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Physical and Chemical Characterization of Roasted Cashew Nut (*Anacardium occidentale*) Flour and Oil

Ogungbenle H. N.[1,*], Afolayan M. F.[2]

Department of Chemistry, Ekiti State University, Ado-Ekiti, Nigeria

Abstract Proximate and physico chemical properties of roasted cashew nut (*Anarcadium occidentale*) flour and oil were investigated. The result showed that moisture (5.90 %), crude fat (42.9 %), crude protein (26.1 %), crude fibre (3.11 %) and carbohydrate (19.0 %). The physico chemical properties of roasted cashew nut oil were as follow; colour (yellow), refractive index (1.460), specific gravity (0.964), acid value (11.2 mgKOH/g), saponification value (139 mgKOH/g), iodine value (42.1 mg iodine/100g) and free fatty acid (4.70 %). This is an indication that the oil is non-drying, edible and may not be useful for soap making. The fatty acid values were: myristic acid (0.07 %), palmitic acid (12.06 %), palmitoleic acid (0.29 %), stearic acid (9.05 %), oleic acid (58.7 %), linoleic acid (18.9%), linolenic acid (0.12 %), arachidic acid (0.18 %), behenic acid (0.14 %) and lignoceric acid (0.40 %). Oleic acid was the highly concentrated while linoleic acid was the least concentrated. The percentage oil yield makes the nut a good source of oil. The total saturated fatty acid was 21.6 % while the total unsaturated fatty acid was 78.1%. It is an indication that the oil is economically viable.

Keywords Proximate, Physico chemical, Fatty acid, Roasted, Cashew, Oil

1. Introduction

Global trends in acute food shortages in both developed and developing countries demand that food scientists should intensify efforts to salvage the situation by providing nutritional information to educate the teeming population so as to expose some under utilized legumes. Plant sources of protein are the major avenue for protein intake in some developing countries [1]. Increase in the world population has contributed to substantial decline in per capital supply of conventional protein foods [2]. This has led to over dependency of people on starchy foods in developed and under developed countries [3]. Cashew (*Anacardium occidentale*) is a tree in the family Anacardiaceous. It is originally native to North-east of Brazil and spreads across Africa and West indies [4, 5]. It is a drought resistant tree widely grown in tropical climates between the tropics of Cancer and Capricorn basically for its cashew apples and nuts. The cashew seed is heart like shaped and the tree grows well in a variety of soils and climatic conditions where other commercial trees would not grow. It is edible and has a ‘’sweet’’ taste. The pulp of the cashew apple is very juicy, fragile and unsuitable for transport but can be used as fruit drinks with refreshing taste [5, 6, 7].

The motivation to do this work is that cashew is common and widely grown in Africa but yet there is limited information on the nutritional composition, utilization and physico chemical properties; therefore, compositional data from the study would provide scientific knowledge on the nutritional status of roasted cashew nut flour and oil and this would further expose its potentials as food. The data obtained would also add or contradict the existing ones if available. Ogungbenle [3] reported the proximate, minerals, anti nutrients and amino acid of the kernel. This paper reveals the proximate, physico chemical, kinematic viscosity and fatty acid of the oil.

2. Materials

Cashew nut seeds were purchased from Ado-Ekiti Central market, Ekiti State, Nigeria in Africa continent. The seeds were roasted in a Cabolite oven at regulated temperature of 150-200℃ and then removed from the pods. The roasted seeds were screened to remove the bad seeds. The remaining good seeds were dehulled and blended into fine flour. The oil from the cashew nut flour was extracted using petroleum ether of Analar grade (British Drug House, London) boiling range 40-60℃.

3. Methods

3.1. Proximate Analysis

The moisture and ash contents determined using the air

* Corresponding author:
httphenryo@yahoo.com (Ogungbenle H. N.)
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oven and dry ashing method Pearson [8]. The sample was analyzed for crude fat, fibre and crude protein according to the methods described by AOAC [9]. Nitrogen was determined by micro-Kjedahl method [9] and the percentage nitrogen was converted to crude protein by multiplying by a factor of 6.25. The total carbohydrate content was calculated by method of difference as described [3].

$$\%\text{Carbohydrate} = \{100 - (\%\ \text{Moisture} + \%\ \text{Ash} + \%\ \text{Crude fibre} + \%\ \text{Crude fat} + \%\ \text{Crude protein})\} \quad (1)$$

3.2. Physico Chemical Properties

3.2.1. Determination of Saponification Value

A 2.0ml of the oil sample was added to the 20ml of ethanolic potassium hydroxide in 500ml round bottom flask. The flask with its content was refluxed for 30 minutes. 2ml of phenolphthalein indicator was added and the hot solution was allowed to cool and later titrated against the 0.5M hydrochloric acid. A blank titration was carried out using the same procedure [8, 10].

$$\text{Saponification value} = \frac{56.1N\ (V_1 - V_2)}{W} \quad (2)$$

Where:

N = molarity of hydrochloric acid.
V_1 = volume of HCl used in the test.
V_2 = volume of HCl used in the blank.
W = weight of sample oil.

3.2.2. Determination of Peroxide Value

A 2.0g of the oil sample was weighed into the 200ml conical flask containing 20ml of petroleum ether and heated for 30 seconds in a water bath. 20ml of 50% aqueous solution of potassium iodide and 25ml of distilled water were added. The resulting mixture was titrated with 0.002M sodium thiosulphate solution. During the titration a milky white precipitate was observed and the total disappearance of the precipitate indicated the end point of the titration. The peroxide value of the sample oil was estimated on the basis of the equation below. The same procedure was repeated for the blank [11].

$$\text{Peroxide value} = \frac{100\ (T_B - T_S)}{\textit{Weight of sample oil}}\ \text{MEq}\ O_2/\text{kg} \quad (3)$$

Where:

N = molarity of thiosulphate
T_S = volume of thosulphate used in the sample test.
T_B = volume of thiosulphate used in the blank.

3.2.3. Determination of Acid Value

A 5g of the sample oil was weighed into a 250 ml conical flask. 50 ml of hot neutralized alcohol was measured into the flask. The content in the flask was boiled on a water bath, after which 5 drops of phenolphthalein indicator was added into the content of the flask. The mixture was then titrated with 0.1M sodium hydroxide using a burette until a pink colour was observed, indicating the end point [11].

$$\text{Acid value} = \frac{N \times T_B - T_S}{\textit{Weight of sample oil}} \quad (4)$$

Where; N = molarity of sodium hydroxide
T_S = Titre value of the sample.
T_B = Titre value of the blank

3.2.4. Determination of Iodine Value

0.2g of the sample oil was transferred into a flask containing 10ml carbon tetrachloride. 25ml of Wijs solution was added into the flask containing the sample (Wijs solution consists of iodine monochloride in glacial acetic acid). Blank was prepared. The mixture was stored in a dark place for 30 minutes at temperature of 25°C after which 15ml potassium iodine solution was added along with 100ml of distilled water. The resulting mixture was titrated with 0.1M sodium thiosulphate solution using 2ml of 1% starch indicator. The titration was continued until the blue colour just disappeared, indicating the end point [8, 11].

The iodine value was calculated on the basis of the following equation:

$$\text{Iodine value} = \frac{12.692\ (T_B - T_S) \times N}{\textit{Weight of the sample oil}} \quad (5)$$

Where; N = molarity of the solution.
T_S = Titre value of the sample.
T_B = Titre value of the blank

3.2.5. Determination of Unsaponifiable Matter

After saponification, 300ml of the mixed solvent of ethanol (70%), toluene (25%) and 5ml oil was added to the packed glass column. It was allowed to run through the column at the rate of 12ml / minute. The glass column was washed with 150ml of the solvent mixture at the same rate. It was concentrated to 25ml using rotary evaporator and then transferred to the tarred dish for evaporation in oven at 105°C for 15 minutes. The dried sample was weighed and titrated for the remaining acids; the weight was corrected for the unsaponifiable matter [9].

3.2.6. Determination of Specific Gravity

The sample (40ml) was homogenized and poured into a 500ml measuring cylinder gently to avoid air bubbles. The temperature was controlled to avoid drifting in the temperature value. Hydrometer was dipped into the oil carefully to avoid resting on the wall of the cylinder and the reading was then taken [11].

3.2.7. Determination of Refractive Index

The oil was dried to make it free of moisture. Two drops of the oil was put on the lower prism of the equipment and the prism was closed up. The water was passed through the jacket at 45℃, the jacket was adjusted until the equipment read temperature of 40℃. The light was adjusted and the compensator was moved until a dark border line was

observed on the cross wire. The reading on the equipment was recorded [11].

3.2.8. Determination of Kinematic Viscosity

This was determined by following the method described by Nzikou et. al. [12]. The capillary viscometer tube was used for the determination. The sample was filtered to remove impurities and then introduced into the viscometer and was allowed to stay in a regulated water bath long enough to reach the desired temperature. The head level of the test sample was adjusted to a position in the capillary arm of the equipment to about 5mm ahead of the first timing work. As the sample was flowing freely, the time required for the meniscus to pass from the first time mark to the second was read.

The equation used was:

$$V = c \times t \quad (6)$$

V - Kinematic viscosity
c - Calibration constant
t - Flow time in seconds

3.2.9. Determination of Flash and Fire Points

The dried sample was poured into the cup of the tester to the mark and then placed the cup and cover with the left hand pointing toward the left front corner of the test compartment. Stirrer driver was fixed into the tester properly and the resistance thermometer probe connected. Flame and the pilot light were carried out by lighting and the drought screen was closed. The tester was switched on and the heater temperature was regulated to provide homogeneity. The flash occurred when a large flame was observed on the cup and the temperature at which this occurred was recorded as the flash point for the oil sample. The fire point was temperature observed when the oil combustion was sustained after the flash point of the oil sample was recorded [13].

3.2.10. Determination of Pour Point

The sample was homogenized and poured into the test jar to mark level. The jar was closed tightly with the cork carrying the high pour thermometer that was placed 3mm below the surface of the oil. The disc was placed in the bottom of the jacket and the ring gasket was placed around the jar at the 25mm from the bottom. The test jar was then placed in the jacket. The oil was allowed to cool without disturbance to avoid error. The test jar from the jacket was removed carefully and tilted to ascertain whether there is a movement of the oil. The procedure continued in this manner until a point was reached at which the oil in the test jar showed no movement when the test jar held in a horizontal position for 5 minutes [13].

3.2.11. Determination of Cloud Point

The determination of cloud point was done using a high precision cloud meter (waveguide sensor total - reflection type), the wave guide sensor have an incidence channel, emergence channel and a detector surface that intersect along the detection surface. The incidence optical fibre connected to the exit of the emergence channel, and a cooling / heating of the waveguide sensor was done within a desired temperature range. The sample was placed on the detection surface and light introduced into the incidence optical fibre. The emergence light from the optical fibre was detected. The wave guide sensor was cooled / heated thereby cooling / heating the sample and the temperature wherein the total reflection of light in the emergence optical fibre as the cloud point of the oil sample [13].

3.3. Fatty Acid Profile

The fatty acid profile was determined using a method described [14]. The fatty esters analyzed using a PYE Unicam 304 gas chromatography fitted with a flame ionization detector and PYE Unicam computing integrator. Helium was used as carrier gas. The column initial temperature was 150℃ rising at 5℃ min^{-1} to a final temperature of 200 ℃ respectively. The peaks were identified by comparison with those of standard fatty acid methyl esters.

4. Results and Discussion

The results of proximate analysis of the roasted cashew nut flour are shown in Table 1. Most of present proximate results obtained were similar to that reported for cashew kernel [3] but slightly differ from those reported by some previous workers [5, 15, 16, 17]. The moisture content of cashew nut was 5.90 %. This value was higher than that of date palm fruit (5.24%) [18] but lower than those of walnut (11.01%) [19] and velvet tamarind (8.22%) [20]. Ash content of roasted cashew nut presently reported was 2.91%. This value was higher than those of African nut meg (2.27% [21], pearl millet (1.8%) and quinoa (1.2%) [22] but lower than that of benniseed [22], cashew nut may be suitable for animal and human feeds. The values of crude fat and crude protein were: 42.9% and 26.1%. The crude fat was comparable with those values for varieties of underutilized oil legumes that ranged between 43.8-51.9% [23], but higher than those reported for unhulled *Bracystegia eurycoma* (15.0%), *Detarium microcarpum* (18.5%) [24] and kidney bean [25]. The value for crude fat presently reported for roasted cashew nut was a little higher than that reported [5, 26]. The differences may be due to analytical conditions involved during analysis, species of the cashew nut, processing and the environment in which they are grown. Crude fat is very important as it helps to increase the mouth feels of foods. This value of fat shows that cashew nut is an oil seed. The high crude protein and crude fat content reported in this work were in agreement with the work of Arogba [27] on cashew and lower than that reported for cashew nut [5]. The crude protein content (26.16%) was higher than those values reported for some flours like *Moringa oleifera* leaves (3.00%) [28] and *Parinari curatellifolia* (12.7%) [29]. The crude fibre currently

reported for cashew nut (3.11%) was higher than those of kidney bean (2.68%) [25], cowpea (2.10%) [30], cream coat bambara groundnut (2.00%) [15] but the value was lower those of *Terminalia catappa* oil (4.94%) [12], scarlet runner bean oil [23], velvet tamarind (7.15%) [20] and Cladodes whole flour (CWF) (9.33%) [31]. This observation suggests that the sample would provide good dietary fibre in the diet. It has been observed that polysaccharides also influence digestion and absorption processes in the small intestine. Main effects are exerted in the large intestine [32, 33, 34]. Crude fibre helps in the maintenance of normal peristaltic movement of the intestinal tract hence diets containing lower fibre could cause constipation and eventually lead to colon disease, piles, cancer and appendicitis [35].

Table 1. Proximate Composition of Cashew Nut

Component	%
Moisture	5.90
Ash	2.91
Crude fat	42.9
Crude protein	26.1
Crude fibre	3.11
Carbohydrate	19.0

Table 2. Physical Parameters of Roasted Cashew Oil

Parameters ^{o}C	
Fire point ^{o}C	342
Pour point ^{o}C	4.20
Flash point ^{o}C	280
Cloud point ^{o}C	6.50
Kinematic viscosity mPa.Sec @25^{o}C	55.4
Specific gravity	0.964
Refractive index	1.460
Colour	Yellow

Table 2 presents the results of physical parameters of roasted cashew nut oil. The oil extracted from the cashew nut is yellowish in colour. It has a specific gravity of 0.964 which showed that it is less dense than water as expected theoretically that oil would float on water. The refractive index of 1.460 showed that it is not as thick as most drying oil whose refractive indices fell between 1.475 and 1.485 [36]. The value of the refractive index for cashew oil was lower than the range of 1.475-1.485 reported for linseed oil, soy bean oil and cod liver oil [37]. Refractive index is the measure of the thickness as well as purity or clarity of the oil. The value of the specific gravity was higher than those of kidney bean oil (0.900), *Citrullus colocynthis* (0.910) and bottle gourd oil (0.940) [38]. The values of the fire point, pour point, flash point, cloud point and kinematic viscosity were: 342℃, 4.20℃, 280℃, 6.50℃, 55.4℃, respectively. These values showed that the oil has a combustion characteristic. These values compared favourably with the values reported for crude soybean oil [39]. The characteristic that is necessary for the confirmation of identity and edibility oil is free fatty acid [40]. The kinematic viscosity is a measure of resistance of fluid to deform under shear stress. It is commonly perceived as the thickness or resistance to pouring. Viscosity describes a fluid's internal resistance to flow and may be thought as a measure of fluid friction [12]. The kinetic viscosity of cashew oil was 55.40 mPa sec. (Table 4). This result was higher than that of *Terminalia catappa* (32.92 mPa sec) reported [12].

Table 3 presents the results of chemical parameters of cashew nut oil. The iodine value of cashew nut oil was 42.1 mg iodine/100g. The iodine value and oil components are inversely related. The iodine value gives a proximate amount of the unsaturated fatty acids in any sample oil thereby, providing a comparative idea of the saturated fatty acid components [10, 41]. The iodine value (42.1 mg iodine/g) was lower than those of bottle gourd (98.7 mg iodine/100g), *Citrullus colocynthis* (153 mg iodine/100g) reported [38] and previous work on cashew oil (44.4 mg iodine/100g) [15]. Oils are classified into drying, semi drying and non-drying according to their iodine values. Drying oils have iodine value above 100 [36]. Since the iodine value of cashew nut oil was lower than 100 it could be classified as non-drying oil. The low iodine value indicates that the oil has a low content of unsaturated fatty acids which is evident in the acid value of 11.2%. The peroxide value of cashew nut oil (19.1 mg/KOH/g) was high this indicates that the oil would not easily go rancid when properly stored. The unsaponifiable matter value for cashew nut was 1.42%. The saponification value for cashew nut oil was 139mgkOH/g. This value was lower than those range reported for varieties of melon oil (159-225.1 mgKOH/g), coconut oil (253 mgKOH/g), butter fat (220-241%), coconut oil (200-250 mgKOH), cotton seed oil (190-200 mgKOH/g) and soybean oil (190-194 mgKOH/g) [37]. The low saponification value is an indication that the oil may not be suitable for soap making. The value obtained for free fatty acid was 4.70% oleic acid. This value indicates that the oil can be refined to edible vegetable oil and may not undergo oxidative rancidity that produces off - flavour [10].

Table 3. Chemical Parameters of Roasted Cashew Nut Oil

Parameters	
Iodine value (mg iodine/100g of oil)	42.1
Saponification (mg /KOH/g of oil)	139
Peroxide value (mgEquiv.O_2/kg of oil)	19.1
Unsaponifiable matter (%)	1.42
Acid value (mg /KOH/g of oil)	11.2
Free fatty acid (% oleic acid)	4.70

Table 4 shows the fatty acid composition of roasted cashew nut oil. The fatty acid results were: capric acid (0.04%), myristic acid (0.07%), palmitic acid (12.1%), palmitoleic acid (0.29%), stearic acid (9.05%), oleic acid (58.7%), Linolenic acid (18.9%), linolenic acid (0.12%), Arachidic acid (0.18%) behenic acid (0.14%) and lignoceric acid (0.40%). The total saturated fatty acid was 21.6 % while

the total unsaturated fatty acid was 78.1%, 0.26% were the percentage of fatty acid undetected. Oleic acid dominates the fatty acid present in the oil with the value of 58.7%. Since the unsaturated fatty acid has the highest percentage, it implies that the oil may be desirable for eating. Since unsaturated fatty acid may lower blood serum cholesterol [42]. The caproic acid in calabash seed (9.12%) [43] was higher than that of roasted cashew nut (0.04%). Oleic and linoleic acids are the most concentrated fatty acid in cashew nut oil. This was observed by some previous workers for African yam bean (AYB) oil (0.21%, 35.16%) [44], kidney bean oil (25.2%, 50.3%) [25], *Moringa oleifera* (4.28%, 4.23%) [28] and African nut meg (42.54%,31.42%) [45]. The total unsaturated fatty acid (TUFA) (78.14%) was higher than that of saturated fatty acid (SFA) (21.6%). This is an added advantage to the edibility and quality of the cashew nut oil. The value of TUFA was higher than those range of 50.55-57.07% reported for African yam bean oil [44], pigeon pea oil (68.7%), cowpea oil (66.5%), lima bean oil (69.0%) [46] and gbafilo (*Parinari excels*) seed oil (37.54%) [47] respectively.

Table 4. Fatty Acid Composition of Roasted Cashew Nut Oil

Fatty Acid	Carbon number	Value (%)
Capric	$C_{6:0}$	0.04
Myristic	$C_{14:0}$	0.07
Palmitic	$C_{16:0}$	12.1
Palmitoleic	$C_{16:1}$	0.29
Stearic	$C_{18:0}$	9.05
Oleic	$C_{18:1}$	58.7
Linoleic	$C_{18:2}$	18.9
Linolenic	$C_{18:3}$	0.12
Arachidic	$C_{20:0}$	0.18
Behenic	$C_{22:0}$	0.14
Lignoceric	$C_{24:0}$	0.40

Table 5. Fatty Acid Distribution In Roasted Cashew Nut Oil

PARAMETERS	VALUE
TSFA	78.1
TUFA	21.6
MUFA	60.0
PUFA	19.0
TUFA/TSFA	3.6

The total unsaturated fatty acids (TUFA) was greater than total saturated fatty acids (TUFA > TSFA). The mono saturated (palmitic and oleic acids) were present at high levels in cashew oil. Poly saturated fatty acids (PUFA) (19.0%) (linoleic and linolenic acids) were also present at high amounts but lower than that of the mono saturated counterpart (MUFA) (60.0%). PUFA moderately reduced serum cholesterol and LDL levels [48]. The relative quantities of PUFA and SFA in oils are important in health and nutrition. The ratio of total unsaturated (TUFA) to saturated (TSFA) (TUFA/TSFA) is important in projecting the detrimental effects of dietary fats. The higher the TUFA/SFA ratio the more the nutritional potentials is the oil. Since the cashew nut oil TUFA>TSFA and TUFA/TSFA ratio was 3.6 (Table 5), the oil would be nutritionally suitable for both domestic and industrial utilization.

5. Conclusions

It can be concluded that the roasted cashew nut is a good source of protein and oil. The results obtained from the analyses were compared favourably with conventional edible oils. The high oil yield makes it economically and industrially useful. The oil also exhibits good physical and chemical properties that enable it ranks good among edible oils.

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