Available online at www.koozakar.com/journal/koozakar-proceedings

African Institute for Science Policy and Innovation
International Biennial Conference
Conference Proceedings

VOLUME 2

2nd AISPI International Biennial Conference on Harnessing Science, Technology and Innovation for Inclusive Development in an Uncertain Future, 2021

Evaluation of Physico-Chemical Characteristics and Fattyacid Composition of Tiger Nut Oil (*CYPERUS ESCULENTUS L.*)

T. A. Ademiju*, E. R. Olaroye, and J. N. Eze

Dept. of Agricultural Education, Federal College of Education (Technical), Asaba, Nigeria.
*Corresponding author's email address: tessy6u@gmail.com

Abstract

Despite the fact that tiger nuts oil is not entirely new, it is still largely untapped in many parts of the world and underutilized even in areas where it is grown, especially in Nigeria. Therefore, the objective of this study is to evaluate the physicochemical properties and fatty acids composition of tiger nuts (Cyperus. esculentus) tuber oil. The oil was extracted from milled tiger nuts using the evaporation process with redistilled industrial grade n-hexane as solvent. The quality of the extracted oils was assessed in terms of acid value, iodine value, saponification value, peroxide value, refractive index, and unsaponifiable matter. Physiochemical properties of the oil samples were determined. The peroxide value, free fatty acid, and moisture content of tiger nut oils were monitored for four (4) weeks during the storage studies. The refractive index, specific gravity, acid value and free fatty acid value ranged between 1.46 - 1.47, 0.89 - 0.90, 0.4 - 1.40mg/g, and 0.20 - 0.75% respectively. The peroxide, saponification and iodine values ranged between 3.99- 4.43meq/kg, 183.25 -202.87 mg/kOH/g and 29.69- 31.74g/l2/g respectively. The major fatty acids (FAs) of the tiger nut oil were oleic (77.71%), palmitic (16.17%), and stearic (5.08%) acids for the black cultivar; oleic (64.12%), palmitic (11.86%), linoleic (11.87%) and dihum, linolenic (1.71%) for the brown cultivar while the yellow cultivar had oleic (68.89%), linoleic (12.77%), palmitic (13.33%) and stearic (4.46%). During storage, the oil's peroxide value, free fatty acid and moisture content was 5.62 mmol 20/kg, 1.54 mg KOH/g and 01338 respectively. These results indicate that tiger nut tuber oil could be a good source of edible oil, can replace imported olive, maize, sunflower and/or soy bean oils in foods and address domestic supply gaps of edible oils in Nigeria

Keywords: Tiger Nut, Oil, Physico-chemical, Fatty acid, Evaluation

Selected and peer-reviewed by ASIPI, Obafemi Awolowo University, Ile-Ife, Nigeria.
Published 2024 by Koozakar LLC. Norcross GA 30071, United States.
https://doi.org/10.69798/26780337

1.0 Introduction

Tiger nut (*Cyperus esculentus* L.) is an edible perennial grass-like plant belonging to the sedge family, and is a lesser-known vegetable that produces sweet nut-like tubers known as earth almonds. Tiger nut is a highly adaptable crop and grows well under a wide range of climatic and soil conditions. It is found throughout the tropics, subtropics and warm temperature regions. There are mainly three varieties namely**:** black, brown and yellow, and only yellow and brown are readily available in the Nigerian markets. The yellow variety is preferred to all other varieties because of its inherent properties like its bigger size, attractive colour and fleshier body. The yellow variety also yields more milk, contains lower fat and higher protein and less anti-nutritional factors especially polyphenols (Okafor, 2003). Tiger nut has been reported to be a health food since its consumption can help prevent heart disease, thrombosis, activate blood circulation (Chukwuma, *et al.*, 2010) and assist in reducing the risk of colon cancer (Adejuyitan *et al.*, 2009). The tiger nut tuber is rich in energy content (such as starch, fat, sugar, and protein), minerals (mainly phosphorus and potassium), and vitamins E and C (Belewu and Belewu, 2007) thus making this tuber also suitable for diabetics and for those who wants to lose weight (Borges *et al.*, 2008). Tiger nuts have excellent nutritional quality with a fat composition similar to olive oil and rich mineral content, especially phosphorus and potassium (Moore, 2004).

Products from tiger nuts may include aqueous solutions (as a base for non-alcoholic beverages), milky solutions (as refreshing beverage or partial milk substitute), flour which is a good alternative to many other flours like wheat flour, as it is gluten free and good for people who cannot take gluten in their diets (Belewu and Abodunrin, 2006) and tiger nut oil. Tiger nut oil has a mild, pleasant flavour and is considered as food oil similar but superior in quality to olive oil. Tiger nut oil is 80% unsaturated fatty acid, mainly oleic (64.2 – 68.8 %). This shows that tiger nut oil has a good potential as a substitute for imported olive oil. The oil is golden brown in colour and has a rich, nutty taste. The iodine level of tiger nut oil comes under a non-drying oil which is substantially unsaturated, which could be utilized for cooking and may find application as a raw material in industries for manufacturing soap, vegetable oil-based ice cream, salad cream and other non-food applications. The oil remains in a uniform liquid form at refrigeration temperature. It is regarded as high-quality oil due to its extraction without adding any external heat (cold pressed oil), and is highly recommended for cooking over other oils because it is more resistant to chemical decomposition at high temperatures (Shaker *et al*., 2009).

Furthermore, less fat is absorbed into the food as it creates a crust on the surface during cooking, preventing the oil itself being absorbed into the product. In the textile industry, the oil is used to waterproof textile fibres. The oil compares well with corn, soybean, olive and cotton seed oil and can thus serve as a substitute for these oils especially in times of scarcity. The oil is a potential source of biodiesel and much research has been conducted. In Nigeria, tiger nut is available in fresh, semi-dried and dried form in the markets where it is sold locally and consumed even uncooked. Tiger nuts are under-utilized due to lack of information on their nutritional potential and a lot of people eat the tiger nut without knowing the nutritional benefits and products that can be obtained from it like tiger nut oil (Rita, 2009). Therefore, this study is aimed at evaluating the physico-chemical characteristics and fatty acid composition of tiger oil and determine the storage stability of the oil.

2.0 Materials and Methods

2.1. Sample collection, identification and preparation

Fresh Tiger nut (Cyperus esculentus L.) seeds were bought from Hausa Market, along Asaba- Onitsha Road, Asaba, Oshimili South Local Government Area of Delta State, Nigeria, as shown in Plate 2.1. In order to remove adherent soil particles, foreign materials and bad nuts that may affect the consistency of the oil extract, they were washed with water. Using the skinning machine (King Runda 6FW-B7 model), the seeds were skinned to remove the bark (skin) and it was washed again after skinning and sun dried for a few weeks to remove moisture and finally oven-(Memmert Type Oven)dried at about 70^{o}C within which constant weight was obtained. As shown in Plate 2.2, the dried tiger nuts were ground into flour and packed in polyethene bags and then held in a 10^{o}C refrigerator until used for the analysis.

Plate 1: Fresh Tiger Nut Seeds

Plate 2: Dried Tiger Nut Seeds

2.2 Extraction of Oil from Tiger Nut Seeds

The oil was extracted using the evaporation method from the tiger nut flour. In order to obtain appreciable amounts of both polar and non-polar lipids in the sample, 8kg of milled tiger nut was transferred to a glass container and 15 Litres(L) of redistilled commercial grade n-hexane was extracted using muslin cloth as an extension for 72 hours. Another 10 litres of pure n-hexane were added to the residue and macerated in the cold for 3 days, so the procedure was repeated. The combined n-hexane extract was then filtered further using filter paper and concentrated to remove the solvent using a rotary evaporator at 105°C and was further dried using a vacuum oven set at 105°C and at a pressure of 700 mg/Hg. As described by Kwiatkowski and Cheryan (2002), the extracted oil was then purified. The obtained purified oil was placed in a dark bottle in the refrigerator at 5°C until required for analysis. The quantity of oil that was extracted was calculated using question below;

$$Weightofextract Oil(Kg) = Z - Y$$

$$where;$$
$$Z = weightofthebottle \wedge extract$$
$$Y = Weightofbottlewiththesample$$

The volume of oil was recorded and expressed as oil content (%) as calculated below:

$$OilContent = \frac{Weightofoil}{WeightofSample} x100$$

2.3 Determination of Physical Properties

The method described by Lee *et al.* (2004) was applied in determination of the physical properties of the extract tiger nut oil such as colour, moisture content, refrative index, specific gravity, pH, temperature and relative index.

2.3.1 Colour

The sample of tiger nut oil (10ml) melted in a cuvet was put in a water bath at 35°C and analyzed using a Lovi bond-Tintometer model E, S. No. 5064E, England. When a complete color match was achieved, the colours of the red, yellow and blue units were adapted. The unit value of the lower unit color was subtracted from the colours, leaving two units that were then used to characterize the sample colour (AOAC, 2010).

2.3.2 Moisture contents

Tiger nut oil moisture content was determined by the AOAC (2010) as adopted by the FSSAI (2012). Within the tared, dried and weighed moisture dish, 2.00 grams of tiger nut were poured, heated in an oven at 105°C for 1 hour, cooled and weighed in a desiccator containing phosphorus peroxide. This was repeated until a constant weight was obtained and the percentage (%) of the moisture content in the oil was measured using the following equation;

$$MoistureContents(\%) = \frac{M_s - M_h}{M_s - M_t}$$

$where;$

$M_s = WeightofMositureDish\ Sample(g)$
$M_h = WeightofMoistureDish\ Sampleafterheating(g)$
$M_t = WeightofMositureDish(g)$

2.3.3 Refractive index

The refractive indices (RI), of the oil samples were measured using the Abbe refractometer connected to a thermostatically controlled water bath that maintained the temperature of the refractometer at 40°C. The prism of the instruments was cleaned thoroughly and a drop of the oil sample was placed on the prism. The temperature of the oil was allowed to equilibrate with that of the thermos stated fluid and reading of the thermometer was noted. Water at 30°C was circulated round the glass slide to keep its temperature uniform. The knobs of the instrument were set and the fluid was demarcated by a sharp line dividing the field of view into two equal halves and when line conceded with the spot marks "X" in the field of the view. The reading was taken at this point that is at normal temperature of 25°C but 40-60°C is for high melting fats (AOAC, 2010). At no parallax error, the pointer on the scale pointed to the refractive index. This was repeated and the mean value noted and recorded as the refractive index. The Refractive index was determined using the following equation;

$$Ri = R + k(T_1 - T_2)$$

$where;$

$Ri = refractiveindexreducedstandardtemperature$
$R = Readingobtainedattemperature T3$
$T_1 = StandardTemperature 25^0C$
$T_2 = Temperatureatwhichreadingwastaken$
$K = substitutingfactor(constant)which 3.85x10^{-4}$

2.3.4 Specific gravity

The specific gravity bottle (Pycnometer) was used in measuring the density/specific gravity of the sample. The specific gravity of oil is the ratio of the weight in air of a given volume of the oil at a defined temperature to that of the same volume of water at same temperature (AOAC, 2012). Cleaned, dried pycnometer was weighed and the bottle was filled to the brim with water and stopper was inserted. Extra water spilled out. The water on the stopper and bottle were carefully wiped off and reweighed (W_1). Same process was repeated, but using oil samples instead of water and weighted again (W_2). The specific gravity of the oil samples was calculated using the following formula;

$$SpecificGravity = \frac{W_2 - W_0}{W_1 - W_0}$$

$where;$

$W_0 = WeightofEmptySpecificGravityBottle$
$W_1 = WeightofWater \wedge SpecificGravityBottle$
$W_2 = WeightofTestSample \wedge SpecificGravityBottle$

2.3.5 Relative Density

A specific density bottle was washed, dried and weighed (W_0). It was filled with distilled water and weighed (W_1). The water was poured off and the bottle was dried to it previous constant weight and then filled with the oil sample and weighed (W_2). The relative density was determined using the following formula;

$$RelativeDensity = \frac{W_2 - W_0}{W_1 - W_0}$$

$where;$

$W_2 = WeightofSpecificDensityBottle \wedge Oil$

$W_1 = WeightofSpecificDensityBottle \wedge water$

$W_0 = WeightofSpecificDensityBottle$

2.4 Determination of Chemical Properties

The iodine value, saponification value, unsaponifiable matter, acid value, and peroxide values were determined according to standard IUPAC methods for the analysis of oils and fats. The ester value was obtained by subtracting the acid value from the saponification value. All experiments were conducted in triplicate.

2.4.1 Iodine value

The method described by Nadeem *et al*. (2013) was used to determine the iodine value. Two grams of tiger nut oil was weighed into a conical flask, and 20ml of carbon tetrachloride and 25ml of DAM'S reagent were added. A stopper was inserted and the content in the flask was swirled vigorously. The sample was then kept in the dark for 1 hour and 30 minutes. Twenty millilitres of 10% potassium iodide (KI) solution and 100ml of water were added. The content in each flask was then titrated with 0.1M sodium thiosulphate solution using starch as indicator. Titration continued until sudden disappearance of blue colour. After the blank determination, iodine value is calculated with the formula;

$$IodineValue = \frac{(A-B)x(Na_2S_2O_35H_20)X12.69}{Q}$$

Where

A = volume of 0.1 M $Na_2S_20_35H_20$ solution used for the blank titration.

B = volume of 0.1 M $Na_2S_20_35H_20$ solution used for the sample titration.

Q = Weight in gram of the oil sample

Conversion Factor = 12.69

N = Normality of $Na_2S_20_35H_20$

2.4.2 Saponification value determination

This is the weight of potassium hydroxide, in milligrams, needed to saponify one gram of oil (Sadoudi,*et al.*, 2017). Two (2) g of sample was weighed into a conical flask and 25ml ethanolic potassium hydroxide was then added. The flask was configured to a condensing set-up and heated on a water- bath for 1 hour with frequent shaking and the content was allowed to cool. Phenolphthalein indicator was then added to the content and was titrated with 0.5M hydrochloric acid until the pink color disappear. Equivalent titration was performed for the blank and generated values were employed for computation according to the following equation;

$$SaponificationValue = \frac{A-B}{Q} X28.05$$

Where

A = Volume of 0.5M of Hydrochloric acid used in the blank titration.

B = Volume of 0.5M of Hydrochloric acid used in the sample titration.

Q = Weight in grams of the oil sample.

Conversion Factor = 28.05

2.4.3 Peroxide value

Peroxide value was obtained by AOCS iodometric official method Cd 8-53 (Crowe and White, 2011). Oil sample (2.0 g) was accurately weighed into a conical flask, and dissolved in solvent mixture containing 12 ml chloroform and 18 ml glacial acetic acid. To the solution 0.5 ml of a saturated aqueous potassium iodide solution was added. The flask was stoppered and allowed to stand for 1 min. Thirty millilitres of water was

added and the solution was titrated with 0.1 M sodium thiosulphate solution until the yellow colour had almost gone. About 0.5 ml of starch solution was introduced and titration continued with the reagent added slowly until the blue-black colour disappeared. During titration, the flask was continuously and vigorously shaken to transfer the liberated iodine from the chloroform layer to the aqueous layer. A blank titration was also performed, and the peroxide value was obtained from the formula (Sadoudi et al., 2017):

$$PV\left(meq\frac{O_2}{kg}oil\right) = \frac{(V - V_O)}{m}x10^3$$

Where PV is peroxide value;
V = volume of $Na_2S_2O_3$ solution used for the sample test (in mL);
V_0 = volume of $Na_2S_2O_3$ solution used for the blank test (in mL);
N= normality of $Na_2S_2O_3$ solution;
m =weight of the oil sample taken (in g)

2.4.4 Acid value

Acid value of the oil sample was determined according to International Standard Organisation (ISO) by dissolving 2g of oil in 25ml diethyl ether with 25ml ethanol and phenolphthalein and was neutralized with 0.1M sodium hydroxide (NaOH). The mixture was then titrated with 0.1M sodium hydroxide (NaOH) until a pink color which persists for 15seconds was obtained. The peak was measured by triangulation and the relative proportion of individual compound were therefore obtained by determination the partial areas in relation to total area (Samuel *et al.,* 2012).
Calculation is as follows:

Acid Value = (56.1 x C x V) / W

Where;
C = concentration of NaOH used
V = volume (ml) of NaOH used
W = Weight of sample

Percentage free fatty acid (% FFA) (as oleic) was determined by multiplying the acid value with the factor 0.503. Thus % FFA = 0.503 x acid value.

2.5 Determination of Fatty Acid Composition

This involves the use of Gas chromatography linked to Mass spectrometry. Oil extracted from each sample was methylated by dissolving 0.2g of the oil in a conical flask with 6cm^3 of methanolic NaOH (2g NaOH in 100ml methanol). This was refluxed for 10 3minutes. 10ml of n hexane, was added to the mixture, refluxed for 2 minutes then cooled. 10ml of distilled water was added and the lower aqueous layer separated from methylated oil. CCl4 was added to remove excess water. The methylated oil was dissolved in pure hexane and introduced into the injector of GC/MS – gas chromatographic system at an injection temperature of 250^{o}C using Helium as a carrier gas at a pressure of 100.2KPa. The fatty acids were eluted as peaks whose retention times were measured by the mass spectrometer detector and compared with those of known standards. Individual fatty acids were identified with those standards.

2.6 Statistical analysis

The experimental data were subjected to analysis of variance (ANOVA) for a completely randomized design using a statistical analysis system SAS (2000). The least significant difference (L.S.D) test was used to determine the difference among means at 0.05 level of significance

3.0 Results and Discussion

3.1 Physical and Chemical Properties of Tiger Nut Oil

The processing of tiger nut oil involves slowly pressing the flour with large presses, making it sweat in the first cold oil extraction and then filtering with strengthened filters. This production method offers a highly recommended oil consistency for cosmetics, massages, bio-diesel and culinary use. Tiger nut oil is currently considered to be a stable oil, high in monounsaturated fatty acids and marketed as cold-pressed oils (Ezeh *et al.*, 2014). The findings of the physicochemical analysis shown in Table 1 show that fresh and stored tiger nut oil has the same specific gravity of 0.939 and the specific gravity of 0.901 is also the same for fried and stored tiger nut oil. This specific gravity obtained for both the fresh and fried oil of 0.939 and 0.901 is an indicator that tiger nut oil is less dense than groundnut oil. Consequently, the specific gravity values explained that there were no significant differences between fresh and stored tiger oils ($p>0.05$) (El - Naggar, 2016). The refractive index was obtained for both fresh and stored oil at 1.4680 and for both fried and stored oil at 1.4720. These values are in line with the olive oil value of 1.466.

Table 1: Physical and Chemical Properties of Tiger Nut Oil.

Parameter	**Values**		
		Fried and stored oil	
	Fresh Oil	**Wk1**	**Wk 4**
Colour	**Golden brown**	**Light brown**	**Light brown**
Specific gravity (200C kg/dm3)	0.939	0.901	0.901
Refractive index (200C)	1.468	1.472	1.472
Acid value (mg KOH/g)	2.29	3.21	3.06
Relative density(g/cm3)	0.919	0.9	0.9
Saponification value (mg KOH/g)	115.1	154.27	159.15
Iodine value (g/100g)	103.29	107.87	114.21
Peroxide value (mmol 20/kg)	4.31	5.37	5.62
Flash point	340	310	290
Moisture content	1.4661	0.145	0.1338

This showed that, compared to other drying oils with refractive indexes between 1.475 and 1.4855, the oil is less dense. In general, the refractive index sheds light on structural properties, such as the average molecular mass and the degree of fatty acid unsaturation in oils and fats. However, no significant difference ($p<0.05$) between fresh and stored tiger nut oil was observed and the findings were similar to those reported by Olagunju (2006); Bamishaiye *et al.* (2010) and Muhammad *et al.* (2011). The near iodine values of fresh and stored oil are 103.29 and 105.10 and the equivalent peroxide values are 4.31 and 4.80, respectively. This finding shows that there was no appreciable difference between the physicochemical parameters of fresh and stored tiger nuts, so that the oil could be stored without deterioration for up to 1 month after usage. The iodine value is an indicator that the oil contains a high amount of unsaturated fatty acid relative to other saturated oils, as determined by the degree of unsaturation in the oil and the high iodine value obtained in tiger nut oil. The greater the iodine content, the greater the unsaturated fatty acid and the higher the oil's susceptibility to oxidative rancidity. (Oluba, *et al.*, 2008). Significant differences ($P<0.05$) in iodine value have been observed for most of the tested oils. A small amount of linoleic acid present in tiger nut oil may be due to this low iodine content. Tiger nut oil could then be graded as non-drying oil, with higher oxidation resistance and high quality.

The aforementioned findings of iodine value test are in line with those obtained by Bamishaiye and Bamishaiye (2011) and Muhammad, *et al.* (2011). On the other hand, peroxides are the primary reaction products produced at the initial stages of oil oxidation, so the low value obtained for tiger nut oil (4.31 and 4.80) for fresh and stored oil (5.37 and 5.12) for fried and stored oil falls within the range of 0-20 for most

freshly prepared oil. These values give an indication of the process of lipid peroxidation (Onwuka, 2005). The reaction between unsaturated fatty acids and oxygen is based upon lipid peroxidation. The implication is that the Tiger nut's inherent peroxidation is minimal, so it can survive long-term storage without oxidative peroxidation. As a result, the peroxide value reduced the significant differences ($P<0.05$) between tiger nut oil and olive oil. Peroxides are the primary reaction products produced in the initial stages of oil oxidation, providing an indication of the lipid peroxidation process (Shaker *et al.*, 2009). Acid values provide an indication of the composition of free fatty acids due to enzymatic activities.

The acid value of fried and stored oils (3.21 and 3.06 mg $KOHg^{-1}$), and fresh and stored oils (2.29 and 2.15 mg KOHg-1) is poor compared to soybean, tropical almond (7.6 mg KOHg-1), fluted pumpkin oils (7.6 mg $KOHg^{-1}$) and pumpkin oils (3.5 mg $KOHg^{-1}$) (Christian, 2006). This is an indication that there was no hydrolysis of the triglycerols present, suggesting that the oil is less sensitive to the action of lipase than soybean, tropical almond and fluted pumpkin oil. The acid value is also a measure of the free fatty acid in the oil sample and can therefore be used as an indicator of the oil age and as one of the measures of essential quality attributes (Muhammad *et al*., 2011; Onwuka, 2005 and Belewu and Belewu, 2007). The result also indicates a similar saponification value for fried and stored tiger nut oil (154.27 and 159.15 mgKOH/g) and for fresh oil (115.10 and 129.15 mgKOH/g). The saponification value of some vegetable oils such as maize oil (189mgKOH/g) and sunflower oil (190mgKOH/g) is not similar to that of tiger nut oil. The saponification value is an indicator of the triglyceride molecular weights in the oil and a high percentage of triglycerides means that the oil is suitable for soap production. The fairly high percentage of triglycerides in tiger nut oil, is an indication that the oil may be suitable for soap making. High fatty acid in oil will decrease the storage stability of that oil, thus since tiger nut oil has fairly high saponification value is an indication that the fatty acid value will not be too high and so it could be stored for a long period of time without deteriorating.

As reported by Muhammad *et al.* (2011) oil with higher saponification values contain high proportion of lower fatty acid. Therefore, the value obtained for tiger nut oil in this study show that it contains high amounts of long chain fatty acids (Ekeanyanwu, *et al.*, 2010). Golden brown is the colour of the fresh tiger nut oil, while light brown is the fried oil. In food products, colour is an important consideration since colour and general appearance are typically the first impressions consumers have about a particular product, as this tiger nut oil is suitable for various uses, especially in the production of salads. The moisture content of the fresh and stored oil is 0.1470 and 1.4661%, 0.1338 and 0.1450 respectively of the fried and stored oil, and the low moisture content of this oil is an indicator of the oil's low perishability and can be said to be responsible for its relatively long shelf-life. Moreover, the low moisture content indicates the presence of a smaller amount of water in the oil. The low moisture content observed in this study is therefore an indication that there is very little dirt and impurities in tiger nut oil. The flash point of fresh and stored oil was 340 and 350 respectively, while that of fried and stored oil was 310 and 290. This is an indicator that the fried oil has a lower viscosity than the fresh oil and therefore gets quicker to its flash point than the more viscous fresh oil.

3.2 Fatty Acid Composition

The chemical, physical and biological properties of lipids are largely dependent on the glycerol backbone composition and positional distribution of fatty acids, so the stereospecific analysis of fatty acids in triacylglycerol was considered essential for dietary and industrial use of the lipid (Hunter, 2001; Yoon and Kim, 2003). According to Table 2, tiger nut oil contains approximately 20% saturated fatty acids. Saturated fatty acids build straight chains and can therefore be very tightly packed together, allowing organisms to store chemical energy very densely (Patsch *et al.*, 2000). Saturated fatty acids are in high demand in tiger nuts. Consequently, the ingestion of oil extracted from Tiger nut will reduce the risk of cardiovascular disease because it is found that saturated fatty acid increases the production of cholesterol by the body. It also lowers insulin sensitivity, allowing the body to retain food as fat rather than use it for other purposes. Epidemiological evidence also indicated that a high proportion of monounsaturated fatty acids, especially oleic acid, in the diet is associated with a lower risk of coronary heart disease. Tiger nut oil is high in oleic

acid and low in polyunsaturated fatty acids (linoleic acid and linoleic acid), adequate to fulfil the minimum daily requirements for adults (around 10 g) and low in acidity, making it safe for the skin. Due to its extraction without adding any external heat (cold pressed oil), it is considered to be a high-quality oil and is highly recommended for cooking over other oils because it is more resistant to chemical decomposition at high temperatures. The oil compares favourably to corn, soybean, olive, and cotton seed oil, and can thus be used as a stand-in for these oils, especially in times of scarcity. It was noted that the soaking, blanching, and roasting processes typically have a very similar composition of fatty acids relative to the untreated sample. These findings are in line with those mentioned earlier (Kim *et al.*, 2002). The fatty acid composition of extracted oils did not alter substantially after roasting. According to Ozcan (2004), roasting produced minor changes in the fatty acid composition of *P. terebinthus* oil. These findings are in line with those obtained by Yoshida *et al.* (2006), who reported that higher roasting temperatures resulted in a lower percentage of linoleic acid and higher percentages of oleic, palmitic and stearic acids due to longer microwave processing. It is also mentioned that oleic acid is useful for constructing cell membranes, attracting tissue oxygen, converting energy into nerve impulses, and as a precursor to cellular communication molecules, such as prostaglandins or eicosanoids.

Table 2: Fatty Acid Composition of Tiger Nut Oil.

S/N	Name of Compound	Structural Formula	Molecular Weight	% Area	
				Fried oil	Fresh oil
1	Pentadecanoic acid	$C_{17}H_{34}O_2$	270	14.37	9.31
2	Palmitic acid	$C_{16}H_{32}O_2$	256	5.75	7.61
3	16-Octadecanoic acid	$C_{19}H_{36}O_2$	296	36.74	38.79
4	Steric acid	$C_{19}H_{38}O_2$	298	7.99	9.32
5	Oleic acid	$C_{18}H_{34}O_2$	282	28.5	32.88
6	Arachidic	$C_{21}H_{42}O_2$	326	2.22	1.02
7	Behenic acid	$C_{23}H_{46}O_2$	354	1.31	1.07
8	Carboceric acid	$C_{28}H_{56}O_2$	426	2.19	-
9	Cyclopropaeotanoic acid	$C_{18}H_{34}O_2$	282	0.94	-

The result also shows that 16-Octadecanoic acid (38.79) and Oleic acid (32.88) have high molecular weight in tiger nut oil, which means that tiger nut oil is rich in unsaturated fatty acids. The absence of essential fatty acids, according to Muhammed *et al.* (2011), can result in scaly skin, necrosis, and stunted growth. Essential Fatty Acid (EFA) deficiency has been related to elevated blood cholesterol levels, and cholesterol has been shown to be a major component of plaques that grow on the inside of certain blood vessels. As reported by Warner and Gupta (2003), a drop in the content of linolenic acid in oils from 2 to 0.8 percent improved the consistency of flavor and oxidative stability of fried foods. As a result, the lower the linolenic acid content of an oil, the better the oil is for frying. About 14% polyunsaturated fatty acid, primarily made up of linoleic acid, which is an essential fatty acid, was found in tiger nut tuber oil. This means that the tiger nut tuber is a decent source of cooking and frying oil. Linoleic fatty acids (belonging to the fatty acid omega-6 family) and alpha-linolenic fatty acids (belonging to the fatty acid omega-3 family) are considered to be important since they cannot be synthesized by mammals and must be derived from foodstuffs (Moreira and Mancini, 2004). According to Ribarova *et al.* (2003), polyunsaturated fatty acids must account for 7–10% of total energy consumed for an acceptable diet in terms of proper lipid ingestion. In addition, in the treatment of depression and schizophrenia, the omega-3 fatty acid family can have a beneficial effect.

The components present in Tigernut oil were identified by GC-MS analysis for fresh oil and stored oil as shown in Figures 1 and 2 respectively. There were no significant differences (P>0.05) in the GC-MS chromatogram of fresh and stored tiger nut oil. People who consumed the most oleic acid were 89 percent less likely to develop ulcerative colitis than those who consumed the least oleic acid (De Silva, 2014). A diet high in oleic acid may reduce the inflammation seen in obesity and non-insulin dependent obesity. Linoleic acid has been found to be 3.19% and linoleic acid has been shown to prevent atherosclerosis growth, decrease body fat while increasing lean body mass, and modulate immune and/or inflammatory responses (Jun, 2016). However, the levels of oleic acid and linoleic acid vary from those stated by Ezeh, *et al.* (2016), which may be due to the humus content of the soil where it was collected, climatic variation, processing or storage technique, or a combination of these factors.

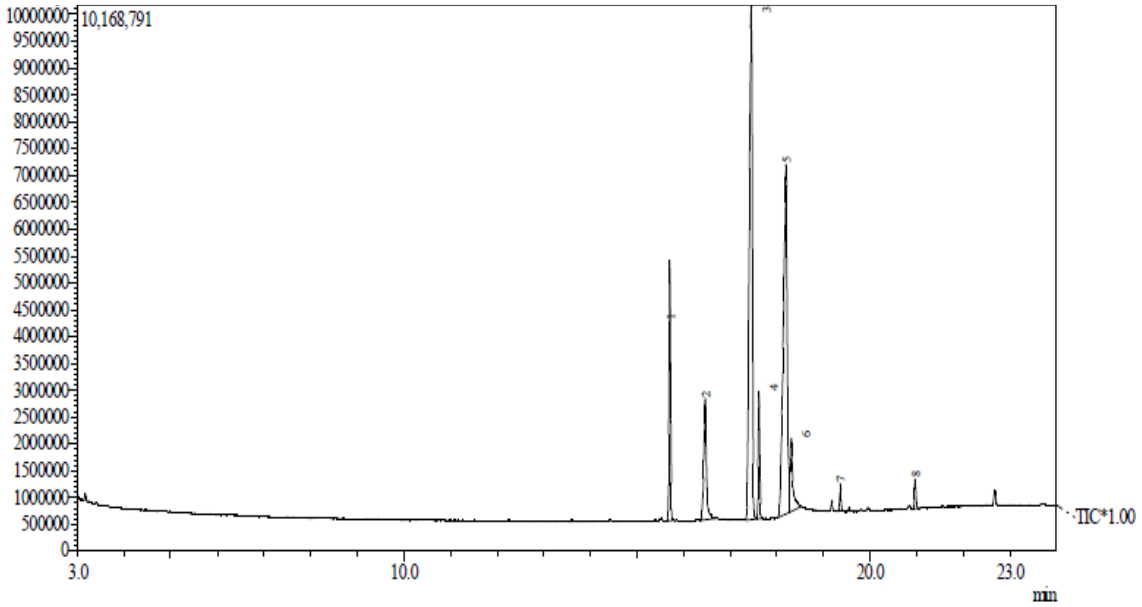

Figure 1: Chromatogram of Fresh Tiger Nut Oil

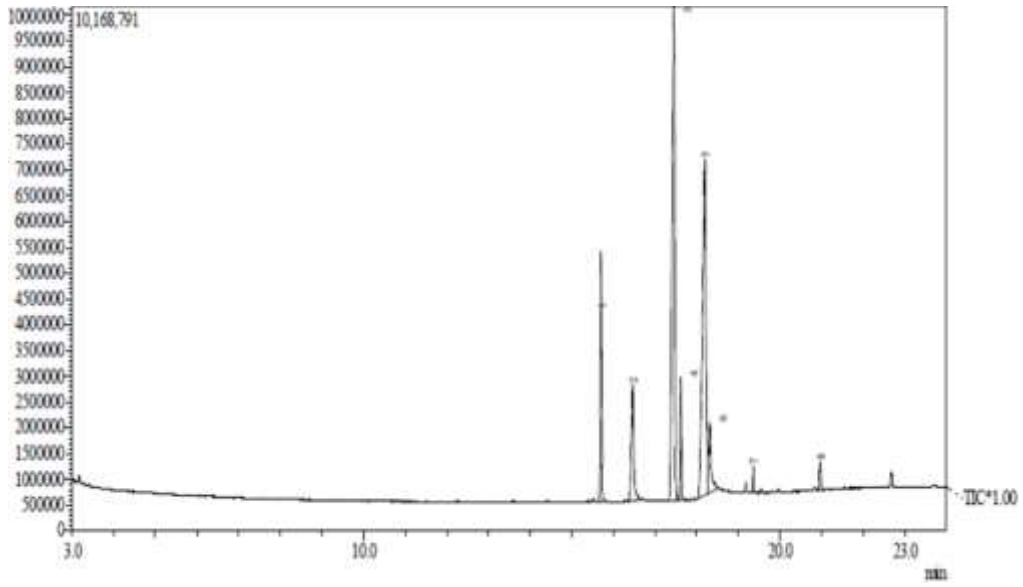

Figure 2: Chromatogram of Stored Tiger Nut Oil

4.0 Conclusion

Tiger nut oil is a fixed oil obtained from the tubers of the *Cyperus esculentus* plant, and the findings of this study indicate that it can be used as an industrial raw material, an effective food supplement, and an important nutraceutical. Tiger nut tubers have a high oil content and a moderate protein content. It also contains a lot of fiber and carbohydrates. The findings of this study have provided a lot of support for using tiger nut oil in food products. Because of its high oleic acid content, tiger nut oil is a very nutritious and health-promoting oil. As a result, tiger nut oil can be made into a commercial commodity for use in food. The fatty acid composition of tiger nut oil revealed that it contains a low amount of saturated fatty acids, making it suitable for human consumption, and a high amount of unsaturated fatty acids, which are essential for cellular membrane construction. The study also revealed that tiger nut oil has a golden brown color, making it ideal for salad preparation and suggesting that it can be stored for one month without degradation after use.

References

Adejuyitan, J.A., Otunola, E.T., Akande, E.A., Bolarinwa, I.F., and Oladokun, F.M. (2009). Some physicochemical properties of flour obtained from fermentation of tigernut (Cyperus esculentus) sourced from a market in Ogbomoso, Nigeria. *African Journal for Food Science,* 3, 51–5. doi: https://doi.org/10.5897/AJFS.9000269

AOAC. (2010). Official Methods of Analysis: Association of Official analytical Chemists, Washington, DC. USA.

AOAC (2012). Official Methods of Analysis. 18th Ed. American Association of Analytical Chemists, Inc., Washington.

Bamishaiye, E. I. and Bamishaiye, O.M. (2011). Tigernut: as a plant, its derivatives and benefits. *African journal of Food Agriculture, Nutrition and Development*, 11(5). https://doi.org/10.4314/ajfand.v11i5.70443.

Belewu, M. A., and Belewu, K. Y. (2007). Comparative physicochemical evaluation of tigernut, soybean and coconut milk sources. *International Journal of Agricultural Biology*, 5, 785–7. Doi:10.12691/ajfn-2-3-3

Belewu, M.A. and Abodunrin, O.A. (2006). Preparation of Kunnu from unexploited rich food source: Tiger nut (Cyperus esculentus). *World Journal of Dairy and Food Sciences*, 1, 19-21.

Borges, O., Gonc¸alves, B., Sgeoeiro, L., Correia, P., and Silva, A., (2008). Nutritional quality of chestnut cultivars from Portugal. *Food Chemistry,* 106, 976–84. doi:10.1016/j.foodchem.2007.07.011

Chukwuma, E. R., Obioma, N., and Cristopher, O. I. (2010). The phytochemical composition and some biochemical effects of Nigerian tigernut (*Cyperus esculentus* L.) tuber. *Pakistan Journal for Nutrition,* 9(7), 709–15. doi:https://doi.org/10.3923/pjn.2010.709.715

Crowe, T. D. and White, P. J. (2011). Adaptation of AOAC Official method for measuring hydroperoxides from small oil samples. *Journal of the American Oil Chemists' Society*, 78 (12), 1267-1269.

De Silva, P. S., Luben, R., Shrestha, S. S., Khaw, K. T. and Hart, A. R. (2014). Dietary arachidonic and oleic acid intake in ulcerative colitis etiology: a prospective cohort study using 7-day food diaries. *European Journal for Gastroenterol Hepatol*, 26(1), 8-11

Ekeanyanwu, R. C., Njoku, O. and Ononogbu, I. C. (2010). The Phytochemical Composition and Some Biochemical Effects of Nigerian Tigernut (Cyperus esculentus L.) Tuber. Pakistan *Journal of Nutrition*, 9(7), 703 – 715. https://doi.org/10.3923/pjn.2010.709.715.

El-Naggar, E. A.(2016). Physicochemical Characteristics of Tiger Nut Tuber (Cyperus esculentus Lam) Oil. *Middle East Journal of Applied*, 6(4), 1003-1011

Eze, O., Gordon M.H. and Niranja, K. (2014). Tigernut oil (cyperus esculentus L.): A review of its composition and physic-chemical properties. Eur.J. *Lipid Sc. Technol*., 116: 783-794

Ezeh O, Keshavan N, and Michael, H. G. (2016). Effect of Enzyme Pre-treatments on Bioactive Compounds in Extracted Tiger Nut Oil and Sugars in Residual Meals. *J. Am. Oil Chem. Soc.*, 293(11), 1541-1549.

Food Safety and Standard Authority of India FSSAI (2012). Manual of Method of Analysis of Foods, Oil and Fat. Vol. 2.

Hunter, J. E. (2001). Studies on effects of dietary fatty acids as related to their position on triglycerides. Lipids 36, 655–668. https://doi.org/10.1007/s11745-001-0770-0.

Jun, H.K., Yoo, K., Young, J. K. and Yeonhwa, P. (2016). Conjugated Linoleic Acid. Potential Health Benefits as a Functional Food Ingredient. *Annual Review of Food Science and Technology*, 7, 221-244.

Kim, I. H., Kim, C. J., You, J. M., Lee, K. W., Kim, C. T., Chung, S. H., et al. 2002. Effect of roasting temperature and time on the chemical composition of rice germ oil. *Journal of the American Oil Chemists' Society*, 79(5), 413–418.

KwiatKowski, J. R. and M. Cheryan, (2002). Extraction of oil from ground corn using ethanol. *Journal of the American Oil Chemists' Society*, 29(8), 825-830.

Lee, Y. C., Oh, S. W., Chang, J. and Kim, I. H. (2004). Chemical composition and oxidative stability of safflower oil prepared from safflower seed roasted with different temperatures. *Journal of Agricultural and Food Chemistry*, 84, 1-6.

Muhammad, N. O.,Bamis haiye, E. B., Us man, L. A., Salawu, M.O. Nafiu, M. O. and Oloyede, O. B. (2011). Phys icochemical properties and fatty acid compos ition of *C. esculentus* (Tiger nut) tuber oil. *Bioresearch Bulletin*, 5: 51-54.

Moore M. (2004) Documents Prepared for Bottlegreen for the Product Tiger White: www.tigerwhitedrinks.com Copyright Miam Ltd. 1-22.

Moreira, A. V. B. and Mancini, F. J. (2004). Influência dos compostos fenólicos de especiarias sobre a lipoperoxidação e o perfil lipídico de tecidos de ratos. *Revista de Nutrição*, 17, 411−424.

Nadeem, M., Abdullah, M., Hussain, I., Inayat, S., Javid, A. & Zahoor, Y. (2013). Antioxidant Potential of Moringa oleifera Leaf Extract for the Stabilisation of Butter at Refrigeration Temperature. *Czech Journal of Food Science*, *31*, 332–339. https://doi.org/10.17221/366/2012-cjfs .

Okafor, J. N. C., Mordi, J. I. Ozumba, A. U., Solomon, H. M. and Olatunji, O. (2003). Preliminary Studies on the Characteristics of Contaminants in Tigernut (Yellow Variety). *Proceedings of the 27th Annual Nigerian Institute of of Food Science and Technology Conference, Kano, Nigeria*, 210-211

Olagunju, A.O. (2006). Extraction and characterization of oil from tiger nut seed (Cyperus esculentus) using 23 full factorial design. M.Sc. Thesis, Dept. of Chemical Engineering, Federal Univ. of Technology, Minna, Niger State, Nigeria.

Oluba, O.M., Ogunlowo, Y.R., Ojieh, G.C., Adebisi, K.E., Eidangbe, G.O., and Isiosio I.O. (2008). Physicochemical properties and fatty acid composition of *Citrullus lanatus* (Egusi Melon) seed oil. *Journal of Biological. Science*, 8, 814-817.

https://doi.org/10.3923/jbs.2008.814.817.

Onwuka G.I. (2005) Food analysis and instrumentation, theory and practice. Napthali Prints, Lagos, 104-120.

Ozcan, M. 2004. Characteristics of fruit and oil of terebinth (Pistacia terebinthus L.) growing wild in Turkey. *Journal of the Science of Food and Agriculture*, 84, 517–520. https://doi.org/10.1002/jsfa.1632.

Patsch J.R., Miesenbock, G., and Hopherwiesser, T. (2000). Relation of triglyceride metabolism and coronary heart diseases. Studies in the postpradial state. Arterioscler Thromb. 12, 1336-45.

Ribarova, F., Zanev, R., Shishkov, S. and Rizov, N. (2003). α-Tocopherol, fatty acids and their correlations in Bulgarian foodstuffs. *Journal of Food Composition and Analysis*, 16, 659−667.

Rita, E .S. (2009). The use of tiger-nut (Cyperus esculentus), cow milk and their composite as substrates for yoghurt production. Pakistan. *Journal.of Nutrition*, 6, 755-758.

Sadoudi, R., & Ali Ahmed, D. (2017). Studies on physico-chemical characteristics and fatty acid composition of commercially available Algerian frying edible oils. Agriculture Department, Faculty of Biology and Agriculture, "Mouloud Mammeri" University of Tizi-Ouzou, 15000, Algeria. *International Food Research Journal*, 24(1): 60-67.

Samuel, O.Y., Yulita, C . M, Jane, C. N., Ludger, W and Juergen, S. (2012). Compositional and structural studies of the oils from two edible seeds: Tiger nut, C. esculentus, and asiato, Pachirainsignis, from Ghana. *Food Research International*, 47, 259-266.

Shaker, M.A., Ahmed, M.G., Amany, M.B., and Shereen, L.N. (2009). Chufa Tubers (Cyperus esculentus L.): As a New Source of Food. *World Journal of Applied Science*, 2, 151-156.

Warner, K. and Gupta, M. (2003). Frying quality and stability of low-and ultra-low-linolenic acid soybean oils. *Journal of the American Oil Chemists' Society*,80(3), 275-280. https://doi.org/10.1007/s11746-003-0689-x.

Yoon, S. H. and Kim, E. (2003). Recent progress in enzymatic production of structured lipids. *Food Science Biotechnology*, 12, 721–726.

Yoshidaa, H., Tomiyamaa, Y., Hirakawaa, Y. and Mizushina, Y. (2006). Microwave roasting effects on the oxidative stability of oils and molecular species of triacylglycerols in the kernels of pumpkin (Cucurbita spp.) seeds. *Journal of Food Composition and Analysis*, 19, 330–339.