Asian Journal of Research in Biochemistry

8(1): 11-21, 2021; Article no.AJRB.63751
ISSN: 2582-0516

Comparative Analysis of Nutrients Content and Characterization of Oil from Two Varieties of Tiger Nut (*Cyperus esculentus*)

A. M. Gadanya[1*], M. Y. Abubakar[1], F. U. Maigari[2] L. Mudassir[3] and S. M. Abubakar[1*#]

[1]Department of Biochemistry, Bayero University, Kano, Nigeria.
[2]Department of Biochemistry, Gombe state University, Nigeria.
[3]Department of Biochemistry, Mewar University, Gangrar, Chittorgarh, Rajasthan, India.

Authors' contributions

This work was carried out in collaboration among all authors. Author AMG designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author FUM performed the statistical analysis. Author MYA performed the laboratory analysis. Author SMA managed the analyses of the study. Author LM managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJRB/2021/v8i130170
Editor(s):
(1) Dr. Mohamed Fawzy Ramadan Hassanien, Zagazig University, Egypt.
Reviewers:
(1) Maya B. Belyakova, Tver State Medical University, Russia.
(2) Cíntia Gonçalves Guimarães, Embrapa Agroenergia, Brasil.
Complete Peer review History: http://www.sdiarticle4.com/review-history/63751

Original Research Article

Received 10 October 2020
Accepted 16 December 2020
Published 05 January 2021

ABSTRACT

Background: Tiger nut (*Cyperus esculentus*) belong to the family of Cyperaceae and the order of Commelinalis. It has been existing for more than 4,000 years ago.
Objective: To determine the nutritional composition (protein, fat, fiber, ash, moisture and carbohydrate) of nut, to extract and characterize oil from varieties of tiger nuts, to determine the mineral elements presence in the nut.
Study Design: A descriptive research design was adopted by this study to determine the nutritional composition (protein, fat, fiber, ash, moisture and carbohydrate) of nut, to extract and characterize oil from varieties of tiger nuts and to determine the mineral elements presence in the nut.
Place and Duration of the Study: The study was conducted at Biochemistry Department, Bayero University Kano, between April, 2019 to September, 2019.

**Corresponding author: E-mail: amgadanya.bch@buk.edu.ng;*

Methods: The Proximate compositions were determined using the method describe by Association of official analytical chemist's, while Carbohydrate were determined by difference. The physicochemical properties were determined using the method describe by American oil Chemist's society and Mineral composition were determined.
Results: The proximate composition of the yellow variety was moisture (9.48%), ash (2.07%), fat (33.5%), protein (6.11%), crude fibre (17.5%) and carbohydrate (31.2%). Corresponding values of the brown variety was moisture (9.62%), ash (2.76%), fat (34.2%), protein (6.93%), crude fibre (15.3%) and carbohydrate (30.9%) respectively. The extracted oil has a golden colour and a nutty taste. The saponification, acid, peroxide, iodine and free fatty acid values of the yellow variety were found to be 210.8±4.28, 3.17±0.64, 1.00±0.52, 78.7±13.1 and 0.40±0.21 and the saponification, acid, peroxide, iodine and free fatty acid values of the yellow variety were also found to be 212.2±4.92, 3.36±0.56, 1.06±0.75, 76.5±14.6 and 0.42±0.04 and was not significantly (P> 0.05) different between th yellow and brown varieties respectively. The mineral element (mg/100g) of the brown variety is Mg 133.67, P 527.33, K 957.67, Ca 394, Cu 2.0 and Fe 1.86. Corresponding values for the yellow variety are Mg 118.13, P 159.61, K 384.33, Ca 152, Cu 2.0 and Fe 1.04. Lead and Cadmium were not detected in both varieties.
Conclusion: These results indicate that tiger nut tuber oil could be a good source of edible oil, highly nutritive and can provide a lot of energy like some starchy food.

Keywords: Mineral composition; physicochemical properties and proximate.

1. INTRODUCTION

Tiger nut is an underutilized crop of the family Cyperaceae, which produces rhizomes from the base and tubers that are somewhat spherical. Pollination is by wind. Young tubers are white, while older tubers are covered by a yellow outer membrane; they are usually found within six inches of the ground surface. Vegetative colonies of its plants are often produced from the tubers and their rhizomes. The derivatives and benefits of *Cyperus esculentus Lativum* as a plant was reported [1]. Tiger nut (*Cyperus esculentus*) belongs to the family *Cyperaceae* and the order, Commelinali*s.* It has been existing for more than 4,000 years ago. Proof of this is that on many occasion archeologists found earthen jars containing tiger nut in graves of pharaohs [2]. It is found worldwide in warm and temperate zones, occurring in Southern Europe and Africa. This plant is cultivated for its small tuberous rhizome which is eaten raw or roasted, pressed for its juice to make beverage or milk, extracted of non-drying oil or used as hog feed [3].

Tiger nut is known in Nigeria by different names. In Hausa, it is known as "aya", in Yoruba "Imumu" and in Ibo "Ofio" or "aki-Hausa". It grows well in the middle belt of Nigeria [4], where three varieties are cultivated; the black, brown and yellow that has two varieties, the large and small. In Nigeria, the utilization of tiger nut is highly limited in spite of the fact that tiger nut is cultivated widely in the Northern part of the country [5]. Oil is a One of the major source of essential mineral content in the diets of common people in Africa. Edible and Non-edible Oil Potentials of Tiger Nut (*Cyperus esculentus*) Grown in Nigeria was investigated [6]. Quality Characteristics of oil from two varieties of *Cyperus esculentus* L. tubers was physicochemical determined [7]. Despite its high nutritional value, tiger nut oil is hardly used in food industries compared to other vegetable oils such as olive and peanut oil. However, its benefits are increasingly being recognized, including its stability and similarity to olive oil in particular. Based on the available data, tiger nut oil has been established as an oil of good nutritional value which may be exploited to the great benefit of growers, processors and dealers of the tuber [8]. Evaluation of the physicochemical properties and fatty acids composition of tiger nut (*Cyperus esculentus*) tuber oil in comparison with olive, maize, sunflower and soybean oils was reported. It showed that Tiger nut tuber oil can replace imported olive, maize, sunflower and or soy bean oils in foods to face the high consumption of edible oils in Egypt [9]. Tiger nut is also rich in mineral content such as calcium, potassium, magnesium, zinc and traces of copper [10]. In addition, tiger nut has been demonstrated to contain higher essential amino acids than those proposed in the protein standard by FAO/WHO (1995) for satisfying adult needs for protein [11].

The tiger nut has higher fiber content than the oat bran, the cabbage, the carrot, plums and the chia seeds. The fiber helps to prevent

constipation and act as an appetite suppressant, which helps human beings to control body weight. It's high content of amino acid arginine helps the body to make nitric oxide which keeps our blood vessels dilated and have a normal blood flow, tiger nut is a source of vitamin E that protect us from the creation of harmful free radical which are responsible for death of the body cells, vitamin E is also essential for fertility in both men and women, it reduces the risk of heart diseases due to it high content of oleic acid, it also give our body more potassium than a banana [12]. The objectives of this research are to determined the nutritional composition (protein, fat, fiber, ash, moisture and carbohydrate) of nut, to extract and characterize oil from varieties of tiger nuts and to determined the mineral elements presence in the nut.

2. MATERIALS AND METHODS

2.1 Materials

Extraction thimble, Soxhlet extraction apparatus, filter paper (Whatman No.1) , Kjeldahl digestion flask and distillation apparatus, (J.P Selector, Ctranillem 583.1) Volumetric flask, Bunsen burner, Oven preset, Hot air oven (jenway, PFPS7) ,Plastic specimen bottles, Freezer, Petri dish, Heating mantle ,weighing balance (Kilo-tech, Elite 210-4), water bath (Grant OLS 200), hot plate, measuring cylinder, beaker, burettes, conical flask ,resort stand, mortar and pestle, Kjeldahl digestion tube, pipette, reagent bottles, cotton wool, crucible, Muffle furnace (Omszov, 04-85TR), and clamps.

2.2 Sample Collection

The dried tiger nut tuber was obtained from Rimi market in Kano Municipal Local Government, Kano State. The dried Tiger nut was thoroughly screened to remove the bad ones and stones. The nuts were washed, dried and ground into powder with mortar and pestle.

2.3 Oil Extraction

Lipid was extracted from the milled Tiger nut using the soxhlet extractor as described by [13]. N-Hexane was employed for the extraction in order to extract an appreciable quantity of both the polar and non-polar lipid in the sample. After extraction the solvent was evaporated by an air-dried of an open conical flask. The extracted oil was then purified as described by [14].

2.4 Mineral Analysis

The minerals were analyzed by dry ashing the sample at 550°C to constant weight and dissolving the ash in volumetric flask using concentrated hydrochloric acid and nitric acid of about 5 mls each. The flask was heated in a fume cupboard until a clear digest was obtained. The digest obtained was transferred into 100 ml volumetric flask and made to mark with 50 ml distilled water. Calcium, Magnesium, Sodium and Potassium were determined using flame photometer (Model, 405, Corning, UK). Standard solution and Blank solution for various elements were similarly prepared. All other metals were determined by Atomic Absorption Spectrophotometer (AAS Buck 210 VGP Model). Determinations were up to 8 in triplicate. Chemicals used were of analytical grade (BDH, London). The detection limits of the metals had been determined according to [15]. The minerals were reported in mg/100 g.

2.5 Proximate Analysis

2.5.1 Determination of ash content [13]

Procedure:

A clean dried Crucible was weighed as (W_1). A dried (moisture free) sample (2 g) was placed into the crucible and weighed as (W_2). The sample was placed in the muffle furnace at 550^0 C. The ash was covered with Petri- dish and placed in a desiccator prior to weighing. This was then measured (W_3).

Calculation:

$$\text{Ash (\%)} = \frac{\text{weight of ash}}{\text{Weight of sample}} \text{ X } 100 = \frac{\text{W3 – W1}}{\text{W2 – W1}} \text{ X } 100$$

2.5.2 Determination of crude protein [13]

Procedure:

The sample (0.15 g) was weighed and transferred into Kjeldhal digestion flask. Catalyst (0.8 g) and $2cm^3$ of concentrated sulphuric acid were added into the Kjeldhal digestion flask. The mixture in the digestion flask was heated on the heating mantle for 1 hour until the liquid becomes clear. The digest was cooled and made alkaline with $15cm^3$ 40% NaOH. The ammonia steamed distilled into $10cm^3$ of 2% boric acid with 5 drops of Methyl red indicator for 15 minutes. The

Distilled ammonia was then titrated with 0.02M Hydrochloric acid.

Calculation:

$$\text{Protein (\%)} = \frac{\text{pg x 100}}{\text{Weight of sample used}}$$

Where;

Pg = crude protein content
F = specific factor (6.25)
Pg = N×F

2.5.3 Determination of crude lipid (fat) [13]

Procedure:

Sample (3 g) was carefully weighed as (W_1) into a folded fat free filter paper and a small cotton wool placed on top. This was properly rapped at both ends and weighed as (W_2), it was then carefully placed in the extraction thimble and small cotton wools placed on top. The whole apparatus was then connected after addition of about 300cm^3 of 60^{0}C – 80^{0}C petroleum ether. The extraction was then carried out for 3 hours using the heating mantle and making sure there was continuous flow of cooled (chilled) water in the condenser. The sample was then removed, air-dried and placed in an oven at 800^{0}C until a constant weight was obtained (W_3).

Calculation:

$$\text{Crude lipid (\%)} = \frac{\text{W2 – W3 x 100}}{\text{W1}}$$

Where;

W_1= weight of sample (gram)
W_2= weight of sample + filter paper (before extraction)
W_3= weight of sample + filter paper (after extraction).

2.5.4 Determination of moisture content [13]

Procedure:

A clean dried Petri-dish was weighed as (W_1), and 1.0g of the sample material was placed on it, and then weighed as (W_2). It was placed in an oven for 3 hours; the dish was removed and cooled in desiccator for 30 minutes and finally weighed (W_3).

Calculation:

Moisture (%) = loss of weight in drying

$$\text{Weight of sample taken} = \frac{\text{W2 – W3}}{\text{W2 – W1}} X\ 100$$

Where;

W_1 = Weight of empty Petri-dish (in grams)
W_2 = Weight of Petri-dish + sample (before drying)
W_3 = Weight after drying + sample (after drying)

2.5.5 Determination of crude fiber [13]

Procedure:

Sample **(**2 g) was weighed into the extraction apparatus and extracted three times with light petroleum ether by stirring, settling and decanting, the air-dried extracted sample was transferred to a dry 100cm^3 conical flask 0.1275 M sulphuric acid (100 cm^3) measured at ordinary temperature and brought to its boiling point. This was boiled for 30 minutes, while a constant volume was maintained, the flask was rotated every few minutes in or to mix the contents and remove particles from the side. Buchner funnel was fixed to a perforated plate and to the funnel a filter paper was also fixed to cover the holes in the plate. The mixture was poured immediately into the prepared funnel. The funnel was adjusted so that filtration is completed within 10minutes the insoluble matter was washed boiling several times until the washing were free of acid. It was then transferred back to the conical flask and 1.24M sodium hydroxide (100 cm^3)

The mixture was boiled for 30 minutes: it was then allowed to stand for 1 minute and then filtered immediately. The insoluble material was transferred to the filter paper by means boiling water, and then it was washed with 1% hydrochloric acid and washed again with boiling water until it was free from acid. Then washed twice with ethanol and three times with ether, the insoluble matter was then transferred to a dried weighed crucible and dried at 100°C to a constant weight the crucible and its content were placed on a heating mantle in a fume cupboard to bum off the organic matter. It was then transferred to a muffle furnace at 550°C for 3 hours the ash content after cooling was then determined by weighing.

Calculation:

$$\text{Crude fiber (\%)}: \frac{\text{W1} - \text{W2} \times 100}{\text{W3}}$$

Where;

W_1=weight of sample extraction + filter paper
W_2=weight of W_1 after ashing
W_3=Weight of sample used

2.5.6 Determination of carbohydrate [13]

Procedure:

To determine the crude carbohydrate content of a sample, the percentages of the remaining constituents are sum up and subtracted from 100%.

The value obtained from this, gives the crude carbohydrate content of the sample.

Calculation:

Carbohydrate (%) = 100 - (% Moisture + % Ash + % Fiber + % Protein + % Fat)

2.6 Physicochemical Parameters of the Oil

Physicochemical properties of oils are determined to know the quality and purity. Characteristic properties are properties that depend on the nature of the oil. These are used to characterize oil, irrespective of location or sources of origin. Example of these properties is iodine value and saponification value. While the variable properties change with location, examples are peroxide value, free fatty acid value, acid value and density [16].

2.6.1 Iodine value by wij's method [17]

Procedure:

An amount of 0.2 g of the oil was weighed accurately into a 500 ml flask. Fifteen milliliters (15 ml) of carbon tetrachloride was added to the sample and swirled to ensure that the sample completely dissolved in it. 25 ml of wij's solution was then added into the flask containing the sample. The sample was pipette into the flask containing the sample. The flask was stopped and swirled to ensure complete mixing. The sample was then placed in the dark| for 30 minutes at room temperature. The flask was removed from storage and 20 ml of 10% KI solution added, followed by 150 ml of distilled water. The mixture was titrated with 0.IN $Na_2S_20_3$ solution, adding gradually and with constant and vigorous shaking until the yellow colour had disappeared. 1.5ml of starch indicator was added and the titration was continued until the blue colour disappeared.

A blank determination was conducted simultaneously. The iodine value was calculated using the equation;

Iodine value= (B - S) x N x 12.69/weight of oil

Where;

B= blank value
S= sample titer value and
N= Normality of $Na_2S_2O_3$

2.6.2 Saponification value by titrimetric method [17]

Procedure:

The oil (2 g) of was weighed into a flask. 25 ml of alcoholic KOH was pipette and allowed to drain for about 1 minute into the mixture. A blank determination was prepared and determined simultaneously with the sample. A condenser was connected to the flask and the mixed sample was allowed to boil gently and steadily for 45 minutes for complete saponification. The flask and condenser were then cooled but not sufficient to form a gel. The condenser was disconnected and 1 ml of phenolphthalein indicator was added to the content of the flask. The solution was titrated with 0.5N HCl until the pink colour just disappeared. The saponification number was calculated using the equation.

Calculation:

(B-S) × 56.1 ×N /Weight of oil sample
Saponification value: Weigh of oil sample

Where;

B= blank titer value
Sample titer value and
N=normality of HCl

2.6.3 Determination of acid value by Titrimetric method [18]

Procedure:

The oil (1.0 g) was weighed and dissolved with 50ml of ethanol in a conical flask, two drops of phenolphthalein indicator was added titrated to pink end point (which persisted for 15

minutes)with 0.1N potassium hydroxide solution(KOH).

Calculation:

$$\text{Acid value} = \frac{56.1 \times V \times C}{M}$$

Where 56.1 is equivalent weight of KOH, V is the volume in ml of standard volumetric KOH solution used, C is the exact concentration in KOH solution used (0.1N), m is the mass in grams of the test portion (1 g).

2.6.4 Determination of peroxide value by Titrimetric method [19]

Procedure:

Five grams (5 g) of oil sample was weighed into a conical flask and, 30 ml of solvent mixture of glacial acetic acid-chloroform in the ratio of 3:2 respectively, were added to the sample. Half ml saturated potassium iodide (KI) solution was added to the solution and allowed to stand for 1 minute thereafter 30ml of distilled water was added and titrated with 0.IN sodium thiosulphate solution using starch indicator until the yellow colour was discharged. A blank was prepared alongside the oil sample**.**

Calculation:

$$\text{Formula: } \frac{10 \times (V1 - V2)}{M}$$

Where V_1 is the volume of $Na_2S_2SO_4$ for determination of test sample in ml. V_2 is the volume of $Na_2S_2SO_4$ determination of blank solution in ml and m is mass of test portion in (5 g).

2.6.5 Free fatty acid value [20]

Free fatty acid is the percentage by weight of a specified fatty acid (e.g. percent oleic acid). Free fatty acid value is often used as general indication of the condition and edibility of oils [21].

High concentrations of free fatty acids are undesirable in crude vegetable oils because they result in large losses of the neutral oil during refining. In crude fat, free fatty acids estimate the amount of oil that will be lost during refining steps designed to remove fatty acids [22]. High levels of free fatty acids especially linoleic acids are undesirable in finished oils because they can cause off-favors and shorten the shelf life of oils. The quantity of free fatty acid in oil is an indicator of its overall quality. They may be formed through hydrolysis or in the advanced stages of oxidation. An excessive amount of free fatty acids lowers the smoke point of oil and will cause 'popping' of the oil during cooking. In refined vegetable oils, the lower the free fatty acid the more acceptable the oil is to man in terms of palatability. The heat of combustion value range between 8904.25 gcal/g and 11303.35 gcal/g with most of the reviewed oils having the value greater than the approximate value for edible oils 9500 gcal/g.

2.7 Data Analysis

Data were analyzed using SPSS statistical software and Microsoft office. Descriptive statistics such as percentage, mean and standard deviation and correlation were used to describe dependent and independent variables. Regression analysis had been used to check for association between dependent and independent variables. In all cases P value less than 0.05 was considered statistically significant.

3. RESULTS AND DISCUSSION

3.1 Results

These results shows the comparison of the proximate composition of tiger nut tuber, mineral analysis and physicochemical properties of its oil are represented in Tble 1, 2 and 3 respectively.

3.1.1 Results of proximate analysis

The result of the proximate composition of yellow and brown tiger nut was given in Table 1. The index of nutritional potentials of a crop has been reported to be based on the food proximate composition [23]. The crude fiber of the yellow variety was (17.5%) and is slightly higher than (15.3%) of the brown variety. High dietary fiber content tiger nut could be effective in the treatment and prevention of many diseases including colon cancer, coronary heart diseases, obesity, diabetics and gastro intestinal disorders [24]. The carbohydrate content of the yellow variety was (31.2%) while the brown variety was (30.9%). Due to no difference between the yellow and brown tiger nut tubers, they were also found to be a rich source of carbohydrates and contains moderate amount of protein (6.94%)

of brown variety and (6.11%), thus being an excellent source of energy (401 kcal/100 g). The protein compares favorably with the value of 9.8% reported for wheat four [25]. The defatted residues consequently became more replete with carbohydrates which could be processed further into livestock feeds, syrups, and other forms for diverse purposes, thus suggesting solvent extraction as the most acceptable and economical method of oil extraction relative to those enumerated. The moisture content of the yellow variety was (9.62%) while the brown variety has value of (9.48%). The difference is however, not significant. The *Cyperus esculentus* tubers remain an asset in storage and preservation of the nutrients. The crude fat of the yellow variety was (33.5%) and was slightly lower than (34.4%) of brown variety. Fat is important in diets because it promotes fat soluble vitamin absorption [26]. The ash content value of *Cyperus esculentus* of the yellow and brown variety are (2.07%) and (2.76%) which are within the range of 1.5-2.5% as recommended for animal feed.

3.1.2 Physicochemical analysis

The physicochemical parameters indicate that the oil have high saponification value when compared with maize oil (189 $mgKOHg^{-1}$) and sunflower (190 $mgKOHg^{-1}$) [22].The free fatty acid had the value of, was within the range recommended for fresh edible oil which (0-10 m/mol/kg) range [27]. The iodine value was found to be high when compared with soybean oil [28]. The Acid value was found to be low when compared with soya bean oil, tropical almond (7.6 mgKOHg-1) and fluted pumpkin (3.5 mgKOHg-1) [29]. The peroxide value was within the range (0-5$meqkg^{-1}$). Recommended by Aletor et al. [30].

Table 1. proximate composition of two varieties of tiger nut tuber

Parameter (%)	Moisture	Ash	Fat	Protein	Fiber	CHO
Yellow Variety	9.48±1.16	2.07±0.28	33.5±16.2	6.11±1.27	17.5±2.00	31.2±0.54
Brown Variety	9.62±0.79	2.76±0.47	34.2±16.8	6.93±2.67	15.3±1.94	30.9±0.82

Values are expressed as mean ± standard deviation readings were taking in triplicate, values with the same superscript at the same column indicate statistically significant with (P<0.05)

Table 2. Physicochemical properties of two varieties of tiger nut tuber oil

Sample	Saponification (mg/g)	Acid(mg/g)	Peroxide(mEq/kg)	Iodine(mg/g)	FFA(mg/g)
Yellow Variety	210.8±4.28	3.17±0.64	1.00±0.52	78.7±13.1	0.40±0.21
Brown Variety	212.2±4.92	3.36±0.56	1.06±0.75	76.5±14.6	0.42±0.04

Values are expressed as mean ± standard deviation, reading were taking in triplicate, values with the same superscript at the same column indicate statistically significant with (P<0.05)

Table 3. Mineral composition of brown and yellow tiger nut

Elements (mg/100 g)	Brown variety	Yellow variety
Mg	133.67±1.52	118.13±0.01
P	527.33±1.52	159.61±0.55
K	957.67±1.52*	384.33±1.52*
Ca	394.00±1.00*	152.00±2.00*
Cu	2.00±0.10	2.00±0.01
Fe	1.86±0.01	1.04±0.10
Pb	NIL	NIL
Cd	NIL	NIL

The elements are Magnesium (Mg), Phosphorus (P), Potassium (P), Calcium (Ca), Copper (Cu), Iron (Fe), Lead (Pb) and Cadmium (Cd). Values are expressed as mean ± standard deviation readings were taking in triplicate, values with the same superscript at the same row indicate statistically significant with (P<0.05) and NIL (Nothing)

3.1.3 Mineral analysis

Mineral parameter of the elemental analysis of yellow and brown varieties of tiger nut concealed that both can provide a good source of minerals. For the yellow variety, the level (mg/100 g) of Mg, P, K, Ca, Cu, and Fe are 118.13, 159.61, 384.33, 152, 2.00 and 1.04 respectively. Corresponding Brown variety levels (mg/100g) of Mg, P, K, Ca, Cu, and Fe are 133.67, 527.33, 957.67, 394, 2.00 and 1.86 respectively. The result concealed the brown variety contained more mineral content compared to the yellow variety. The least abundant minerals were Cu and Fe while K was the most dominant. Potassium has previously also been reported as most dominant mineral in Nigerian agricultural products [31,32]. Therefore intake of tiger nut may probably reduce high blood pressure a dreaded diseases. Pb and Cd were not detected in both varieties and this makes the tiger nuts safe for human consumption. Cadmium and lead are toxic metals that must not be present in any food item.

3.2 Discussion

3.2.1 Proximate analysis

The results of this study have established that tubers of *Cyperus esculentus* are very nutritious. The proximate composition of food is a major index of nutritious potentials of crops. The yellow variety gave proximate values (%) of 9.48, 2.07, 33.5, 6.11, 17.5 and 31.2 for moisture, ash, crude fat, protein, crude fiber and carbohydrate and corresponding value of the brown variety gave 9.62, 2.76, 34.2, 6.93, 15.3 and 30.9 for moisture, ash, crude fat, protein, crude fiber and carbohydrate respectively.

The protein level of *Cyperus esculentus* is quite higher and within range for other nuts like the hickory nut (3.60%), chest nut (4.53%), Hazelnut (17.60%) and pine nut (6.81%) [33].

Tiger nut tuber has a fat content of (33.5%) and (34.2%) which are comparable to values for some widely consumed nuts already reported in Nutrition composition of other nuts. Fat is important in diets because it promotes fat soluble vitamin absorption [26].

Tiger nut gave relatively high levels of fiber are (15.3%) and (17.5%) in comparison with the amounts given in nutrition composition for some other nuts [33]. The existence of a causal relationship between the absence of fiber in diet and the incidence of a wide range of diseases in man, notably diabetes mellitus, obesity and coronary heart disease has long been reported [34,35]. The consumption of significant quantities of *Cyperus esculentus* would therefore not constitute a risk factor to such pathological states.

The ash content value of *Cyperus esculentus* is (2.76%) and (2.07%) which are within the range of 1.5-2.5% as recommended for animal feeds.

The percentage of moisture value for *Cyperus esculentus* were (9.62%) and (9.48%) which are higher or within the value reported for nuts like Walnut (5.42%), brazil nut (4.68%), hazel nut (7.32%), hickory nut (0.76%), peanut (9.71%), and pine nut (1.90%) but lower than the values reported for chest nut (51.9%) and coconut (37.6%) as reported in Nutrition composition of other nut.

The value obtained for carbohydrate is comparable with the accepted mean values of widely accepted nuts. The calorific value of *Cyperus esculentus* shows that it could be reliable source of energy and can thus provide large portion of the daily requirement of 2,500-3000 kilocalories for adults if large quantities are consumed. Carbohydrate provides energy for the brain, tissues, and cells of the nervous system and red blood cell. Muscles also depend on the supply of carbohydrate to support physical activities [36].

3.2.2 Physicochemical properties

The physicochemical parameters of tiger nut oil were determined. The tiger nut tuber oil has a golden colour with a saponification value of 210.8 mg KOH g^{-1} and 212.24 mg KOH g^{-1} which are greater than the values obtained for some Vegetable oil ranging from 188-196 mg KOH g^{-1} [21]. This value obtained is higher than the range obtained for maize oil (189 mg KOH g^{-1}) and sunflower (190 mg KOH g^{-1}) [22]. However, it was found to be lower than some vegetable oils with higher saponification values such as coconut oil (253.0 mg KOH g^{-1}), palm kernel oil (247.0 mg KOH g^{-1}) and butter fat (225.0 mg KOH g^{-1}) [37]. Saponification value is an indication of the molecular weights of triglycerides in oil and the fairly high proportion of triglycerides in the tiger nut tuber oil suggests that the oil will be a good raw material for soap making industries. As reported by [21], oil with

higher saponification values contain high proportion of lower fatty acids. Therefore, the values obtained for tiger nut tuber oil in this study show that, it contains high amounts of long chain fatty acids.

The low acid value obtained for Tiger nut oil in Table 2 shows that the triacylglycerol's present have not been hydrolysed, which is an indication that the oil is less susceptible to lipase action than soybean oil, tropical almond (7.6 mg $KOHg^{-1}$) and fluted pumpkin (3.5 mg $KOHg^{-1}$) [29]. Acid value is a measure of the free fatty acid in the oil sample and it can also be used as an indicator for the age of the oil [38].

The free fatty acid had the value of 0.42mg/KOHkg-1 and 0.4042mg/KOHkg-1, the value were within the range recommended for fresh edible oil which (0- 10m/molkg-1) range [27].

The high iodine value(78.7 mg Iodine g^{-1}) and (76.5 mg Iodine g^{-1}) for both the yellow and brown variety obtained in tiger nut tuber oil indicates high amount of unsaturated fatty acid in it as compared to soybean oil [28]. It was also higher than value reported for Cashew nut oil (44.4 mg Iodine g^{-1}) [37] and *citrillus vulgaris* oil value of 38.1% [39]. Iodine value measures the degree of unsaturation in oil sample, the higher the iodine value, the greater the degree of unsaturation and the greater the susceptibility of the oil to oxidative rancidity [40]. The peroxide value yellow variety was (1.00 $MeqO_2kg^{-1}$) and the brown variety was (1.06 $MeqO_2kg^{-1}$) were found lower than (10$meqO_2$ kg^{-1}) of standard specified by WHO [41]. (Ngando *et al.,* 2011) though [30] presented a stricter limit (0-5meq kg^{-1}). Peroxides are the primary reaction products formed in the initial stages of oxidation of oil and therefore give an indication of the process of lipid peroxidation [42]. This implies that inherent peroxidation in tiger nut is low hence it may be able to withstand long time storage, without undergoing oxidative peroxidation. This is why the peroxide value when compared with palm kernel oil (3.58%) indicates that oil can be kept for a very long period of time [43].

3.2.3 Mineral analysis

Mineral parameter of the elemental analysis of yellow and brown varieties of tiger nut concealed that both can provide a good source of minerals. The result concealed the brown variety contained more mineral content compared to the yellow variety. The least abundant minerals were Cu and Fe while K was the most dominant. Potassium has previously also been reported as most dominant mineral in Nigerian agricultural products [31,32]. Cadmium and lead are toxic metals that must not be present in any food item.

4. CONCLUSION

Conclusively, the results of this study have established that tubers of *Cyperus esculentus* are very nutritious. Because, the crude fiber of the yellow variety was slightly higher than that of the brown variety. There was no difference in carbohydrates content between two tiger nut tubers, but the brown variety was found to be a rich source of crude fat and protein content and thus being an excellent source of energy. The tiger nut tuber oil has a golden colour with a saponification value which are greater than the values obtained for some Vegetable oils and also higher than the range obtained from maize oil and sunflower. These results also indicate that tiger nut tuber oil could be a good source of edible oil, highly nutritive and can provide a lot of energy like some starchy food.

ACKNOWLEDGEMENTS

Our sincere gratitude to those who directly or indirectly helped us to carried out this Research work successfully. We deeply thanks to all lecturers of Biochemistry department Bayero University Kano and the University as large.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bamishaiye EI, Bamishaiye OM. Tiger nut: As a plant, it's derivatives and benefits. African Journal of Food, Agriculture, Nutrition and Development*;* 2011.
2. Obadina AO, Oyawole OB, Ayoola AA. Quality assessment of gari produced using rotary drier: In food processing, methods, techniques and trends. Edited by Valerie C Belling house. Nova Science Publishers; 2008.
3. Ogbonna AC, Abuajah CI, Utuk RA. Tiger nut milk: A nutritious under-utilized food ingredient. Food Biology. 2013;2(2):14–17.
4. Okafor JN, Mordi JI, Ozumba AU, Solomon HM, Olatunji O. Preliminary studies on the characterisation of contaminants in tiger

nut (yellow variety). In: Proceedings of 27th Annual Conference and General Meeting of Nigerian Institute of Food Science and Technology Kano. 2003;210-211.

5. Ukwuru MU, Omachona LJ, Onokah N. Production and quality assessment of tiger nut (*Cyperus esculentus*) imitation milk during storage. Journal of Food Science and Technology. 2011;45:180 – 182.
6. Oyedele OA, Oladipo IO, Adebayo AO. Investigation into edible and non-edible oil potentials of tiger nut (*Cyperus esculentus*) grown in nigeria. Global Journal of Engineering Design and Technology. 2015;(4):20-24.
7. Warra AA. Quality characteristics of oil from brown and yellow *Cyperus esculentus* L. Tubers. Research and Reviews: Journal of Botanical Sciences. 2014;3(1):23-26.
8. Ezeh O, Gordon MH, Niranjan K. Tiger nut oil (*Cyperus esculentus* L.): A review of its composition and physico-chemical properties. European Journal of Lipid Science and Technology. 2014;116:1-11.
9. El-Naggar EA. Physicochemical characteristics of tiger nut tuber (*Cyperus esculentus* L.) oil. Middle East Journal of Applied Sciences. 2016;6(4):003-1011.
10. Oladele AK, Aina JO. Chemical composition and functional properties of tiger nut; 2007.
11. Bosch L, Alegna A. Reverse-phase high pressure liquid chromatography (RP-HPLC) determination of tiger nut and orgeal amino acid contents. Food Science Technology International, 2005;10:30–40.
12. Saduwa. Benefits of taking tiger nut; 2015. Available:www.google.com
13. AOAC. In Official Methods of Analysis. Association of official analytical chemists.15th edition. Washington, D.C; 2005.
14. Lasekan O, Abdulkarim SM. Extraction of oil from tiger nut (*Cyperus esculentus* L.) with supercritical carbon dioxide (SC-CO2). LWT. 2012;47(2), 287-292.
15. Teshtron V. Basic atomic absorption spectroscopy: A modern introduction. Dominican Press Victoria, Australia. 1975;104-106.
16. Shorunke P. Acctylaled Monoglyccridcs as Coaling or Selected Food. Technology inter-Science Publishers Division. New-York. 1986;1462-1468.
17. AOCS. Official methods of analysis American oil chemist's society 18th edition; 1993.
18. AOAC. In Official methods of analysis. Association of Official Analytical Chemists. 15th edition. Washington, D.C; 1990.
19. AOAC. Official methods of analysis. No.925.40.17th edition Association of Official Analytical Chemists. Washington, D.C; 2000.
20. Aremu MO, Amos VA. Fatty acids and physico-chemic oil properties of sponge luftii (*Luffa cylindrical*) kernel oils. International Journal of Chemical Science. 2010;3(2):161–166.
21. Pearson D. The chemical analysis of foods.7th Edition Churchill Living Stone.1976;493.
22. Weiss TJ. Physical and chemical properties of fat and oils in food oils and their uses. AVI Pub. Co. Inc. Westport.com. USA 2nd edition. 1983;25–84.
23. Ekeanyanwu RC. Ononogbu CI. Nutritive value of Nigerian tiger nut (*Cyperus esculentus* L.). Agricultural Journal. 2010; 5:297-302 .
24. Anderson JW, Smith BM, Gustafson NJ. Health benefits and practical aspects of high fiber diets. The American journal of Clinical Nutrition. 1994;59:1242-1247.
25. Akubor PI, Badifu GIO. Chemical composition, functional properties and baking potential of African bread fruit kernel and wheat four blends. International Journal of Food Science and Technology. 2004;39:223–229.
26. Bogert JL, Briggs GM, Galloway DH. Nutrition and physical fitness .International Journal Food. 1994.
27. FAO/WHO. Report of the 21st session of the codex alimentarius committee on fats and oils. Kola Kinabalu. Malaysia; 2009.
28. Robert KM, Daryl KG, Victor WR. Harper's biochemistry, 23rd edition. Lange Medical book. Prentise-hall International Inc; 1993.
29. Christian A. Studies of selected physicochemical properties of fluted pumpkin (*Telf eiria occidentalis Hook* F.) seed oil tropical almond (*Terminalia catappa*L.) seed oil. Pak Journal Nutrition; 2006;5:306-307.
30. Aletor VA, Ikhena GA, Egharevba V. The quality of some locally processed Nigerian palm oil: An estimation of some critical variables. Food Chemistry. 1990;36:311–317.

31. Aremu MO, Bamidele TO, Agere3 H, Ibrahim H, Aremu SO. Proximate composition and amino profile of raw and cooked black variety of tiger nut *(Cyperus esculentus* L). Grown in Northern Nigerian. Journal of Biology, Agriculture and Healthcar. 2015;5(7):213-221.
32. Olaofa O, Sanni CO. Minerals contents of agricultural products. Food Chemistry.1988;30:73-77.
33. Salau RB, Ndamitso MM, Paiko YB, Jacob JO, Jolayemi OO, Mustapha S. Assessment of the proximate composition, food functionality and oil characterization of mixed varieties of *Cyperus esculentus* (tiger nut) rhizome flour. Continental Journal Food Science and Technology. 2012;6 (2):13–19.
34. Eastwood MA. Dietary fiber in human nutrition. Journal of Science, Food and Agriculture. 1974;29:1523-1527.
35. Mendeloff AI. Dietary Fiber and Gastrointestinal Disease: Some facts and fancies. Medical Clinic of North America. 1978;62(1):1417-1426.
36. Caret LR, Denninston JK, Topping JJ. General organic and biochemistry, 3rd edition. McgrawHill. 2001;495-497.
37. Aremu MO, Olonisakin A, Bako DA, Madu P. compositional studies and physicochemical characteristics of cashew nut (*Anarcadiumoccidentale*) flour. Pak Journal Nutrition. 2006;5:328-333.
38. Onwuka GI. Food analysis and instrumentation. Surulere, Lagos. 2005;143.
39. Oladimeji FA, Orafidiya OO, Okeke IN, Dagne E. Effect of autoxidation on the composition and antimicrobial activity of essential oil of Lippia multiflora. Pharmaceutical and Pharmacological Letters. 2001;11(2):64-67.
40. Oluba OM, Adeyemi O, Ojieh GC, Isiosio IO. Fatty acid composition of Citrullus lanatus (egusi melon) and its effect on serum lipids and some serum enzymes. Inter J Cardio Res. 2008;5(2-10).
41. Ngando EGF, Mpondo MEA, Dikotto EEL, Koona P. Assessment of the quality of crude palm oil from smallholders in Cameroon. Journal of Stored Products and Postharvest Research 2011;2(3):52-58.
42. Onwuka GI, Onwuka ND. The effects of ripening on the functional properties of plantain and plantain based cake. International Journal of Food Properties. 2005;8(2);347-353.
43. Ogbuagu MN. Inhibitory effect of onion and garlic extracts on the rancidity of palm and palm Kernel Oils. Journal Chemistry Society of Nigeria. 2008; 33(1):43-44.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/63751