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# Evaluation of the Physico-Chemical Composition and Fatty Acid Profile of Cashew Nut Oil (Anacardium Occidentale) Compared to Sunflower Oil

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**Abstract** | **Original Research Article**

The cashew nut (*anacardium occidentale*) is rich in fat, but little exploited in Côte d'Ivoire, the world's leading producer and exporter. A better perception and consumption of cashew kernel oil could contribute to improving the population's nutrition. The aim of this study is to determine the physico-chemical quality and nutritional value of artisanal oil derived from the artisanal pressing of cashew kernels in Côte d'Ivoire. To achieve this objective, the physicochemical parameters and fatty acid profile of cashew kernel oil were determined and compared with those of sunflower oil in accordance with standard methods. On completion of the work, the fat extraction rate for roasted cashew kernels was 60.75 ± 5.6%. Physicochemical analysis of cashew nut oil yielded moisture content 0.2%, oleic acidity 0.93 ± 0.00%, acid value 17.95 ± 0.00 mg OH/g oil, peroxide value 10.1 ± 0.00 meq O2/kg, saponification 192.14 ± 0.00 mg KOH/g oil, iodine value 79.31 ± 0.00 g I2/100 g, ester value 174.19 ± 0.00. As for the fatty acid profile, the total fatty acid concentration was 94.02%. The most representative unsaturated fatty acid is oleic acid (62.19 ± 0.007), which exceeds that of sunflower oil by a factor of 4. Linoleic acid represents 16.30 ± 0.007% and linolenic acid is in trace form with 00.2 ± 0.014%. In conclusion, the analysis of the various properties studied shows that cashew nut kernel oil is a highly valued edible extra-virgin oil, which could be valorized in the food and cosmetics industries.

**Keywords:** Côte d'Ivoire, cashew kernel, physico-chemical analysis, fatty acid profile.



## INTRODUCTION

African flora is rich in plant species that have long been used by local populations as sources of food, timber, energy and remedies for various somatic and spiritual ailments [1]. In the tropics, there are many sources of plant oils available, but not exploited or not used optimally [2]. They are substances obtained from seeds, kernels and "oleaginous" fruits [3].

Vegetable oils represent a vast and varied group of fats of different origin, composition, quality and taste. They are presented according to their physico-chemical characteristics, method of production, composition in fatty acids, vitamins and minor compounds, nutritional value and uses. They all have different benefits. They account for a third of our diet and are omnipresent in cosmetics. They play a decisive role in our relationship with health, both good and bad.

In Côte d'Ivoire, cashew nuts are available, as the country has been the world's leading producer and exporter since 2015 [4]. The country is also taking up the challenge of increasing its cashew processing capacity. Indeed, cashew butter, a product similar to peanut butter, and cashew kernel oil can be obtained from shelled cashew kernels [5]. At the present stage of knowledge, the literature on artisanal cashew nut oil in Côte d'Ivoire remains very limited and does not offer any values on the chemical composition of these new products. However, there is a strong demand from the field for knowledge of these values, as a prerequisite to calculations for their use. The present study was initiated to help determine the physico-chemical composition and nutritional value of artisanal oil derived from the pressing of cashew kernels in Côte d'Ivoire.

## MATERIALS AND METHODS

### Plant material

Cashew kernel oil and sunflower oil were the vegetable oils used in the study. Cashew kernel oil was

produced using declassified cashew kernels from the SOBERY plant in Bouaké and the CAJU INDUSTRIE plant in Kolia, in central and northern Côte d'Ivoire respectively. As for sunflower oil, it's an imported oil that's qualified as the best.

**Cashew kernel oil extraction process**

Cashew kernel oil was produced using a mechanical press on the farm of the Centre d'Apprentissage, de Perfectionnement et de Production en Elevage in Bingerville. Dried cashew kernels were roasted in an artisanal oven for 30 min before being ground in a mill. The resulting paste was mixed homogeneously with water at a rate of one liter of water per 10 kg of ground kernels. The homogenate was dried for two hours in the sun, then placed in a vat and covered with a tarpaulin. It was then pressed using an artisanal press. After maximum removal of fat after 72 hours, 3 liters of lipid extract were obtained for 10 kg of homogenate [6, 7].

**Physical-chemical analysis and fatty acid profile of cashew kernel oil**

**Iodine index**

The iodine value is the mass of iodine in grams required for the double bonds contained in 100 g of fat. It is determined according to the It is determined using the standard method [8]. A quantity of 0.15g of oil was solubilized in 5ml of chloroform. Then 7ml of Wijis reagent (iodine chloroform in acetic acid) was added to the mixture. The flask containing the mixture was capped, shaken and left to stand in the dark for 1h. After this time, 3ml of 10% (w/v) potassium iodide solution and 50ml distilled water were poured into the reaction medium. The resulting solution was titrated with a 0.1N sodium thiosulfate solution in the presence of starch starch (1% aqueous solution). A blank test was carried out under the same conditions.

$$Ii = \frac{12{,}69\text{xNx}(\text{V} - \text{Vo})}{\text{w}}$$

Ii: iodine value (gI2/100 g oil)
V0: Volume of sodium thiosulfate used for the blank test in ml;
V: Volume of sodium thiosulfate used for the test sample;
N: normality of sodium thiosulfate solution;
w: weight of test sample

**Saponification value**

The saponification number of a fatty substance is the number of "milligrams of potassium hydroxide (KOH) required to saponify one gram of product. The method used is: Two (2) g of oil were solubilized in 25ml of 0.5N alcoholic KOH. The mixture was heated in a boiling water bath for 1h under reflux refrigeration. The solution was then cooled and the excess alcoholic KOH was titrated with a 0.5N HCL solution in the presence of phenolphthalein. A blank test was carried out under the same conditions [8].

$$Is = \frac{56{,}1\text{xNx}(\text{V} - \text{Vo})}{\text{w}}$$

Is: saponification number
Vo: number of ml of HCL solution used for blank test
V: number of ml of HCL solution used for the fat body
C: exact concentration of HCL solution used
w: weight in grams of test sample

**Peroxide value**

The peroxide value of a fatty substance is the number of milliequivalents of active oxygen contained in one kilogram of product and potassium iodide oxidizer with iodine release and titration with sodium thiosulfate. It was determined according to the protocol [8].

In an Erlenmeyer flask, 1g of oil was solubilized in 6mL of a chloroform/glacial acetic acid mixture (2:3; V/V). One (1) Ml potassium iodide 130% (w/v) (1ml distilled water + 0.5g potassium iodide) was added to the mixture and the stoppered Erlenmeyer flask was shaken for one minute and kept in the dark for 5 minutes. Six (6) ml of distilled water was added to the mixture, and the resulting solution was titrated with 0.01N sodium thiosulfate in the presence of starch employment (1% aqueous solution). A blank test was carried out under the same conditions.

$$Ip = \frac{(\text{V} - \text{Vo})\text{xN}}{\text{w}}$$

Ip: peroxide value (meq O2/kg oil)
V: number of mL of sodium thiosulfate solution Na2S2O3.
Vo: number of mL of sodium thiosulfate solution used for the blank test.
w: test sample weight in grams.
N: normality of sodium thiosulfate solution (0.01N).

**Acid value and acidity of oil**

Acid number is the number of milligrams of potassium hydroxide (KOH) required to neutralize the free fatty acids contained in one gram of fat; while the acidity of a fat is the percentage of free fatty acids conventionally expressed as a percentage of free fatty acids.

The index is determined using the standard method [8]**.** In a first step, one (1) g of oil was solubilized in 5ml of ethanol-diethyl ether mixture in the proportions 1:1 (v /v) (5mL of 95% ethanol and 5ml of ethyl ether). The solution was titrated with 0.1N alcoholic KOH in the presence of 3 drops of phenolphthalein (10g in 1 liter of 95% ethanol). A blank test was carried out under the same conditions.

$$Ia = \frac{56{,}1 \text{ x N x } (\text{Vo} - \text{V})}{\text{w}}$$

$$Ip = \frac{282 \text{ x N x V}}{\text{w}}$$

% a: acidity (% oleic)
Ia: acid number (mg KOH/g oil)
V: volume of mL of KOH solution at equivalence for test (mL)
Vo: volume of mL KOH solution at equivalence for blank test (mL)
N: normality of KOH solution m: mass in grams of oil sample
w: weight in grams of test sample.

**Ester index**

The ester number (Ie) of a fatty substance is the number of milligrams of potassium hydroxide (KOH) required to neutralize the acids released by the hydrolysis of the esters contained in 1 g of fatty substance. In particular, the ester number is equal to the saponification number for pure glycerides. In practice, this index is not measured experimentally, but is instead deduced by calculating the difference between the saponification index (Is) and the acid index (Ia).

$$\mathbf{Ie} = \boldsymbol{Is} - \boldsymbol{Ia}$$

**Humidity**

Volatile matter and water content were determined according to the method described [8] by AOAC (1997). Volatile matter is the part of a plant material that remains once the water has been completely extracted. The principle is based on oven-drying samples to a constant weight. Five (5) g of sample are weighed and homogenized in a crucible previously oven-dried at 105°C for 24 hours, after which successive weighings (every hour) are carried out until constant weights are obtained. The water and volatile matter content (in % of sample mass) is calculated according to the formula:

$$\text{H} = \frac{\text{CR} + \text{E} - \text{CR} + \text{Es}}{\text{E}} \; X \; 100$$

H: humidity in % of sample mass
CR+E: mass of crucible and test sample
CR+Es: mass of crucible and test sample after drying
E: sample mass

**Saponifiable fraction**

Fatty acids were determined by gas chromatography (% by weight methyl esters). 10mg was weighed into a 20ml flask and dissolved with methanol for the control and 1g was weighed into a 20ml flask and dissolved with methanol for the test. The fatty acids are calculated according to the formula:

$$\mathbf{T} = \frac{\textbf{Area E x PT}}{\textbf{Area T x PE}} \; \boldsymbol{X} \; \mathbf{100} \; \textbf{en} \; \%$$

Area T: control area
Area E: test area
PE: test mass in g
PT: mass of control in g

**Statistical analysis**

The results of this study were statistically analyzed using Graph Pad Prism 8.4.3 (Microsoft, USA). The mean values per diet from the study criteria were subjected to a one-way analysis of variance (ANOVA), followed by Tukey's multiple comparison test at the 5% significance level. Results were expressed as the mean followed by the standard deviation. The multiple comparison test compares the means of three independent samples. Differences are considered significant at $P < 0.05$, highly significant at $P < 0.01$, and very highly significant at $P < 0.001$. Graphical representations were made using the same software.

## RESULTS

**Oil content of cashew kernels**

The average artisanal fat extraction rate for cashew kernels was 60.75 ± 5.6%. After artisanal oil extraction, the cashew kernel cake still contained around 21% oil.

**Physicochemical parameters**

Values for acid value, peroxide value, saponification value and iodine value are given in Table I. The peroxide value of cashew kernel oil (HANC) (10.1 ± 0.00) is 6 times higher than that of sunflower oil (HT) (1.6 ± 0.00). The saponification value of HANC (192.14 ± 0.00) is also higher than that of HT (189 ± 0.00). As for the acid value, it is absent in HT but at a very low acidity, equal to 0.02%. The acid value of HANC (17.95± 0.00 mg KOH//g) is equivalent to an acidity of 0.93% oleic acid. On the other hand, the iodine value of sunflower oil (96.44±0.00 gI2/100g) is higher than that of HANC (79.3±0.00 gI2/100g). Moisture content is the same in both oils, at 0.02%.

**Table I: Physical and chemical parameters of oils**

| Parameters | Sunflower oil | Cashew kernel oil |
|---|---|---|
| Humidité (%) | 00,2 | 00,2 |
| Acid value (mg OH / g oil) | 00 | 17,95 |
| Acidity (% oleic) | 00,02 | 00,93 |
| Iodine index (g I2 / 100 g) | 96,44 | 79,31 |
| Peroxide value (meq O2 / kg oil) | 01,6 | 10,1 |
| Saponification value (mg KOH / g oil) | 189,33 | 192,14 |
| Ester index | 189,33 | 174,19 |

**Fatty acid profile**

The linolenic acid content of HANC is 0.20±0.014%. On the other hand, the linoleic acid content of HT is 4 higher than that of HANC, which is 16.30±0.007%. On the other hand, the oleic acid content of HANC is 4 times higher than that of HT. However, the palmitic acid content of HT and HANC is 3.61±0.021 and 10.02±0.028% respectively. As for stearic acid content, the values are 4.41±0.014% for HT and 5.31±0.021% for HANC (Table II).

**Table II: Fatty acid profile**

| Acide gras (%) | Sunflower oil | Cashew kernel oil |
|---|---|---|
| **Acide gras insaturés** | | |
| Oleic acid (omega 9) | 17,19 ± 0,021 | 62,19 ± 0,007 |
| Linoleic acid (omega 6) | 66,13 ± 0,035 | 16,30 ± 0,007 |
| Linolenic acid (omega 3) | 0,03 ± 0,01 | 00,2 ± 0,014 |
| **Saturated fatty acids** | | |
| Palmitic acid | 03,61 ± 0,014 | 10,02 ± 0,028 |
| Stearic acid | 04,41 ± 0,021 | 5,31 ± 0,021 |

## DISCUSSION

The average on-farm artisanal fat extraction rate for cashew kernels is 60.75±5.6%. This value is similar to that obtained by authors in Côte d'Ivoire [7].

The acid value of a fatty substance is a good indicator of its deterioration. The cashew kernel oil studied has an acid value of 17.95 ± 0.00 mg KOH/g oil and an acidity equivalent to 0.93 ± 0.00% oleic acid. This acidity is approximately in line with the value obtained by Boris (1949) on cashew kernel oils. This value is comparable to that of sweet almond oil (*Amygdallus communis L*.), which is between 0.3 and 1.8% oleic acid [9]. According to FAO/WHO, for an oil to be pure and stable at room temperature, its acidity must be less than 4 (<4) [10]. According to the Ivorian standard CODINORM [11], acidity must be less than or equal to 10 (≤10). This standard is met for cashew kernel oil in this study, as its acidity is well below both standards and it can be recommended as a good quality edible oil. This also indicates that the extracted cashew kernel oil is a top-quality extra-virgin oil.

In oil analysis, it is the iodine value that represents the most useful constant, as it is on the values of this index that the important division of vegetable oils into drying, semi-drying and non-drying oils is based. The iodine value of cashew kernel oil is 79.31 ± 0.00 g I2/100 g. Iodine values for non-drying oils range from 0 to 110 g I2 /100 g. This oil is therefore classified as non-drying [12]. The iodine value found in this study is comparable to the iodine indices of the olive oil, which ranges from 75 to 94 gI2/100 g oil according to CODEX alimentarius standards [12, 13]. However, the iodine value of cashew kernel oil is lower than that of sunflower and sweet almond oil, which range from 94 to 101g I2/100 g. Based on this iodine index value, cashew kernel oil is a non-drying oil and can be kept for a long time with self-maintenance.

The peroxide value is a very useful criterion for assessing the early stages of oxidative deterioration of an oil. According to CODEX Alimentarius (2019) standards [13], which set the peroxide value for refined oils at or below 10 meqO2/kg and for crude oils at or below 15 meqO2/kg [14]. The peroxide value of cashew kernel oil is 10.1 meqO2/kg and that of sunflower oil is 1.6 meqO2/kg. They are comparable with the standards of CODEX Alimentarius [13] and the Ivorian standard [11]. The result shows that cashew kernel oil is not oxidized, so it can be stored for a long time. This confirms the oxidation stability of cashew kernel oil at room temperature and its resistance to rancidity [15].

The results obtained from cashew kernel and sunflower oil show a moisture content of 0.2%. According to CODEX Alimentarium and the Ivorian standard CODINORM [11-13], the acceptable limit for the moisture content of crude and refined oils is 0.2%. We can therefore deduce that the oils comply with the standards. Moisture index is an important parameter to be considered, as the high moisture content of oils supports microbial development and enzymatic action, leading to hydrolysis and oxidation of fats [16]. Cashew kernel oil that complies with standards can be stored for a long time without risk of microbial contamination.

Knowing the saponification value of a fatty substance gives us information about the carbon chain length of the acids making up the fatty substance. The shorter the carbon chain of the fatty acids, the higher the saponification value. The saponification value of cashew kernel oil is 192.14 ± 0.00 mg KOH/g oil, which is close to that of cotton seed oil (189 to 198), sunflower oil (188 to 194), palm oil (190 to 209) and palm olein (194 to 202). These values are comparable to those found in other studies [17]. These oils are usually used in food [18]. Cashew kernel oil can be used in soap-making and cosmetics.

The ester value of cashew kernel oil is 174.19 ± 0.00 mg KOH/g oil. This ester number is lower than the saponification number, which is 192.14 ± 0.00 mg KOH/g oil. This means that this oil contains an appreciable quantity of free fatty acids. Consequently, pre-refining and packaging precautions must be taken to limit further denaturation, which would lead to discoloration of the oil.

These partial results show that cashew kernel oil produced in Côte d'Ivoire has physico-chemical characteristics very similar to those of the most widely consumed conventional oils.

According to the results obtained on the acidity of cashew kernel oil, 15.33% are saturated acids, mainly composed of palmitic acid (10.02%). According to FAO/WHO, the limit for palmitic acid is less than or equal to 11 (≤ 11) [10], and according to the Ivorian standard CODINORM, the limit for stearic acid is 3.9 to 6% [11]. The stearic acid (5.31%) and palmitic acid (10.02%) contents of the cashew kernel oil studied comply with standards. 78.69% of unsaturated acids are represented exclusively by oleic acid (62.19%). According to FAO/WHO, the limit for oleic acid is set at 62-76%. The linoleic acid limit is from 5.2 to 18.7% [10]. The linoleic acid (16.30%) and the linolenic acid (0.2%) content of cashew kernel oil complies with standards of FAO/WHO and CODINORM. It states that the oleic acid content must be less than 0.6 (< 0.6) [10, 11]. This chromatography yielded a total fatty acid concentration of 94.02% for cashew kernel oil was reported by other authors [12]. The omega-6/omega-3 ratio of cashew kernel oil is 81.5. This value is intermediate with hazelnut oil and sweet almond oil, which range from 30.2 to 141 [19]. Their high oleic acid content makes them an excellent dietary energy source, and the lower the omega-6/omega-3 ratio, the healthier the oil. These are good quality oils.

## CONCLUSION

In this study, the physicochemical characteristics of cashew kernel oil show that it has interesting properties overall and is similar to hazelnut oil and sweet almond oil. In addition, these characteristics are in line with international and Ivorian edible oil standards. The overall analysis of the various properties studied suggests that cashew kernel oil is a highly prized extra-virgin edible oil, which could be put to good use in the agri-food and cosmetics industries.

In order to take full advantage of all the benefits associated with the use of cashew kernel oil, further studies could be carried out to determine the pharmaco-nutritional qualities of cashew kernel oil.

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