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Physicochemical Properties of the Seed Oil of *Khaya senegalensis*

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Abstract

The physicochemical characteristics of *Khaya senegalensis* seed oil were investigated. Iodine value, saponification value, percentage free fatty acid (FFA), acid value, and peroxide value were the chemical parameters examined in the oil analysis, while specific gravity and refractive index were examined as physical parameters. The results showed that the acid value was 1.18 ± 0.01, the saponification value was 191.76 ± 0.01 mgKOH/gm, and the iodine value was 102.79 ± 0.01. It contained 0.59 ± 0.01 percent free fatty acid. The value of peroxide was 6.83 ± 0.01 meq/kg. The results showed that the refractive index was 1.462 ± 0.02 and the specific gravity was 0.9194 ± 0.04. The established parameters fell within the worldwide and Nigerian vegetable oil industry standards.

Keywords

Khaya senegalensis, Physicochemical Parameters, Vegetable Oil

1. Introduction

Vegetable oils and seeds contain a combination of different properties that in many ways play important roles in the comfort of human life [1]. In particular, they contain natural antioxidants, vitamins, flavonoids, minerals, dietary fiber and carbohydrates [2]. When consumed in large quantities, they are associated with many health benefits, including antimutagenic, anti-inflammatory, reduced lipoprotein synthesis, and antioxidant effects, which may reduce the risk of cancer [3] [4]. The commercial application is based on the fatty acid composition of the oil. For example, linseed oil, rich in unsaturated fatty acid linolenic, is a drying oil and used in protective coatings such as paints and varnishes. Vegetable oils are used in sealants, printing inks, gums, coatings or essential oils, oils and

plastics. The foundation of many agricultural economies has been formed by vegetable oils and seeds [5]. Due to the high quality of their proteins, most of them also contribute significantly to diets, as noted by [6] [7] [8] [9]. It is important to note that both components serve as the primary storage reserves for mature oilseeds, with proteins being stored in protein bodies and oils in oil bodies [2].

Khaya senegalensis is a species of tree in the Meliaceae family in Africa. *Khaya senegalensis* is used as a popular traditional medicine in parts of Africa and is highly valued in Nigeria for its medicinal properties. The oil is used in combination with other substances to treat diseases like stomach upset, syphilis, various skin infections like rashes, open wounds and skin ulcers. [10] [11]. This oil is rich in oleic acid (66%) [12]. It has also been reported to be used in cooking, cosmetics and pesticides in West Africa [12] [13]. *Khaya senegalensis* is a large tree, reaching a height of 15 to 30 m and a diameter of 1 m. It has a clean stem of 8 to 16 m, dark gray and small, thin and red bark. The slices are dark red to purple in color and exude a bitter red sap. This plant can be recognized by its evergreen round crown of darkly shiny leaves. The leaves are pinnate, alternate, compound and without stipules. The leaves are 3 - 4 in number, rarely 5 - 7, usually in opposite pairs, oblong to narrowly oblong-ovate, 4 - 12 cm long, 2 - 5 cm wide, with short-tipped acute apex, and rounded edges. They are light green and have 4 to 8 pairs of nerves. The flowers, less than 1 cm long, bloom singly in the main panicles, with pale green, pink and bright red sepals under the ovary (4 cells). This gives the characteristic almost spherical wooden capsule, 4 to 6 cm in diameter, which opens with four valves at the top. Each cell contains 6 or more seeds and is broadly oval to flat, measuring about 25 mm long and 18 mm wide, with narrow wings at the edges.

For *Khaya senegalensis* seeds sourced in India, Karigar *et al.*, (2010) [14] reported the physicochemical parameters of the oil as refractive Index (1.4693), acid value (3.2 mgKOH/g), iodine value (110.6 gI_2/100g), and saponification value (193.38 mgKOH/g). According to Langa *et al.*, (2022), [12] with KSSO sourced from different zones in Chad, the physicochemical parameters were density (0.88 - 0.92), acidity (1.26 - 1.97 mgKOH/g), peroxide values (2.75 - 2.95 meq/Kg), and saponification values (156 - 163 mgKOH/g). Ayo *et al.* (2007), [15] reported that the physicochemical parameters of KSSO from Zaria in northern Nigeria were refractive index (1.458), iodine value (88.40 gI_2/100g), relative density (0.53) and saponification value (195.53 mgKOH/g). The present research aimed to determine the physicochemical properties of *Khaya senegalensis* seed oil (KSSO), which can give an insight into a wide range of industrial applications.

2. Methodology

The experiments were conducted in the Industrial Laboratory of the Department of Chemistry, University of Ibadan, Nigeria between the months of January and

March 2023 under ambient laboratory conditions. *K. senegalensis* seeds were obtained from Bauchi, northern Nigeria and were authenticated at the herbarium unit of the Botany Department of the University of Ibadan, Nigeria, after which they were air-dried and then ground into powder. Oil extraction from the grounded *K. senegalensis* seed was carried out using n-hexane in a Soxhlet extractor for 10 h, and then the extract was concentrated.

Physicochemical Parameters of KSSO

Determination of physicochemical parameters of this seed oil for acid value, % free fatty acids, specific gravity, refractive index, iodine value, saponification value and peroxide value were carried out according to the AOAC method (1990).

Determination of Acid Value

2.00 g of the sample was weighed into a conical flask. 5 cm^3 of chloroform was added and a mixture of 25 cm^3 diethyl ether and ethanol 1:1 (v/v) was also added. A few drops of phenolphthalein indicator were added, and the mixture titrated against 0.1 M KOH. The end point was noted when the pink color appeared and persisted for 30 seconds. The acid value was calculated using the formula below.

$$\text{Acid Value} = \frac{\text{titre value} \times N \text{ of KOH} \times 56.1}{W}$$

where W = weight of sample in grams and N = Normality of KOH.

Determination of Saponification Value

From the oil sample, 2.00 g was weighed in a conical flask and dissolved in 5 cm^3 of chloroform, 25 cm^3 of 0.5 M alcoholic KOH was added. The flask was corked, and the moisture was refluxed for 30 minutes. The mixture was then transferred into a conical flask, few drops of phenolphthalein indicator were added, and it was titrated against 0.5 M HCl until the pink color disappeared indicating the end point. The saponification value was calculated thus:

$$\text{Saponification value} = \frac{(b-a) \times M \times 56.1}{W}$$

where a = sample titre value, b = blank titre value, M = molarity of the HCl and 56.1 = molecular weight of KOH. W = weight of sample taken for the test.

Determination of Iodine Value

From the oil sample, 0.30 g was dissolved in 10 cm^3 of chloroform in 100 cm^3 glass stoppered flask. 25 cm^3 of Wij's solution was added, and the flask allowed to stand in a dark place for 30 minutes. 20 cm^3 of 10% Kl was then added and the mixture was titrated against 0.1 M sodium thiosulphate with few drops of starch as indicator. A blank titration was also carried out. The iodine value was calculated using.

$$\text{Iodine value} = \frac{(b-a) \times 1.269}{W}$$

where a = sample titre value, b = blank titre value and W = weight of sample

used (g).

Determination of Specific Gravity

Density bottles were used in determining the specific gravity of the oil. A clean and dry density bottle of 25 cm^3 capacity was weighed W_0 and then filled with the oil, stoppered and reweighed, to give W_1. The oil was then substituted with distilled water after washing and drying the bottle and weighed to give W_2. The specific gravity was calculated thus:

$$\text{Specific gravity} = \frac{W_1 - W_2}{W_2 - W_0}$$

where W_0 = weight of dry empty density bottle; W_1 weight of density bottle + oil; W_2 = weight of density bottle + distilled water.

Refractive Index

Abbe's refractometer was used in the determination of refractive index and in this case, a few drops of the sample were transferred into the glass slide of the refractometer. Water at 30˚C was circulated round the glass slide to keep its temperature uniform. Through the space of the refractometer, the dark portion viewed was adjusted to be in line with the intersection of the cross. At no parallax error, the pointer on the scale pointed to the refractive index. The refractometer was calibrated using distilled water where the refractive index of water at that temperature was obtained. The procedure was repeated for triplicate samples and their refractive indices were obtained at 30˚C. The mean value for each sample was noted and recorded as the refractive index.

Determination of Peroxide Value

Into a 250 cm^3 Erlenmeyer flask, 1.00 g of the oil sample, 1.00 g of potassium iodide and 20 cm^3 of solvent mixture (glacial acetic acid/chloroform, 3/2 by volume) were added and the mixture was heated and allowed to boil for one minute. The hot solution was then poured into a flask containing 20 cm^3 of 5% potassium iodide. Thereafter, 3 drops of starch solution were added to the mixture and titrated with 0.025 N standardized sodium thiosulphate. The peroxide value was determined.

$$\text{Peroxide Value} = \frac{S \times N \times 100}{W}$$

where S = Volume in cm^3 of $Na_2S_2O_3$, N = normality of $Na_2S_2O_3$ and W = weight of oil sample (g).

The FFA was calculated as oleic acid by dividing the acid value by 2.

Data Analysis

Various descriptive statistical measures such as range, mean, standard deviation (SD) and ANOVA were used for categorization and describing the data obtained during the experiments. Significant difference of $p < 0.05$ was observed for each of the physicochemical parameters considered.

3. Results

The physicochemical parameters are presented in Table 1.

Table 1. Physicochemical parameters of *Khaya senegalensis* seed oil.

Parameter	Value from study	Range of values from Researchers
Acid value (mg KOH/g oil)	1.18 ± 0.01	2.69 - 10.873 [15] [16]
Free fatty acid (%)	0.59 ± 0.01	1.35 - 4.908 [15] [16]
Specific gravity	0.9194 ± 0.04	0.53 - 0.9004 [15] [16]
Refractive index	1.462 ± 0.02	1.4576 - 1.4693 [14] [16]
Peroxide value (mg O_2/g Oil)	6.83 ± 0.01	2.75 - 4.6 [12] [15]
Saponification value (mg KOH/g)	191.76 ± 0.01	156 - 199.71 [12] [16]
Iodine value (g I_2/100g oil)	102.79 ± 0.01	88.40 - 110.6 [14] [15]

Each value represents the mean ± SD of 3 determinations.

The result obtained for the physicochemical characterization of *Khaya senegalensis* seed oil is presented in **Table 1**. The acid value obtained is in tandem with results obtained by previous researchers [15] [16]. The free fatty acid of the oil sample is also within acceptable range for oils that are of good quality. Free fatty acids are prooxidants and contribute to the decreased shelf life of oils. The specific gravity gives information on the buoyancy of the oil. The value obtained for this oil shows that it is of good purity. The refractive index is in the same range reported for most oils. The saponification value is in the same range reported for other oils such as soybean. Iodine value could be used to quantify the amount of double bonds present in the oil and it reflects the susceptibility of the oil to oxidation.

4. Discussion

The acid value of *Khaya senegalensis* seed oil was found to be 1.18 ± 0.01. The acid value indicates the quality of fatty acids present in the oil. This low acid value indicates that the oil is stable for a long time and avoids rancidity and peroxidation. This may be due to the presence of natural antioxidants such as vitamins C and A in the seeds, as well as other phytochemicals such as flavonoids. Acid value is also used as an indicator of oil edibility. It indicates the purity and stability of the oil [17]. The acid value obtained in this work is lower than the value generally reported in literature by previous workers but within the range for other oils in the industry such as cotton seed oil as reported by [18] where a value of 0.660 was obtained. The high acid value of any oil indicates that it may not be suitable for cooking but is useful in the production of paints, soaps and shampoos [17]. High acid values also indicate that the plants may be harmful to animals [19]. The % free fatty acid of this oil was 0.59 ± 0.01. This value shows that the oil is of good quality. This indicates that the ester moiety of the oil has not changed. Excess fatty acids reduce oil smoke point and cause "splashing" when cooking [17]. Good oils have a low free fatty acid content. In refined vegetable oil, the lower the free fatty acid content, the more suitable the oil is for humans in terms of taste [17]. The voluntary industry standard for FFA content

in refined oil is 0.05% or less (by weight of oil). In the food industry, frying oil with an FFA content greater than 2% is discarded or fresh oil is added to reduce the FFA content [20]. The specific gravity of KSSO in this study was found to be 0.9194 ± 0.04. This value is within the range reported for pumpkin seed oil [21], cashew nut oil [22] and sesame oil [23]. Specific gravity is often used in conjunction with other parameters when measuring oil purity. The saponification value (SV) provides information on the average molecular weight of all fatty acids in the oil. The higher the SV, the lower the molecular mass of the acid present. In this study, the SV of *Khaya senegalensis* oil was found to be 191.76 ± 0.01 mgKOH/g. This value is within the SV range obtained by previous researchers. Karigar *et al.*, [14] reported 193.38 mgKOH/g as SV of KSSO, while Ayo *et al.*, [15] reported that the SV of KSSO was 195.58 mgKOH/g. A high SV indicates that the oil will be suitable for making soap, oil-based ice cream, and shampoo [24]. A high iodine value (102.79 ± 0.01) in KSSO indicates the presence of unsaturated fatty acids and indicates that the oil is a non-drying oil. According to Ayo *et al.*, [15] iodine value of KSSO was found to be 110.6 gI_2100g. This oil is not suitable for glue and paint due to its non-drying properties but can be useful in soap making. The peroxide value of KSSO is 6.83 ± 0.01 meq/kg from this work. This is within the range of oils that are good for human consumption. The peroxide value reported for cotton seed oil was 10.40 meq/kg [18]. The commercial standard for cooking oil is that it should not exceed 10 meq/kg [20]. The peroxide value is an indicator of the initial stage of oil oxidation, because the hydroperoxide produced is unstable and decomposes very quickly. The refractive index is in the same range as stated for most oils. Values of 1.460 to 1.469 have been reported for peanut, sesame, sunflower and palm oil [25]. This is further proof that the oil is good and edible.

This study is limited to the physicochemical parameters of the oil as a prerequisite for viable feedstock for wide range of industrial applications. Other analyses such as GCFID, FTIR and GCMS were not included, but could become viable tools to getting additional information on the oil.

5. Conclusion

Khaya senegalensis oil has been extracted and its physicochemical parameters have been determined. The results obtained are consistent with the results of previous researchers. They are also in tandem with international and industry standards. The oil is non-drying, may be used in soap and ice-cream making and is edible.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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