

EXTRACTION AND DETERMINATION OF PHYSICOCHEMICAL PROPERTIES OF CASHEW NUT OIL

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Abstract: This study was carried out to extract oil from cashew nuts purchased from SabonGari market in Fagge local government area, Kano state and to characterize the oil; with the view to ascertain its suitability for consumption and other uses. Soxhlet apparatus was used for the extraction using n-hexane as solvent. The physicochemical properties of the extracted oil were analyzed. The oil was light yellow in appearance. The percentage oil extracted was found to be 29.5%, the boiling point of the oil was 230°C, the acid value was 12.57 mgKOH/g, the Free fatty acid (FFA) was found to be 6.36 mgKOH/g, the saponification value and pH were 131 mgKOH/g and 6.65 respectively. The results of the physicochemical analysis as compared with the standard show that the cashew kernel oil is non-toxic.

Keywords: physicochemical, Saponification, soxhlet, Extraction, Cashew nut.

1. INTRODUCTION

The cashew tree (*Anacardium occidentale L.*) is a medium-sized tropical tree cultivated for its fruit (cashew nut) and pseudo fruit (cashew apple). It is also a multipurpose species that provides a broad range of services. About 30-40% cashew kernels are discarded during the process of roasting and are then fed to livestock (Göhl, 1982). The cashew industry ranks third in the world production of edible nuts with world production in 2000 put at about 2 million tons of nuts-in-shell and an estimated value of US \$2 billion, the world cashew nuts production comes from both wild and cultivated trees. The four major cashew producing regions are India, Brazil, Nigeria and Tanzania. During the last decades, the production of cashew nuts in Nigeria has increased from 30,000 tons in 1990 to 176,000 tons in 2000 (FAO, 2000).

Cashew apples are sometimes made locally into fruit drinks, wines and pickles. In some countries they are also osmo-sol dried to produce a date like caramel. The cashew apple is very sour and astringent until fully ripe, when it becomes edible. In contrast to the nut, the apple was neglected until recently, although it is available in far greater tonnage. A number of processes have now been developed for converting the cashew apple into various products such as juice, jam, syrup, chutney and beverage. In addition, the cashew apple is consumed locally and rich in vitamin A and C. The shell of the nut yields phenol-containing oils which are used for preserving and waterproofing and, after distillation; it can be used for oil proof brake lining (Idowu and Abdulhamid, 2013).

The most important product of the cashew tree is the nut, which is used as confectionery. Cashew shell nut liquid (CNSL), which is of great industrial importance is obtained from the seed pericarp by steam distillation or extraction with solvents. When unprocessed or improperly roasted, the cashew nut is very astringent (Abitogun and Borokini, 2009); the complete roasting makes all the allergens inactive. Cashew nut is a high value edible nut which yields two “Oils” one of these found, between the seed coat or pericarp and the nuts, is called the Cashew Nut Shell Liquid (CNSL). It is not a triglyceride and contains a high proportion of phenolic compound. It is used in industry as a raw material for brake lining compounds, as a water proofing agent, a preservative and in the manufacturing of paints and plastics, it is toxic and corrosive to the skin.

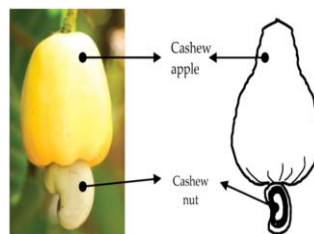
The second type of oil is found in the kernel of the cashew nut. This is called the cashew kernel oil (CKO). It contains high proportion of unsaturated fatty acids. It finds uses in medicine and cosmetics industries (Akpanet *et al.*, 2004).

According to Abitogun and Borokini (2009), Cashew nut oil is neutral when is unprocessed and is the best for human health. It is especially rich in unsaturated fatty acids and is least damaging to heart and arteries. In fact, it constitutes about 47% of the total weight of the nut. Nut often produces oil half their weight, the oil is referred to as ‘good fat and the ratio of saturated to monounsaturated to polyunsaturated fatty acid is 1:2:1 which is ideal for human consumption. According to Achal (2002), the relative abundance of monounsaturated fatty acids in cashew nut oil is conducive to promotion of good health and poses no nutritional risk.

Edible oil can be extracted from cashew nuts but hitherto, there is no evidence of it being carried out commercially. Despite the fact that Nigeria is one of the major cashew producers in the world, it is worthy of note that the utilization of the fruit is still very low. The nut, most times, is discarded, after the consumption of the edible cashew apple, despite its richness in oil. Again, even though it has been discovered that edible oil can be extracted from cashew nut, a thorough characterization of the oil has not been carried out. Cashew nut contains oil of economic importance and due to the efforts of Nigerian government to improve the production of the crop; it is of economic interest to characterize and to improve the oil extracted from the abundant cashew nuts for possible consumption as vegetable oil. (Achal, 2002)

1.1 BOTANY AND TAXONOMY OF *ANACARDIUM OCCIDENTALE* L.

Cashew (*Anacardium occidentale* L.) belongs to the order Sapindales, family Anacardiaceae and genus *Anacardium*. The Anacardiaceae family consists of about 75 genera and 700 species. Botanically, the Anacardiaceae includes primarily trees and shrubs with resin canals, resinous bark and clear to milky exudates. The trees or shrubs have alternate, often trifoliate or pinnate leaves. Flowers are generally not highly conspicuous and can either be unisexual or bisexual. Only one carpel matures, forming a drupe (a fleshy fruit with a stony seed). In some cases, the drupy fruits produce an irritant called urushiol. Cashew is related to Mango (*Mangifera indica* L), Pistachio (*Pistacia vera* L), Poison ivy (*Toxicodendron rydbergii*) and Poison oak (*Toxicodendron diversilobum*) which are also in the Anacardiaceae family. In the genus *Anacardium*, nine species are identified under numerical taxonomy. These include, *Anacardium microcarpum* A. St.-Hil., *Anacardium nanum*, *Anacardium negrense* Pires & Froes, *Anacardium occidentale* L. and *Anacardium spruceanum* Benth. ex Engl. Of all, only cashew (*A. occidentale*) is of economic importance because of its edible apple and nutritious kernel humid climate. The main producers however are Brazil, Benin Republic, Coted’Ivoire, Ghana, Guinea Bissau, India, Mozambique, Nigeria, Philippines, Srilanka, Tanzania and Vietnam (Achal, 2002).



Flate 1.1: Cashew Description

1.2 HISTORY OF CASHEW IN NIGERIA

Cashew was introduced into Nigeria by the Portuguese traders around the 16th century (Ohler, 1979). It was first planted in Agege, Lagos State, from then, it spread to a few other parts of the country through transfer of nuts by man. For over 400 years after introduction, cashew trees were exploited mainly for apple; no commercial value was attached to the nuts (Aliyu,

2012). Many of the trees flourished in the wild while being utilised for afforestation and erosion control scheme particularly in the escarpment areas of Udi in Anambra state. The first commercial cashew planting in Nigeria was in the mid 1950 at Ogbe, Oji, Udi and Mbala by the defunct Eastern Nigeria Development Corporation (ENDC) and Iwo, Eruwa and Upper Ogun by the defunct Western Nigeria Development Corporation (WNDC) (; Asogwa *et al.*, 2009). These plantations were established with introduced Indian cashew varieties. Progress in the cashew industry then was low due to general neglect and poor management of the plantations. With the involvement of private entrepreneurs, Federal and State Governments, and affluent farmers more nuts were obtained in 1978, 1980 and 1982 from India, Tanzania, Mozambique and Brazil to broaden the cashew genetic base of the country. Today, cashew cultivation has spread to almost all the states of Nigeria with increased processing, shipping and exporting activities. The major Cashew growing areas in the different parts of Nigeria in the order of the level of productivity with respect to the different regions of the country are: Enugu, Abia, Imo, Anambra, Ebonyi and Cross River States in the east and southern part, Oyo, Osun, Ondo, Ekiti and Ogun States in the western part, Kwara, Kogi, Nassarawa, Benue, Taraba, Niger, Federal Capital Territory (Abuja), Kaduna and Plateau in the Middle Belt and Sokoto and Kebbi States in the Northwestern of the country (Ezeagu, 2002; Chemonic 2002)

Germplasm (different genetic composition) collection or assemblage is the first step in crop improvement programme. Desai (2008) reported that the initial germplasm collection and evaluation for cashew breeding programme in India, Brazil, Tanzania, Australia, and Mozambique started in 1970 and onwards. Similarly, research into the breeding, cultivation and use of cashew in Nigeria started in 1972 by the Cocoa Research Institute of Nigeria (CRIN). Many breeding trials were established from locally collected materials, and half-sib accessions from India, Tanzania, Mozambique, and Brazil. Some of the trials conducted included grading, planting and evaluation of cashew according to nut weight and size. There were experiments to evaluate the performance of the Brazilian Jumbo nut type at different spacing of 9×9 m, 8×8 m and 6×6 m. The trials facilitated better understanding of the morphology and agronomy. Hybridisation trials showed both self and cross compatibility in cashew genotypes, but low percentage fruit set was recorded for hand pollinated flowers. With respect to entomology and pathological research, suitable fungicide and insecticide mixtures were developed and successfully used to control the incidence of ravaging inflorescence blight disease of cashew. The screening and breeding of cashew genotypes for resistance to the disease and others including the cashew stem girdler (*Analeptestriafaciata*) insect pest is a feat to be achieved. Although cashew flourishes in soils where most other crops do not (Ohler, 2011) it does perform better with nutritional assistance. Cashew responded well to fertilizer application, especially during the vegetative growing period (Hammed *et al.*, 2011). The use of organic fertilizer amended with phosphate fertilizer and arbuscularmycorrhizalfungi (AMF) inoculation were found to have positive influence on the growth of cashew and the chemical properties of the soil. Nigerian Sokoto rock phosphate was discovered a viable option to single super phosphate for cashew production (Ibiremo, 2010; Ibiremo *et al.*, 2012). Recent work by Adewale *et al.* (2013) also revealed that the trend of growth and development of cashew genotypes differed in response to varied combination of soil nutrients.

On-farm evaluation of cashew accessions introduced from India, Tanzania and Mozambique led to the initial selections and subsequent release to farmers of half-sib cashew genotypes called the "G-series" in the 1980s with potential for high yield of 1000 kg nuts/ha (Aliyu, 2012). Although, Nigeria was first to release cashew seeds that have been evaluated to a certain degree to farmers compared with other African countries like Guinea, Guinea Bissau, Cote d'Ivoire and Ghana (Topper, 2002);

1.3 CASHEW NUT OIL

Cashew nut shell is the by-product of the cashew industry which has 1/8-inch thickness of soft honey comb structure containing a dark reddish brown viscous liquid called cashew nut shell liquid (CNSL). CNSL consists of unsaturated phenolic compounds, anacardic acid (90%) and cardol (10%) with minor amounts of 2-methyl cardol and cardanol. CNSL is extracted from Cashew nut shell by different methods like roasting, hot oil process, Screw pressing, solvent extraction and Super Critical Carbon di oxide extraction. CNSL obtained by the cold extraction is denominated as natural CNSL and when extracted in hot extraction is denominated as technical CNSL. Solvent extracted CNSL contains anacardic acid (60-65%), cardol (15-20%), cardanol (10%) and traces of methyl cardol. Technical CNSL contains mainly cardanol (60-65%), cardol (15-20%) and traces of methyl cardol (Chaudhari *et al.*, 2012).



Flate 1.2: Cashew nut Oil

1.4 CASHEW NUT PRODUCTION

In recent times, there has been a steady increase in Nigeria's annual cashew nut production from 466,000 MT in the year 2000 to 836,500 MT in year 2012. The production figure of 2012 for Nigeria worth 45% of cashew nuts produced in African Countries (FAOSTAT, 2013). Africa contributed over 45% of an estimate of 4,152,315 MT of the global cashew production in 2012. Other major cashew producing countries in Africa are Cote d'Ivoire, Tanzania, Mozambique and Guinea Bissau (Chaudhariat *et al.*, 2012)

There are conflicting records of the position of Nigeria in cashew nut production in Africa and in the World. There are *reports* that Nigeria has led Africa in cashew nut production in the past decade with about half the African production. Nigeria ranked second in the world in 2010, 2011 and 2012 with estimated nut production of 650,000, 813,023 and 835,500 MT respectively (Ogunsina and Lucas, 2008; Aliyu, 2011; FAOSTAT, 2013). African Cashew Alliance (ACA) 2012 report however gave cashew nut production estimates in Nigerian as 70,000 and 90,000MT for 2010 and 2011 respectively. This record placed Nigeria fourth position behind Cote d'Ivoire (9,385,000MT), Guinea-Bissau (190,000MT) and Tanzania (110,000MT) and seventh in the world (ACA 2012). These records of production may be based on unimproved planting materials in aged plantations and wild grooves. A committed research attention leading to release of better performing genetic materials may revolutionize cashew production in Nigeria. Potentials of Nigeria in cashew production seem promising. The discrepancies in the above reports on cashew nut production in Nigeria could be largely due to poor commercialization and lack of proper documentations (Chemonics, 2002). Estimated production values cited for Nigeria are reported to be often times obtained from import records of buyers and informal sources (Chemonics, 2002). Since there is a lot of unknown border crossing of raw cashew nuts and unregistered small scale local processors; proper accounting is often inhibited. Production statistics are reported to be difficult to accumulate and only the Food and Agricultural Organization (FAO) make an attempt at estimating and collating country data (Jaeger, 1999).

1.5 INDUSTRIAL APPLICATIONS OF CNSL

CNSL is a versatile raw material and has many industrial applications with 200 patents. The most important use of CNSL is for the manufacture of friction modifying material for brake lining, clutch facing and industrial belting. Other major industrial applications of CNSL include the following (Tejaset *et al.*, 2012).

1.5.1 PAINTS AND ENAMELS

Because of its dark colour, CNSL is used in the manufacture of dark coloured paints and enamels. Paints and varnishes made from CNSL have superior properties than those of conventional oils or synthetic resins. Varnishes resistant to water and gasoline have been made by incorporating sulphur in CNSL (Tejaset *et al.*, 2012).

Lacquers developed from CNSL could be used for insulation, protective or decorative coatings for furniture, buildings, automobiles etc. The films have toughness and elasticity, excellent gloss and superfine adhesive qualities. The dried films are superior to those of ordinary oil paints in respect of resistance to oils, grease moisture and chemicals. Cashew lacquers are cheaper than ordinary oil varnishes (Tejaset *et al.*, 2012).

1.5.2 ELECTRICAL INSULATING VARNISHES

Electrical insulating varnishes are obtained by treating CNSL with formaldehyde and compounding the resulting material with pure phenolic resin varnish or alkyl resin in suitable proportions. Films of those materials are water chemical resistance, as bobbin enamels and laboratory table tops (Tejas *et al.*, 2012).

1.5.3 POLYMERS

Cashew polymers react with formaldehyde to give a rubbery gel, which can be used as a cement hardening agent that would be immune to acids and alkalis reaction. It can be used for cementing floors exposed to chemical attack. CNSL modified by heating at 160 °C in the presence of certain accelerators give enamels that resistant to alkali and acid solutions. Apart from polymeric products, CNSL forms the basic raw material for a vast number of industrially important chemicals and chemical intermediates. The various components of cardanol can be suitably modified to obtain emulsifiers, surface active agents, dye stuffs, antioxidants, stabilizers, accelerators, plasticizers, reclaiming agents and ion exchange resins (Tejas *et al.*, 2012).

1.5.4 LAMINATION

CNSL or cardanol derivatives are extensively used in the laminating industry for reducing brittleness and improving the flexibility of the laminates. Adhesives suitable for plywood are made by oxidising CNSL with potassium permanganate or manganese dioxide at 100 °C reacted with paraformaldehyde and compounded with cuprous chloride. Also CNSL modified furfural, aniline; xylol gives plywood adhesives (Tejas *et al.*, 2012).

1.5.5 RUBBER PRODUCTS

The use of CNSL in rubber composition has been found to improve the performance of rubber products. It helps processing and enhances the vulcanization properties. CNSL enhances the insolubility of natural rubber vulcanizates in petroleum solvents. It helps in the incorporation of ingredients in to rubber and increases its resistance to moisture. Oxides of Cu, Ba, Zn. Harden CNSL and give hard products (Tejas *et al.*, 2012).

1.5.6 PHENOPLASTS

CNSL and its derivatives can also be converted to phenoplasts with better processability, hydrocarbon solubility and resistance to acid and alkalis than the conventional phenol based systems. Moulding powders from CNSL, shellac and fillers such as wood flour, saw dust, asbestos are found to give articles with excellent finish, good flexural, tensile strengths and satisfactory water resistance. Stable rigid or flexible covering materials in the form of tiles sheets etc., are made from compositions containing CNSL, formalin, natural rubber and synthetic rubber and other conventional ingredients (Tejas *et al.*, 2012).

1.5.7 PESTICIDAL ACTION

Chlorinated and copperized CNSL have been found to have pesticidal effects on insects and fungi (Tejas *et al.*, 2012).

1.6 MEDICINAL APPLICATIONS CASHEW NUT SEED OIL

Anacardic acids were reported to have greater antibacterial activity compared to other constituents of CNSL. Anacardic acid found to be useful against medically important bacteria that are involved in the tooth decay (*Streptococcus mutans*), acne (*Propionibacterium acnes*), ulcers (*Helicobacter pylori*), and infection (*Staphylococcus aureus*). Anacardic acid has synergistic effects with methicillin against methicillin-resistant *Staphylococcus aureus* (MRSA) (Parasale *et al.*, 2011). Anacardic acid inhibits both gram positive and gram negative bacterial growth. It displays anti-cancer activity and were most effective against breast cell cancer lines. It also acts as a non-competitive inhibitor of the histone acetyl transferase (HAT) activity of the transcriptional co activators p300 and PCAF. Dietary consumption of foodstuffs containing anacardic acids may have chemotherapeutic or chemopreventative actions (Parasale *et al.*, 2011).

1.7 EXTRACTION METHODS OF CASHEW NUT SEED OIL

Extraction of CNSL is carried out by various methods that are explained in the literature are discussed in detail. The variability of composition depends on extraction method but in general, the composition of natural CNSL is a mixture of anacardic acid, cardanol, cardol and 2-methyl-cardol in smaller quantities. (Rajapakse *et al.*, 1977).

1.7.1 ROASTING METHOD

In this method, the nuts are fed into a rotating drum, which is heated initially to red hot sufficiently to allow the shell portion of the nut to ignite and burn. Once ignition starts no further heating is necessary and the drum maintains the temperature on its own because of the burning of oil, which oozes out of the nuts. The temperature of the drum is 180-185 °C. It is stated that in this method of roasting shell becomes very brittle and the rate of shelling and out-turn of whole kernal is higher compared to other methods. The roasting generally takes about 3-5 minutes and the drum is rotated by hand. This method recovers 85-90% of the liquid (Parasalet *al.*, 2011).

1.7.2 HOT OIL BATH METHOD

The hot oil-bath method is the most common commercial way of processing the nuts and extracting CNSL partially. Here the raw nuts are roasted in a bath of CNSL maintained at 185⁰C to 190⁰C, the time of contact of the nuts with the liquid being 2-3 minutes. The shell of the nut gets brittle due to partial release of CNSL in to the liquid bath. The temperature of the bath should be maintained at 185⁰C to 190⁰C. If it is below this range, the process tends to be inefficient. This method yields CNSL of around 7-12 % by weight (Rajapakseet *al.*, 1977).

1.7.3 USING SOLAR COOKER

CNSL was extracted using concentrating solar cooker of 1.4 kW capacities and a diameter of 1.4 m. The focal point diameter of the cooker was 30m and was used to collect the reflected heat from reflector and achieved a temperature of 225-300 °C. Solar cooker of the following specifications was used for carrying out the extraction. Specifications Type: Parabolic Solar Cooker Model: S K-14 Reflector: Aluminium sheet (reflectivity >75%) Diameter: 1.4 m Reflector area: 2.2 m² Temperature: 200–215 °C Thermal efficiency: 40 % Cooking capacity: 13 x 10⁻³ m³/hr. The authors could achieve CSNL to the tune of 550 x 10⁻³ m³ from 5 kgs of shells in 5 minutes. The composition of analysis of CNSL could not be performed. They carried out the proximate analysis of detailed cake. Low percentage of ash content and higher percentage of volatile matter and calorific value revealed the suitability of de-oiled cashew shell as a fuel for thermal application using the gasification route for better control and higher efficiency. Combustion of shell could be done either in a fixed bed combustion chamber which gave 50% efficiency or fluidized bed chamber which gave 85% efficiency (Rajapakseet *al.*, 1977).

1.7.4 SCREW PRESS METHOD

The raw cashew nut shells are put in the hydraulic press on screw pressing and then exert high pressure in order to release CNSL from shells. This method is rather straightforward and quick among others. Work was reported for extraction of CNSL by means of tapered compression screw, feeding rollers of transversal zigzag surface type and cylindrical casing with 2 mm diameter holes. By using screw speed of 7-13 rpm and feeding rate of 54-95 kg/h, the percentage of CNSL extracted was 20.65-21.04 percent, the percentage of CNSL purity was 85.53-87.8 wt % and the rate of extraction was 11.93-14.90 kg/h. However, the residue from this method still contained significant proportions of CNSL (around 10 to 15%). Moreover, this meathod of extraction had higher levels of impurity, higher viscosity, lower thermo-oxidative stabilities and lower ebullition temperature. The CNSL obtained by this process contained 42% cardol, 47% anacardic acid and 3% Cardanol (Rajapakseet *al.*, 1977).

1.7.5 SOLVENT EXTRACTION:

This method gives off most of CNSL compared to other methods. The oil remains in the residue was less than 1% by weight. Extraction solvents fall in to two groups, which are lesser than water and which are denser than water. Commonly used extraction solvents are of two types first includes diethyl ether, ethyl acetate and hydrocarbons such as light petroleum, hexane, toluene and second includes chlorinated solvents, such as dichloromethane and chloroform, with dichloromethane being the preferred solvent because of its lower toxicity. However, chlorinated solvents do have a greater tendency to form emulsions than non-chlorinated solvents. Emulsions are suspensions of small droplets of one immiscible liquid in another. Properties like dielectric constant, boiling point, flammability and toxicity of extracted CNSL varies with the type of solvent used for extraction is mentioned in the literature (Rajapakseet *al.*, 1977).

Solvent extraction was carried out by placing the freshly broken shells (50 g) in an Erlenmeyer flask and covering them with the pentane (100 mL). The extract was filtered off after 12 h, and the shells were again covered with the solvent. Five such extracts were combined and evaporated on rotary evaporator under reduced pressure, below 30 °C. Pentane used for the extraction was obtained by fractionating commercial pentane using a packed column and collecting the fraction distilling at 32 °C (Nikornet *al.*, 2007)

2. METHODOLOGY

2.1 Sample Collection and Preparations

The cashew nuts were purchased from SabonGari market at Fagge local government in Kano state and air-dried in cool place for seven days prior to grinding with mortar and pestle into powdery form suitable for extraction so as to give good yield. The ground cashew nuts were then stored in a container.

2.2 Oil Extraction

Hundred grams (100 g) of the ground cashew nuts were placed into a thimble and inserted into the Soxhlet extractor. Exactly 200 ml of n-hexane were then introduced into a round bottom flask and heated using a hot plate at 60°C for three hours. The extracted oil was then placed into a beaker and covered with porous Aluminium foil to permit the escape of n-Hexane as it is volatile. The oil free from n-hexane was then recovered after 24 hours.

- **Phenolphthalein (1%, w/v)**

One gram (1 g) of phenolphthalein solute was weighed into 100 ml volumetric flask and dissolved with 96% absolute ethanol and made up to the mark.

- **Bromophenol Blue in 98% Ethanol**

About 24 ml of ethanol was dissolved with distilled water to 25 ml and 0.02 g of bromophenol blue was dissolved in the solution prepared.

- **Potassium Hydroxide (KOH) 0.1M**

About 0.65 g of potassium Hydroxide (KOH) was dissolved in 100 g of distilled water to get 0.1 M of KOH, this was achieved by using mole ratio equation

2.3 PHYSIOCHEMICAL PARAMETERS

2.3.1 YIELD

Oil yield is the amount of oil recovered from certain mass of nuts and it can be expressed mathematically as

$$OY = \frac{\text{weight of oil extracted (g)}}{(\text{weight of oil extracted} + \text{weight CAKE})} \times 100\% \quad 2.1$$

Where, OY = oil yield

2.3.2 DETERMINATION OF ACID VALUE

Exactly 25 ml of ethanol was heated with 2.5 ml of the oil sample in a conical flask until it began to boil, then the flask was removed from the heater and allowed to cool. About 2 – 3 drops of phenolphthalein solution were added to the flask and titrated against 0.1M KOH with constant shaking until a pink color is obtained Akpanet *al.*, (2004) The acid value is then determined from the relation:

$$\text{Acid value} = \frac{56.1 CV}{W} \quad 2.2$$

Where,

56.1 = constant

V = volume in ml of standard potassium hydroxide used

C = concentration of KOH solution

W = weight in gram of the sample

2.3.3 FREE FATTY ACID

The oil sample (2.5 g) was weighed into 250 ml conical flask and 25 ml of ethanol was added and heated until it began to boil, After the heating was achieved and the mixture was allowed to cool. About 2 – 3 drops of phenolphthalein solution

were added to the sample and titrated against standard alkali solution (0.1M KOH), shaking vigorously during the titration, until pink coloration remained or persisted indicating the end point

$$FFA = \frac{28.2 CV}{W} \quad 2.3$$

Where 28.2 is constant and,

V = volume in milliliters of standard potassium hydroxide used

C = concentration of potassium hydroxide solution

W = weight in gram of a sample

The method as described by Devine and Williams (1961)

2.3.4 DETERMINATION OF PH VALUE

The pH meter was calibrated and then inserted into the cashew nut oil, the pH value was indicated by the appearance of an arrow on the screen of the pH meter. The pH value was determined by the method as described by Atofaranti (2004)

2.3.5 DETERMINATION OF SAPONIFICATION VALUE

Exactly 2 g of oil sample was weighed in to 250 ml of conical flask, 25 ml of 10% alcoholic KOH was added and heated for about 30 mins with occasional shaking. After cooling, 0.5 ml of 1% phenolphthalein indicator solution was added; the mixture was titrated with 0.5M HCl until the dark pink color disappeared. The blank titration was carried out for oil sample but without the oil sample.

Saponification value was obtained using the expression giving below;

$$\text{Saponification value (mg KOH/g)} = \frac{\{(B-S) \times N \times 56.1\}}{W} \quad 2.4$$

Where,

B = Volume in ml of HCl required by blank titration

S = Volume in ml of HCl required by oil sample titration

N = normality of HCl

W = weight (g) of oil sample

The method was adopted from Strong and Cock (1974).

2.3.6 DETERMINATION OF BOILING POINT

About 3 ml of the oil was introduced into a 250 ml beaker. The beaker was heated on a hot plate to boil, and the mercury in glass thermometer was inserted in the beaker for some time to determine the temperature.

2.3.7 DETERMINATION OF DENSITY

About 2 ml of oil was measured in a measuring cylinder of known weight. The weight of the cylinder was subtracted from the weight of both oil and measuring cylinder.

$$\text{Density} = \frac{(W_a - W_b)}{V} \quad 2.5$$

Where,

W_a = weight of measuring cylinder and the oil

W_b = weight of measuring cylinder

V = volume of the oil sample

This method is described by AOAC (1990)

3. RESULTS

The summary of the results for all the properties measured are presented in Table 3.1 for the physicochemical parameters analyzed

Table .I: Results of the physicochemical properties of the oil compared with WHO standards

S/N	PARAMETER	VALUES	STANDARD (WHO)
1.	Percentage yield	29.5%	25-45%
2.	Acid value	12.57	<20.00
3.	Free fatty acid	6.36%	3.5-12.5%
4.	Density	0.89	0.87-0.9
5.	Saponification value	131	175-205
6.	Color	Light yellow	Light Yellow
7.	Ph	6.65	6.25

4. DISCUSSION

The free fatty acid of the oil was found to be 6.36%, which is lower than the previously reported value of $36.09 \pm 1.12\%$ by Idowu and Abdulhamid (2013). This is an indication that when the cashew nut oil is refined it can be edible; and it also implies that the oil may stimulate oxidative deterioration which can result in the formation of off-flavor component, as earlier reported by Abitogun and Borokini (2009).

The acid value of the cashew nut oil was found to be 12.57 mgKOH/g which is higher than 2.24 ± 0.56 reported by Idowu and Abdulhamid (2013). The value is also higher than the value of 0.82 mgKOH/g reported by Aremu *et al* (2006), but lower than the value 15.7 mgKOH/g reported by Akinhanmi and Akintokun (2008), and 5.99 mgKOH/g reported by Ataise *et al* (2009) for groundnut oil. The low acid values obtained for the oil shows that the lipid is in good non-degraded state and the values are within limits for oil used in the manufacture of paints and varnishes (Idowu and Abdulhamid, 2013), (Cock and Rede 1996).

The saponification value which is a measure of the molecular weight of fatty acid present in the oil was found to be 131 mgKOH/g for the oil which is slightly lower than the value 187 mgKOH/g reported by Pearson (1981), for groundnut oil. This low value is an indication that the oil may not be suitable in soap making.

The pH value of the oil was found to be 6.65. Some of the properties obtained here show a slight deviation from those reported by Akinhanmi and Akintokun, (2008); this may be due to differences in the species of the cashew nut, the environment in which they are grown and the methods of extraction of oil before characterization.

The colour of the oil was found to be light yellow and the density was found to be 0.89g/cm³ which conforms with the standard

Results used for this analysis are from the raw unrefined state of the oil. Generally, the physical and chemical properties of the characterized Cashew kernel oil show to a greater extent conformity with the properties exhibited by melon oil and groundnut oil as reported by Bertha (1992) and Weiss (2000). This shows that it could be used in the food and pharmaceutical industries. The CNSL, on the other hand, comprises both the acidic and non-acidic substances called the anacardic and the cardol respectively. The properties of the extracted oil were compared favorably with the physical and chemical properties of the castor oil as reported by Aldo *et al.*, (2012) and linseed oil by Viorica-Mirela *et al.*, (2012). This suggests its application in the processing and manufacturing industries

5. CONCLUSION

The results of this study showed that the chemical properties of cashew kernel oil are within specification for vegetable oils. This suggests its possible use as vegetable oil when refined. The oil extracted by Soxhlet apparatus using n-hexane as solvent has percentage yield of 29.5%. The oil is light yellow liquid with a sweet odor. The physical and chemical properties of the oil show that it is within specification for vegetable oil. The pH value of the oil is also a clear indication that the oil is non-toxic and as such edible.

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