crucible was removed, cooled and moistened with a few drops of distilled water. The water was dried in a water bath and returned to the furnace. The dish was removed from the stove, placed in desiccators, cooled to room temperature, and reweighed as W3 [8].

v. Nitrogen-free Extract

The standard method for determining nitrogen in any sample involves complete digestion of the sample in hot, concentrated acid, in the presence of an appropriate catalyst. Upon the addition of alkali to the digest, ammonia is released, which is distilled out of the sample and determined by simple acid-base titration. The kjeldahi digestion is usually performed by heating the sample with H2SO4 [11].

- *Digestion (Stage 1):* 0.5 g of the sample was weighed into a 50 ml Kjeldahl flask and 20 mL of conc. H2SO4 was added. The sample was heated at low heat for about 15 minutes, then increased to medium heat for about 30 minutes, and finally heated to high heat until digested. The flask was rotated at intervals until the digest was clear (grey white). Heating was continued for a few minutes to ascertain complete digestion. The digest was allowed to cool and made up to 50 ml [11].
- *Distillation (Stage 2):* 5 mL of 2% boric acid (H3BO3) was placed in a 100 mL conical flask (the receiving flask). H3BO3 was used to trap the ammonia vapour from the digest. Three drops of mix indicator (0.198 g bromocresol green plus 0.132 g methyl red in 200 ml alcohol) were added to the receiving flask. The receiving flask was placed so that the tip of the condenser tube was below the surface of the boric acid. 5 ml of the sample was pipetted into the Markham distiller, and 10 ml of 40 % NaOH was added. The joint was tightened, and about 50 mL of the distillate was collected in the receiving flask (V2).
- *Titration (stage 3):* The distillate was titrated with standard mineral acid (0.01M HCl). A blank was also titrated with the acid [12].

vi. Crude Protein

The amount of crude protein in the sample can be obtained by multiplying the sample's nitrogen content by 5.1, a factor for oilseeds [13].

vii. Physico-Chemical Properties of Watermelon Seed Oil.

The following are the physicochemical properties of watermelon seed oil studied:

- *pH*

This is a measure of acidity or alkalinity, with a pH of 7 for pure water; lower values indicate acidity, and higher values indicate alkalinity. A pH meter (Rex, model PHS-25) was used to conduct the test. A pH electrode was lowered into a buffer solution to standardise the pH meter. The calibrated control was adjusted, and the meter displayed the exact pH. The electrode was rinsed with water and then with a portion of the sample oil. The electrode was then immersed in the oil sample until the meter reading stabilised; the result was recorded [14].

- *Refractive Index*

By means of a suitable refractometer (Abbe refractometer), the refractive index of the oil sample was determined. The instrument is temperature-dependent. The refractometer was switched on to generate an optimal temperature of about 20 °C. The prism was thoroughly cleaned with cotton wool damped with petroleum ether. A few drops of the oil were allowed to spread on the prism. The oil was allowed to attain the instrument temperature of 20 °C, and with the aid of the fine adjustment, the reading was taken sharply through the lower eyepiece after a brief adjustment [14].

- *Viscosity*

The oil's viscosity was determined by pouring the sample into the viscometer tube. The time in seconds required for the flow was recorded and multiplied by the tube constant of 1.073 [9].

- *Specific Gravity*

A clean, dry density bottle with a capacity of 25 ml was used. W1 gram was weighed, filled with oil, and reweighed to give W2 gram. The oil was substituted with water, weighing W3 grams. The specific gravity was calculated [9].

- *Free Fatty Acids (Acid Number or Acid Value)*

One gram (1 g) of the oil was dissolved in 50 ml of the neutral solvent in a 250 ml conical flask; 3-4 drops of

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phenolphthalein indicator were added to the mixture, and the content was titrated against 0.1M KOH until a pink colour, which persisted for 15 seconds, was obtained [10].

▪ *Saponification Value*

One gram (1 g) of oil was weighed into a flask, and 50 mL of alcoholic KOH was added to the oil in the flask. A blank was prepared by taking only 50 ml of alcoholic KOH, allowing it to drain into another flask. The reflux condenser was connected to the flask, and the flask was heated gently for about an hour. After cooking, the flask was allowed to cool, and about 1 ml of indicator was added, titrated against 0.5 M HCl until the pink colour disappeared [15].

▪ *Peroxide Value*

One gram (1 g) of the oil was weighed into a clean, dry boiling tube, and 1 g of powdered KI and 20 ml of solvent mixture were added. The tube was then transferred into boiling water so that the liquid boiled within 30 seconds, and the tube was allowed to boil vigorously for no more than 30 seconds. The content was quickly transferred into a conical flask containing 20 mL of 5% KI solution. The tube was washed twice with 25 ml of water each time, and the washes were collected into a conical 31 flask. 0.002 M Na2S2O3 solution was titrated until the yellow colour almost disappeared. 0.5 ml of starch was added; the mixture was shaken vigorously and titrated carefully until the blue colour disappeared. A blank was also set at the same time [8].

▪ *Iodine Value*

It is a measure of oil unsaturation. It is constant for a particular oil or fat. Iodine value is a valuable parameter in studying the oxidative rancidity of oils. The higher the unsaturation, the greater the likelihood that the oil will go rancid. Iodine value or number is defined as the grams of iodine absorbed per 100 g of the oil [9]. A clean glass-stopped bottle was weighed, containing 0.25 g of oil. 25 ml of humus iodine solution was added using a pipette, and drained in a definite time. The solution was mixed well and allowed to stand in the dark for precisely 30 minutes, with occasional shaking. 10 ml of 15 % KI was added and stirred thoroughly, also 100 ml of freshly boiled and cooled water was added to wash down any free iodine on the stopper, the solution was titrated against 0.1M sodium trioxothiosulphate (VI) until the yellow solution turns almost colourless, few drops of starch as indicator will be added and titrated until the blue colour completely disappeared. A blank titration was also prepared and titrated [9, 16].

III. RESULTS AND DISCUSSION

The proximate composition of watermelon (*Citrullus lanatus*) seed is shown in Table 1. The seed's moisture content is relatively low (5.25 %) and falls within the range of similar seeds. The ash content (4.87%) obtained during proximate analysis is higher than the established value for animal feed.

Table I: Proximate Composition of Watermelon Seed

Parameters	Composition
Moisture content	5.25 ± 0.03
Fat	50.50 ± 0.05
Crude protein	33.48 ± 0.02
Crude fiber	6.20 ± 0.02
Ash content	4.87 ± 0.14
Nitrogen-free extract	6.45 ± 0.12

Table 2 shows the physicochemical properties of oil from watermelon seeds. Soxhlet extraction of the oil with Hexane (at 60 °C) yielded a yellowish-brown oil with 48.45% yield from the oven-dried samples and 46.38% from the sundried samples. Free Fatty Acid (FFA) value for the oven-dried sample was 6.4% and 5.2 % for the sun-dried sample. The peroxide, refractive index, pH and specific gravity values were the same for both drying methods. The oil from oven-dried seeds was almost similar to that from sun-dried seeds in refractive index. The saponification value, ester value, and iodine value were slightly higher for the oil extracted from the oven-dried seed sample than for the sun-dried samples. The specific gravity obtained for both was 0.87 g/ml; this is very close to the values of 0.89 –0.92 g/ml reported for edible oils. The refractive index falls within the values reported for similar seed oils: 1.47 for edible oil, 1.47 for soybean oil, and 1.47 for corn oil [17, 45].

Table II: Physicochemical Properties of Watermelon Seed Oil

Parameters	Oven Dried at 30 °C	Sun Dried	Standard Values
Colour	Pale yellow	Pale yellow	Report
Specific gravity (g/ml)	0.87	0.87	0.85 – 0.89
Refractive index (20 °C)	1.468	1.468	1.47
Acid value (mgKOH/g)	10.8	8.40	5.00
Free fatty (mgKOH/g)	6.40	5.20	2.50
Saponification value (mgKOH/g)	185.13	184.29	187 max
Iodine value (gI2/ 100 g)	105.07	103.04	114 max
Peroxide value (meq peroxide/kg)	18.74	18.74	6.25 min
Ester value (mgKOH/g)	172.33	173.09	170 min
pH	6.16	6.16	6.16
Viscosity (mm2 /sec)	11.80	11.80	11.00

A. Discussion of Results

According to the results, the proximate composition (on a dry weight basis) of watermelon seed (*Citrullus lanatus*), as shown in Table 1, was 5. 25 % [9]; 4.91 % for watermelon seeds [18]; 5.50 % for pumpkin seeds [18]; 4.6 % for melon seed [19]; 5.50 % for watermelon seeds [20]; even though [21] reported legumes to be between 7.0 and 10 %. Low moisture content, as observed in this work, confers good stability (keeping quality) and high yield [22]. The low moisture content of watermelon seeds is advantageous for their shelf life; with less moisture, the seeds can be preserved for a longer period [23]. The ash content value obtained was 4.87.

The crude fat extracted with petroleum ether was 50.50%, which agreed closely with the work of [18] on various melon oil seeds, which ranged from 47.9 to 51.1%. When hexane was used, a crude fat content of 48.32% was obtained,

which agreed with that reported for pumpkin seed (48.0%) [24]. It was, however, too high compared to that obtained for soybean 23.5 % [25]. Fat is essential in diets because it promotes the absorption of fat-soluble vitamins. It is a high-energy nutrient and does not add to the bulk of the diet [26]. Given the high level of crude fat in watermelon in this study, it could be considered an oilseed. The brownish-yellow colour of the crude fat extracted is an indication of the presence of various carotenoid pigments, which are highly unsaturated hydrocarbon chains [27]. The results also showed that watermelon has a high crude protein content of 32.38 %. This value compares favourably with those of protein-rich foods such as soybean, cowpeas, pigeon peas, and pumpkin, which have protein contents ranging from 23.1 to 33.0%, as reported by [28].

This protein value also falls within the recommended daily protein intake for children: 23.0 –36.0 g [29]. The high protein content indicates that it can contribute to the daily protein requirement of 23.6 g for adults, as recommended by [29]. It should be noted that proteins functionally promote growth, tissue repair and maintenance. Dietary proteins are needed for the synthesis of new cells, enzymes, hormones, antibodies and other substances required for the healthy functioning and development of the body, as well as its protection [30]. The crude fibre content obtained was 6.20%, which agreed with that of legumes (5.0-6.0%) reported by [31]. As shown in this study, watermelon is low in crude fibre compared to other Cucurbitaceae seeds, such as melon (egusi) at 12.0 % [19] and pumpkin seed at 16.84 % [32]. The crude fibre helps in the maintenance of normal peristaltic movement of the intestinal tract, hence diets containing low fibre could cause constipation and eventually lead to colon disease, such as piles, cancer and appendicitis. Crude fibre contains indigestible materials that can reduce constipation by increasing bowel movements [32, 33].

The physical properties of watermelon seed oil are shown in Table 2. The oil has a specific gravity of 0.87 g/ml, indicating that it is less dense than water, and a refractive index of 1.468, which is in agreement with values obtained for some Nigerian fruits and seeds [14]. This showed that the oil is less viscous and comparable to most drying oils, whose refractive indices range from 1.475 to 1.485 [34]. The refractive index indicates that the oil contains some double bonds in its fatty acid composition; it increases with the number of double bonds [35]. The physicochemical properties of the studied seed oils, as shown in Table 2, were measured, including peroxide value, refractive index, pH, and specific gravity, which were the same for both drying methods (sun-dried and oven-dried) and extractive solvents (hexane and petroleum ether). Saponification value, ester, acid value, free fatty acid and iodine content values were all slightly higher in the oil extracted from the oven-dried seed sample compared to the one from the sundried samples for both extractive solvents.

The saponification values of the oil for both the oven-dried and sun-dried samples were 185.13 and 184.29 mg KOH/g, respectively, which are lower than those of some vegetable oils with higher saponification values, such as coconut oil (253 mg KOH/g), palm kernel oil (247 mg KOH/g), and butter fat (225 mg KOH/g) [36]. However, the value obtained falls within the range reported for some edible oils by [35]. The low saponification value of the seed oil suggests it may not be suitable for soap-making [37]. The acid value of the oil for both the oven-dried and sundried samples was 10.8 and 8.40 mg KOH/g, respectively. The free fatty acid was 6.40 and 5.20 mgKOH/g, respectively, but [20] reported that watermelon seed oil was 2.6 mgKOH/g, [31] reported 0.82 mgKOH/g for cashew nut oil, and [31] reported 0.53 mgKOH/g for pumpkin seed oil.

FFA value is an essential variable for assessing oil quality, as lower FFA levels indicate better quality and serve as indicators of oil edibility and suitability for use in the paint industry [37]. By inference, it therefore implies that oil extracted from the sun-dried sample is of better quality because of its low free fatty acid and acid value, which fall within acceptable limits for edible oils, i.e., ≤ 10 mgKOH/g [9]. The acid value is expected to range from 0.00 to 3.00 mgKOH/g before it can be used for cooking [38], but the oil under study shows a higher value. This acid value can be reduced by refining the oil, which may also improve its quality for industrial purposes.

The iodine value of the oil for both the oven-dried and sun-dried was 105.07 and 103.04 gI2/100 g oil, while [39] obtained 38.10 gI2/100 g oil for watermelon seed. Hausa melon seed was 38.50 gI2/100 g [40], cashew nut oil was 44.40 gI2/100 g [31, 47, 47]. However, the value reported for watermelon seed was 110–128 gI2/100g [40]. In view of the fact that drying oils have an iodine value above 100 gI2/100 g [34, 46], watermelon seed oil, according to this study, could only be categorised as a drying oil. The iodine value is also an index of the oil's tendency to go rancid [13, 16]. The high iodine value suggests the preponderance of high-molecular-weight polyunsaturated fatty acids [41]. This shows that the oil could be nutritionally beneficial, especially now that vegetable oils rich in polyunsaturated fatty acids and naturally occurring antioxidants are being sourced and recommended to patients with hyperlipidemia or other lipid disorders [12]. The iodine value can be used to quantify the amount of double bonds in the oil, which reflects the oil's susceptibility to oxidation [42].

IV. CONCLUSION

The study found that watermelon seeds exhibit reasonable physicochemical properties. Hence, watermelon seed oil has potential for domestic and industrial use, is highly valuable, and is rich in nutrients, making it suitable for a wide range of applications. As shown, all the reasonable physicochemical properties have benefits, providing a scientific basis for the use of seed oil for economic gain and complementing current research on alternative sources of industrial vegetable oils for the production of soap, fragrance, cosmetics, etc. Sensory evaluation of the oil, as well as oxidation and stability tests, could be conducted to stabilise its use further.

DECLARATION STATEMENT

Some of the references cited are older, noted explicitly as [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26],

[27], [28], [29], [30], [31], [32], [33], [34], [35], [36], [37], [38], [39], [40], [41], [42], [43], [44], [45], [46] and [47]. However, these works remain significant for the current study, as they are pioneering in their fields.

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

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AUTHOR'S PROFILE

Uwem Ekwere Inyang obtained his PhD in Chemical Engineering in 2019. He is a lecturer in the Department of Chemical Engineering at the University of Uyo, Nigeria. He has supervised numerous undergraduate and postgraduate students, making significant contributions in the field of Chemical Engineering. He has published many scientific papers in reputable journals. His research interests include Drying, separation processes, waste management, Environmental Engineering, modelling and simulation.

Francis Ubi is a graduate of Chemical Engineering from the Department of Chemical Engineering, University of Uyo, Nigeria. He graduated with good results. I hope to mentor younger individuals interested in Process Engineering. His research area of interest is particulate Engineering and separation processes. He is hardworking and dedicated, and hopes to further his studies so he will remain relevant to current trends in innovation.