Mediterranean Journal of Pharmacy & Pharmaceutical Sciences
www.medjpps.com

ISSN: 2789-1895 online
ISSN: 2958-3101 print

ORIGINAL RESEARCH article

Characterization, physicochemical analysis, and antimicrobial activity of a cream from oil extracted from *Cyperus esculentus l.* (tiger nuts)

Osahon K. Ogbeide, **Cornelius O. Jackson-Akpamu**, and **David O. Akhidenor** *

Department of Chemistry, Faculty of Physical Science, University of Benin P.M.B 1154, Benin City, Nigeria
* Author to whom correspondence should be addressed

Article number: 201, **Received:** 11-02-2025, **Accepted:** 13-04-2025, **Published online:** 16-04-2025

HOW TO CITE THIS

Ogbeide et al. (2025) Characterization, physicochemical analysis, and antimicrobial activity of a cream from oil extracted from *Cyperus esculentus l.* (tiger nuts). Mediterr J Pharm Pharm Sci. 5 (2): 49-61. [Article number: 201].
https://doi.org/10.5281/zenodo.15225961

Keywords: Antimicrobial, *Cyperus esculentus*, GC-MS analysis, proximate analysis

Abstract: *Cyperus esculentus* (tiger nut) seed is the parent of many products like flour, milk, starch, and oil. All these share similar and sometimes better properties when compared to similar products obtained from other sources. This study aimed to produce and characterize a cream made from oil extracted from tiger nuts. The proximate analysis was tested by the established methods and data obtained show that tiger nut powder has a moisture content (14.50%), an ash (1.98%), a fat (51.27%), a protein (8.47%), fiber (13.94%) and carbohydrate (9.98%). The oil from the tiger nut was extracted using the hot press method, the tiger nut oil had an 8.00% yield. The oil was used to produce a body cream which was characterized and tested for its antibacterial activity. Its antibacterial activity showed inhibition against *Klebsiella pneumoniae*, *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomona aeruginosa*. The characterization tests gave results of 1735.80 cP for viscosity, moisture content (1.07%), pH of 6.10, ash (5.11%), volatile matter (94.89%), electrical conductivity (390 µS/cm), Spreadability at 30^{o}C was 145.28 g.cm/s, at 35^{o}C was 149.41 g.cm/s and 152.25 g.cm/s at 40^{o}C. The cream was checked for stability and found to be stable at different temperatures. It was checked for allergens and it exhibited some level of allergic reactions. Physicochemical analysis of the golden-brown oil indicated the specific gravity (0.98), density (0.98 g/ml), acid value (1.82 mg/KOH/g), iodine (37.75 mg), peroxide (2.00 meq/kg), saponification (236.32 mg/KOH/g), free fatty acid (0.91%) and refractive index (1.46). The GC-MS analysis identified a total of 22 compounds. Oil, with the major constituents being palmitic acid (13.70%), oleic acid (18.50%), oleamide (31.25%), acexamic acid (4.68%), stearic acid (2.99%), squalene (2.87%) by composition. The study reveals that oil from tiger nut seed is useful when applied in the production of body creams and has possible uses in the production of antibacterial ointments.

Introduction

The cosmetics industry is expanding rapidly, with both men and women seeking products tailored to their skin needs. While there is a wide range of cosmetics available-from lotions to makeup powders contain harmful chemicals that can cause long-term skin damage, including diseases and even cancer. This highlights the need for safer alternatives that provide desired results without the risks associated with substandard ingredients [1]. Oils are one of the most important ingredients used in the production of creams, and the oil from *Cyperus esculentus L.* (tiger nuts) has a lot of benefits [2]. In addition to its oil, *C. esculentus L.* is recognized for

ISSN: 2789-1895 online
ISSN: 2958-3101 print

containing all the essential and functional compounds necessary for a balanced diet. It is utilized in the production of beverages, dairy or fermented milk products (like yogurt), flour, nougat, jam, honey, beer, candies, chocolate, and more. Tiger nuts accumulate a significant amount of oil in such regions, even though some plants amass enormous levels of starch or sugar in tubers and roots. The high oil yield and milk content make tiger nuts very useful as food and also as an industrial material [3]. The therapeutic benefits of tiger nuts cannot be disregarded due to their frequent use in traditional practices. This paper examines the application of tiger nut oil in the formulation of body creams, highlighting its potential antimicrobial properties, strong antioxidant capabilities, nutritional composition, aesthetic benefits, and spectroscopic characteristics. Tiger nuts are a perennial plant from the sedge family, known by various names across different regions. The tubers are small, round when wet, and asymmetrical when dry [4]. They grow 1-3 feet tall, reproducing through seeds and rhizomes [5]. In Nigeria, they are called Aya, Ofio, and Akiausa by different ethnic groups. Consumed by both humans and animals in Africa, Europe, and America, tiger nuts are valued for their rich nutritional content, including minerals, starch, oil, and vitamins C, D, and E [3]. Due to their high oleic content, tiger nuts are one of the spices that is suggested to prevent certain ailments including heart attack, cancer, and thrombosis. Due to their beneficial micronutrient content, these nuts can also be used as a lactation supplement. The therapeutic application of tiger nuts extends to treating three medical conditions, including erectile dysfunction, blood transfusion and pumping system issues, and cardiac problems [6]. The tubers of tiger nuts benefit human reproductive systems while assisting digestion and serving as medicine for treating colds together with diarrhea and colitis [7-9]. These medical and cosmetic industries benefit from tiger nuts because they help eliminate harmful free radicals according to Bilikis et al. [10]. Research demonstrates that tiger nuts exhibit antimalarial qualities and these nuts function as analgesics and hypoglycemics [11]. The anti-diarrheal properties of the product result from its flavonoids and tannins content [12]. Tiger nuts contain high amounts of arginine that benefit blood vessel functioning while managing blood pressure [13]. Tiger nuts have fatty acids which reduce cholesterol levels as well as vitamin B1 which benefits nerves while lowering stress [13]. According to Belewu et al. [14] tiger nut milk contains carbohydrates, protein, lipids, minerals and vitamins and other essential dietary nutrients. The heart benefits from the oleic acid content in tiger nuts which also supports digestive health [5]. Belewu et al. indicate that its cholesterol- and lactose-free nature makes tiger nuts suitable for dietary restrictions [14]. Tiger nuts house 68.2 grams of oleic acid while they also contain palmitic, linoleic and stearic acids [15]. Scientists have found that the levels of oleic acid in tiger nuts match those found in olive oil and stand close to macadamia and hazelnut and avocado oil levels [3, 16]. Tiger nut oil maintains its shelf life for an extended period due to its high monounsaturated fatty acid composition [17].

Materials and methods

Sample collection and preparation: Tiger nut seeds were obtained from Ugbowo, Benin City, Edo state, Nigeria. They were washed and properly selected to remove bad tiger nut seeds. The seeds were then shade-dried for three days, ground to powder using an industrial blender and stored in an airtight container for further laboratory analyses when needed.

Extraction of tiger nut oil: Using the hot press method, hot water was used as the solvent for extraction. After hot water was poured into the tiger nuts seed powder, extraction was done using several steps. First, the mixture was filtered using a cloth filter to separate the residue (chaff) from the filtrate (milk). The filtrate was then refrigerated for two days before the top layer was scooped into a pot and placed over a low heat source. It was crucial to avoid using high temperatures to prevent burning and turning the sample into a brown, thick substance that solidifies on drying. As the oil slowly came out, it was then decanted into a stainless container and left to cool. The resulting tiger nut oil is a golden yellow color and has a characteristic smell.

ISSN: 2789-1895 online
ISSN: 2958-3101 print

Proximate analysis of tiger nut: The moisture content, ash content, crude fiber, crude protein, and crude fat of *Cyperus esculentus L.* seed powder were determined using the methods described by AOAC [18].

Cream preparation using tiger nut oil: Creams are emulsions made by mixing an oil phase with a water phase and holding them together using an emulsifying agent to keep the solution stable. The water and oil phases were kept in the water bath to keep the temperature even. To prepare 100 g of cream, a two-phase system was created. The water phase was made by dissolving borax salt in 30 g of distilled water, while the oil phase was made by adding grapeseed oil, paraffin oil, beeswax, acetyl alcohol, stearic acid, and mango butter to a beaker and allowing them to melt or dissolve. The oil and water phases were then mixed while stirring continuously until a homogeneous emulsion was achieved, thanks to the emulsifying agent. Tiger nut oil, along with perfume, preservatives, and vitamin E, were added to the emulsion and stirred to achieve homogeneity. Finally, the emulsion was left to cool.

Antimicrobial activity of tiger nut

Preparation of formulated cream sample: In the first step of the procedure, 1.0 g of cream was weighed and dissolved into 3.0 ml of 25% Tween 80 to give a concentration of 250 mg/ml. In the second step, 30.0 ml of sterile molten Mueller Hinton agar was poured into a 90mm sterile petri dish and allowed to solidify. The dish was then dried in a hot air oven at 50^{o}C for 10 min to remove excess moisture from the surface. Next, the entire surface of the agar was seeded with organisms that were adjusted to 0.5 McFarland turbidity to give approximately 10^8 cfu/ml of the inoculum. A well of 10 mm in diameter was drilled into the surface of the agar using a sterile cork borer of 10 mm. The base of the well was then sealed with molten Mueller Hinton agar, and 0.2 ml of 250 mg/ml of the cream was delivered into the well using a micropipette with a sterile teat. The sample was allowed to stand for 30 minutes before being incubated for 24 hrs at 37^{o}C. Finally, after 24 hrs of incubation, the results were observed and recorded.

Methods for the characterization of the cream

Viscosity: The viscosity was determined using a Brookfield NDJ-5S Rotary viscometer. The appropriate spindle number was identified, selected for the test sample, and gently mounted on the machine. A 250 ml beaker was cleaned, and the sample was poured up to the 200 ml mark. The beaker was then placed in a water bath, with the temperature set to a constant 30°C, and allowed to equilibrate for 10 min. The spindle and the machine's temperature sensor were then lowered into the sample, and the power button was activated. The correct spindle number and speed were selected on the display screen, followed by pressing the run button. The machine was then allowed to measure the viscosity until a stable reading was obtained and recorded.

Moisture content determination: To begin the experiment, a clean and labeled evaporating dish was oven-dried and weighed. Next, 1.0 g of the sample was added to the dish and labeled accordingly. The dish containing the sample was then placed in an air-dry oven set to a temperature of 105-110°C for one hour. After this, the dish and sample were removed from the oven and placed into a desiccator to cool for 30 min before being weighed. This process was repeated until a constant weight was obtained.

Ash content determination: To start the experiment, an oven-dried crucible was weighed and labeled. Subsequently, 1.0 g of the sample was added to the crucible and labeled. The crucible with the sample was then placed in a muffle furnace set to 500°C for 2 hrs. After this period, the crucible with the sample was removed from the furnace, placed in a desiccator for 30 min to cool, and then weighed and labeled.

Volatile matter: A crucible was labeled and weighed after oven drying. One gram of the cream sample was weighed and placed in the crucible, which was then weighed again. The crucible with the sample was heated

ISSN: 2789-1895 online
ISSN: 2958-3101 print

at 500°C for 120 min. The weight loss was practically determined by comparing the weight of the crucible before and after it was placed in the oven.

Patch test: This test is qualitative; it was done by applying the cream sample on the skin for 24 hrs and observation would be taken at intervals and at the end of the 24 hrs.

Stability test: This test was carried out to see how the prepared cream would respond to different temperatures. The cream was put at room temperature, extremely low temperature (-8°C), and high temperature (45°C) to see if it would remain stable under these extreme conditions and to know how temperature affects its stability.

Spreadability: The spreadability was done using the methods described by Shankar et al. 2016. The cream was applied between two glass slides of dimension 7.62 cm x 2.54 cm (3-inch x 1-inch) and a weight of 100 g was placed uniformly on the slide for 10 sec to spread it evenly. The weight was removed and the excess of cream was scrapped off. The slides were fixed to a stand at an angle of 45°C without any disturbance so that only the bottom slide was at a fixed position allowing the upper slide to slip off easily under a weight of 20 g. The time taken for the upper slide to separate from the lower slide under the direction of the weight was noted. The experiment was done at different temperatures and the spreadability was calculated.

Electrical conductivity: This test was carried out using an electrical conductivity tester. 5.0 g of the sample was measured and diluted with 50 ml of water. It was stirred until the sample was completely dissolved and the solution was saturated. The electrical conductivity tester was then used to measure the electrical conductivity of the solution.

Gas chromatography - Mass spectroscopic (GC-MS) conditions: The quantity and quality content of tiger nuts oil components were analyzed using a GC - MS under the following conditions: a high plunger speed (suction), viscosity compression time of 0.2 sec, a high plunger speed (injection), the injection mode was set to normal, there were three pumping times with a washing volume of 8.0 ul. The column oven temperature was 100°C and the injection temperature was 250°C. The sampling time was set to 2 min with a pressure flow control mode which was set at 100.0 kPa. The total flow during injection was 8.1 ml/min with a column flow of 1.33 ml/min. The oven temperature was set to increase to 260°C from 100°C after 8 min and then to 300°C after another 8 min. The MS detection was held in the SCAN mode in the range of 60-430 m/z with a total time of 24.5 min.

Phytochemical analysis of tiger nut oil

Acid value: 2.0 g of sample was weighed and placed in a 250 ml conical flask and 25 ml of ethanol and diethyl ether equimolar mixture was added with 1.0 ml of phenolphthalein indicator solution while shaking the content vigorously. The mixture was heated for about 5 min and was then titrated with potassium hydroxide until a pink color was obtained.

Peroxide value (PV): An accurately weighed 1.0 g oil sample was added to a conical flask and dissolved in a solvent mixture of 25 ml acetic acid-chloroform (2:1) solution. To this solution, 1.0 ml of potassium iodide was added, stirring until the oil was fully dissolved. The mixture was then incubated in the dark for one hour at room temperature. After incubation, 35.0 ml of water was added, and the solution was titrated with 0.2 N sodium thiosulphate until the yellow color nearly disappeared, using starch as an indicator.

Iodine value: Weigh oil into a flask with a magnetic bar, 15.0 ml of carbon tetrachloride, and 25.0 ml of Wijs. Cover with foil paper and keep in the dark for one hour. Add 20.0 ml of potassium iodide solution and then 100 ml of water. Titrate with sodium thiosulphate. When it turns to pale yellow, add 1.0 ml of starch indicator which changes the color to blue. The titration continued until the blue color changed to colorless.

ISSN: 2789-1895 online
ISSN: 2958-3101 print

Saponification value: 2.0 g of oil sample was accurately weighed and placed in a 250 ml flask and 25.0 ml of 0.5 N ethanolic potassium hydroxide solution. The mixture was heated with an electric hotplate (coupled to a reflux condenser from the Soxhlet extractor) for 30 min while being stirred continuously. After the fat is completely dissolved, titrate the soap solution while still hot with the standard hydrochloric acid using phenolphthalein as an indicator, and carry out a blank determination at the same time and under the same conditions with the same quantity of ethanolic potassium hydroxide solution.

Specific gravity: A 25 ml specific density bottle was washed, dried, and weighed. It was filled with the oil sample and weighed. The oil was poured off and the bottle was dried to its previous constant weight filled with distilled water and weighed and specific gravity was calculated.

Density: When the density of a liquid and its reference substance are measured in the same units (g/cm^3 or lb/ft^3), the specific gravity of the liquid is found by dividing its density by the density of the reference substance. Conversely, if you know the specific gravity of a substance and the density of its reference substance in a specific unit, you can determine the density of the liquid by multiplying the specific gravity by the density of the reference substance in those units.

Results and discussion

Proximate analysis: Moisture content represents the percentage of water present in a substance. The value obtained from the tiger nuts powder was 14.5% which is lower as compared to the 26.0% [3]. This is most definitely because the seeds were dried for a longer period before they were ground. The ash content tells us the amount of minerals (Na, K, Ca, Mg) present in a substance. The value obtained was 1.98% which is similar to the result of 1.70% [3]. Fats are solid fatty acids (long-chain hydrocarbons with a carboxylic acid functional group; -COOH) at room temperature. The proximate test gave a fat content of 51.27%. This is also of importance because tiger nut oil contains a considerable portion of oleic acid, 18.57% as shown in the GC-MS analysis of the oil. Oleic acid is a monounsaturated fatty acid, less susceptible to oxidation, leading to rancidity. Furthermore, these fats are heart-friendly types, they help protect the heart from cardiac problems because of the presence of high amounts of oleic acid. The values obtained are greater than those obtained by Sánchez-Zapata et al. [3]. This could, however, be due to the time of harvest, geographical location, and duration of drying. Proteins are amino acid polymers that contain the amine functional group (NH_3). The result above shows that tiger nuts contain about 8.47% protein, which means that they can be a very good alternative to protein in our diets. This result is greater than that obtained by Sánchez-Zapata et al. [3]. which is 5.04%. This could be because of the geographical location of cultivation and method of drying as heat is known to denature proteins. The importance of fiber in our diet is undisputed, and tiger nuts are seen to contain 13.94% fiber. This is also higher than the value obtained by Sánchez-Zapata et al. [3]. (8.91%). This could be because of the geographical location and a difference in the soil type used in cultivation. Carbohydrates are polyhydroxy aldehydes or ketones. The carbohydrate content obtained from this experiment (9.98%) however was significantly lower (43.0%) [3]. This could be due to a discrepancy in the method used for the determination. All this goes to show that tiger nuts are very good sources of beneficial nutrients, and they are good substitutes for most of our regular foods.

Antimicrobial activity: The test was carried out using the five aforementioned bacteria with a concentration of 250 µg/ml of cream. The tests showed that there was no inhibition against *Bacillus subtilis.* It showed little inhibition against *Klebsiella pneumoniae* and *Escherichia coli*, while *Staphylococcus aureus* and *Pseudomona aeruginosa* showed the best inhibition from the cream (**Table 1**). These results didn't give us a strong inhibition against the bacteria used, this may mean that the inhibition would be better at higher concentrations or more of the oil should be used in the production of the cream or the method of extraction of the oil affected

ISSN: 2789-1895 online
ISSN: 2958-3101 print

the antibacterial properties of the oil and another method of extraction should be employed in subsequent studies. The antibacterial activity was not taken at lower concentrations as there may be no activity if the concentration is reduced. This however shows that oil extracted from tiger nuts may be used as an antibacterial agent against *Klebsiella pneumoniae*, *Escherichia coli*, *Staphylococcus aureus* and *Pseudomona aeruginosa* in medicinal ointments or drugs.

Table 1: Antimicrobial activity of the cream made from tiger nuts oil

S/N	Microorganism	Inhibition distance with 250 µg/ml
1	*Klebsiella pneumoniae*	1 mm
2	*Bacillus subtilis*	Null
3	*Staphylococcus aureus*	3 mm
4	*Escherichia coli*	1 mm
5	*Pseudomonas aeruginosa*	3 mm

C*haracterization of tiger nuts oil-based cream:* The standard cream used for this comparison is the Familia body pomade. It is a very common and highly recommended cream thus was selected as the best cream for this comparison. The viscosity of the produced cream being 1753.80 cP shows that the cream produced is quite viscous and possesses a good level of internal friction due to its molecular makeup. It also suggests that the cream has a good enough flow. The viscosity however can be improved by a slight increase in the amount of water used in making the water phase used in the production of the cream with a corresponding increase in the emulsifying agent used for the cream production. When compared with the standard cream, the viscosity of the standard cream (1140.80 cP) was lower than that of the produced cream (1753.80 cP). Lower values of viscosity are better, and a better flow in creams is preferable, this means that the standard has a better flow (**Table 2**).

Table 2: Characterization of cream in comparison with a standard commercial cream

No	parameters for characterization	Tiger nuts cream		Standard cream (familia)	
1	Viscosity	1753.80 cP		1140.80 cP	
2	Moisture Content	1.07%		1.04%	
3	pH	6.10		7.30	
4	Ash content	5.11%		2.80%	
5	Volatile matter	94.90%		97.20%	
6	Electrical conductivity	390 µS/cm		19 µS/cm	
7	Spreadability	30ºC	145.28 g.cm/s	30ºC	38.04 g.cm/s
		35ºC	149.41 g.cm/s	35ºC	50.60 g.cm/s
		40ºC	152.25 g.cm/s	40ºC	140.46 g.cm/s

A moisture content of 1.07% shows that the amount of free water present in the cream is very little and that tells us that the cream is less susceptible to degradation by microorganisms and would also have a very good

ISSN: 2789-1895 online
ISSN: 2958-3101 print

shelf life (**Table 2**). It also shows that the cream remains stable at very extreme temperatures, not dissociating which in turn leads to the retention of water. When compared with the standard cream, the moisture content of both creams was found to be relatively equal, that of the standard cream however is slightly lower. Both creams have a very good moisture content and would have a very good shelf and storage life. The cream has an acidic pH of 6.10. The pH of the skin being between 4.1-5.8 would suggest that a cream with a pH value within that range would have been suitable, however, for creams, a pH of 6.1 is acidic enough for the needs of the skin [18]. When compared with the standard cream, the pH of the produced cream was better than that of the standard cream. We have previously discussed the importance of a cream having an acidic pH as the pH of the body is also acidic. In this case, a lower pH is better, hence the pH of 6.10 is better than that of 7.30. An ash content of 5.11% suggests that the cream contains important minerals like calcium, manganese, and aluminum [19]. These minerals play a vital role in fighting skin damage caused by excessive sun exposure, and wrinkles, and maintaining the moisture in the skin. When compared with the standard cream, the produced cream however has a higher ash content signifying a larger mineral content and invariably better skin nutrients. The electrical conductivity of the cream (390 µS/cm) is very high, it suggests that the oil used in the manufacture of the cream has a high concentration of free fatty acids making the cream very ionic causing the high conductance. A range of 10-50 µS/cm is an acceptable range. A possible cause of this high conductivity is the long period between the production of the oil and its use in the production of the cream. The presence of more minerals in the form of ions could also cause the electrical conductivity to be high. Another method of oil extraction should also be explored and the time period between the extraction of the oil and use should be close while taking into consideration proper storage conditions like storage in amber bottles at room temperature. When compared with the standard cream, the electrical conductivity of the produced cream (390 µS/cm) is significantly higher than that of the standard cream (19 µS/cm). Lower values of electrical conductivity are better. This means that the produced cream contains more ionic materials (free fatty acids) that conduct electricity. Hence the standard cream has a better electrical conductivity (**Table 2**). The spreadability of the cream was taken at temperatures of 30ºC, 35ºC, and 40ºC, and from the results, the spreadability increased with an increase in temperature. The higher the value for spreadability the better the cream's absorbance by the skin (**Table 2**). This result shows that the cream has good spreadability and the constituents and components of the cream will easily be absorbed by the skin without retention of the components on the epidermis of the skin. When compared with the standard cream, the spreadability of the standard cream was more affected by temperature change. We can see that the spreadability of the produced cream increased with an increase in temperature but the change was small. The spreadability range of the produced cream at 30ºC, 35ºC, and 40ºC was between 145-153 g.cm/s. The spreadability range of the standard cream was between 38-141 g.cm/s at the same temperatures. The spreadability of both creams can be seen in **Figures 1** and **2.**

Figure 1: Spreadability against temperature

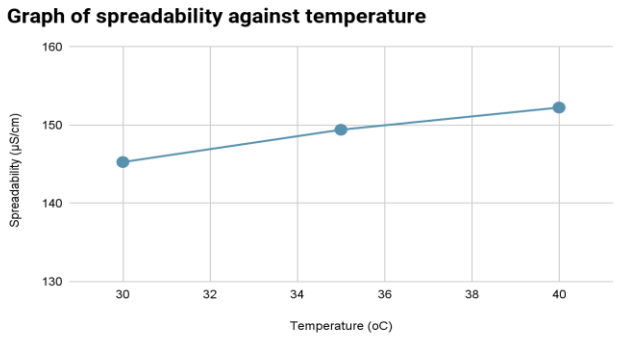
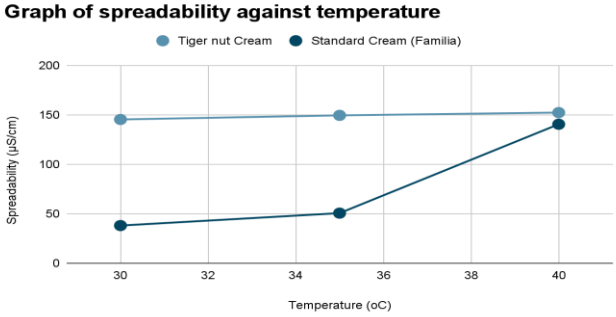


Figure 2: Spreadability of the produced tiger nut cream with the standard cream



ISSN: 2789-1895 online
ISSN: 2958-3101 print

Patch test: A sample of the cream was applied to the upper part of the arm in a patch of 2.0 g. Within the first 12 hrs, no sensation or irritation was felt. Yet, after 14 hrs, an itchy feeling began around the application area which became stronger and harder to resist scratching at 17 hrs. After 23 hrs, the cream changed color from off-white to a brownish color. At 24 hrs and some minutes, the patch was removed, and the area of the patch was significantly darker than other parts of the body. Small spots were observed in the application area after the patch was removed, and these spots persisted for a few extra hours. This reaction is consistent with contact dermatitis. The test showed that some of the constituents of the cream gave an allergic reaction, although the allergy is negligible because the itch did not continue after the patch was removed showing that the itch probably resulted from the heat the patch caused around the application area. Also, the spots did not remain for up to 6 hrs showing that the skin reaction was not severe.

Stability test: The cream remained stable at room temperature without thickening or separating. Its stability was maintained at a temperature of -8^{o}C for 24 hrs, as no creaming, flocculation, or coagulation was observed at this temperature. This was done to stimulate a temperature for some of the coldest areas in the country. It, however, became solid and hard. It remained stable at temperatures of 50^{o}C showing stability. However, it showed phase separation at extreme temperatures; this can be corrected by increasing the amount of the emulsifying agent used in the production of the cream.

Physicochemical properties of tiger nut oil

The physicochemical properties of tiger nut oil are represented in **Tables 3-6**. Thus, the oil that was extracted from tiger nut has a golden-brown color and a pleasant odor. Physicochemical analysis of tiger nuts oil revealed a refractive index of 1.46 at 30°C which falls within the range of recommended values of 1.445-1.470 refractive index for edible vegetable oils [20]. The PV is still the most common chemical method of measuring oxidative deterioration of oils. It is used to determine the rancidity of a sample containing fats and oils subject to oxidation. The PV of fresh vegetable oils is less than 10.00 meq O_2/kg oil [21]. The PV was 2.00 meq O_2/kg which indicates good quality of oil and a good preservative status. Acid value is the indication of the level of free fatty acid in the oil, the acid value of 1.82 mg/KOH/g is in the range of 0.00 to 3.00 mg KOH/g recommended for oil suitable for cooking [22]. For tiger nut oil, most of its reported acid values are quite low, 0.03-1.38 mg/KOH/g, [23]. Hence, tiger nut oil could be an excellent candidate for food preparation. A low acid value implies better storage and shelf life of the oil. The saponification value of oil serves as an important parameter in determining the suitability of oil in soap making. The saponification value is 236.32, therefore tiger nut oil can be used in soap making due to its high saponification value. The iodine value was 37.75 g/100 g, tiger nuts oil is a non-drying lipid suitable for paint making as drying oils have an iodine value above 100 g/100 g [24]. Due to low iodine value, it is said to be a non-drying oil, an oil that does not harden when exposed to air and thus can be used industrially.

Table 3: Proximate composition of tiger nut

No	Proximate test	Value (%)
1	Moisture content	14.38±0.18
2	Ash content	1.98±0.03
3	Fat content	51.27±0.33
4	Protein content	8.47 ±0.09
5	Fiber content	13.94±0.06
6	Carbohydrate content	9.98±0.22

ISSN: 2789-1895 online
ISSN: 2958-3101 print

Table 4: Irritation levels and skin reactions at time intervals

Time period (hrs)	1-6 hours	7-12 hours	13-18 hours	19-24 hours
Irritation level	*	**	***	****
Allergic reaction	*	*	*	*

* No irritation/reaction, ** Low irritation/reaction, *** Severe irritation/reaction, **** Extremely severe irritation/reaction

Table 5: The stability of the cream at different temperatures

Temperature	- 8°C	28°C	50°C	> 150°C
State	*	**	**	***

* Homogeneous solid, ** Homogenous semi- solid, *** Instability and phase separation

Table 6: Physicochemical properties of tiger nut oil

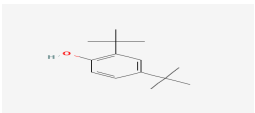
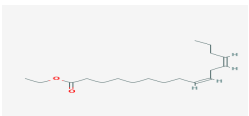
No	Properties	Results
1	Specific gravity	0.98
2	Density	0.97
3	Acid value	1.82
4	Iodine value	37.75
5	Peroxide value	2.00
6	Saponification value	236.32
7	Refractive index	1.46
8	Free fatty acid	0.91

GC-MS analysis of Cyperus esculentus seed oil: The result from the GC-MS revealed the 22 chemical constituents in the tiger nuts oil, consisting of fatty acids, alkanes, alkene, amines, amides, esters, alcohols, and aromatic compounds. The fatty acid was the highest in proportion with over 35.0% in the tiger nuts oil. Oleic acid had the highest percentage composition (18.57), followed by palmitic acid (13.70). Some of the compounds present in tiger nut oil make it very useful in its application in the production of a body cream as they provide a lot of benefits to the skin. Palmitic acid which is a non-drying oil provides surface coating functionalities on the skin which makes the skin always moisturized and tender at all times. In effect, preventing dryness of the skin [25]. Oleic acid is also present in tiger nuts oil and it is very useful in hand creams, lotions, and liniments, where it is used as an antifreeze for gels in cold climates [26]. It serves as an excellent emollient and super-fatting agent, soothing and hydrating the skin, it also forms a protective film on the skin to lock in moisture [25]. They are moisturizing treatments used to help manage itchy, scaly, or dry skin conditions such as ichthyosis, eczema, and psoriasis [26]. Stearic acid, which is one of the most important materials used in the production of body cream, is also present. It is an emulsifying agent that helps hold the oil and water phases in a homogenous mixture. However, it also functions as an emollient and lubricant that can soften the skin. It is used in other personal care products, including moisturizers, sunscreen, vanishing creams, and ointments [27]. Eicosane is a non-volatile hydrocarbon emollient consisting of a mixture of highly branched C20 isoparaffin hydrocarbons. It has a satiny texture and feel. It is a suitable replacement for mineral oil in "oil-free" products. It adds to the spreadability of creams and still provides a satiny feel to the skin when applied. It is an effective plasticizer for color cosmetics, and at the same time, it is non-comedogenic. Eicosane is also very useful in hair products as it gives a high sheen, compatible with silicones for imparting shine, slip, and comb-ability to hair products [11]. Oleamide is used as an antistatic and viscosity controller to reduce viscosity in creams and other cosmetic formulations. Its presence in essential oils that are used to make creams

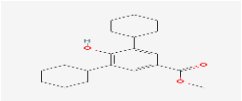
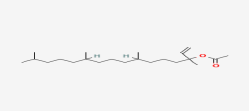
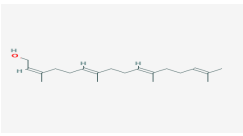
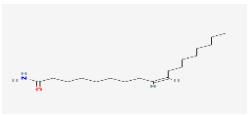
ISSN: 2789-1895 online
ISSN: 2958-3101 print

is invaluable as it increases the stability of the oil and in turn the stability of the cream [28]. Acexamic acid contains non-steroidal anti-inflammatory agents. Besides their anti-inflammatory properties, they also possess analgesic, antipyretic, and platelet-inhibitory effects. These attributes contribute to the therapeutic and antibacterial qualities of tiger nut oil. These agents give tiger nut oil some of its therapeutic and antibacterial functions. Squalene is one of the major components of skin surface lipids. Squalene is not very susceptible to peroxidation and appears to function in the skin as a quencher of singlet oxygen, protecting the human skin surface from lipid peroxidation due to exposure to UV and other sources of ionizing radiation [29]. It is known to be a major scavenger of ozone at the interface between room air and the human envelope. Reactions between ozone and human skin lipids reduce the mixing ratio of ozone in indoor air [30].

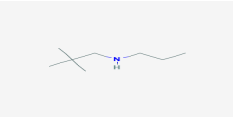
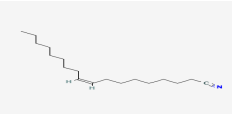
Table 7: Peak report of the different components of tiger nuts oil

Peak	Compound name	Molecular formula	Molecular weight	Composition %	Retention time	Structure
	Fatty acids (-COOH)					
1	Oleic acid	$C_{18}H_{34}O_2$	282.5	18.57	19.464	
2	Palmitic acid	$C_{16}H_{32}O_2$	256.42	13.70	17.351	
3	Stearic acid	$C_{18}H_{36}O_2$	284.5	2.99	19.761	
	Esters (-COOR)					
4	Palmitic acid, methyl ester	$C_{17}H_{34}O_2$	270.5	1.49	16.811	
5	Phenol, 2,4-bis(1,1-dimethylethyl)-	$C_{17}H_{30}OSi$	278.5	2.36	10.875	
6	1-Heneicosyl formate	$C_{22}H_{44}O_2$	340.6	1.34	22.700	
7	Ethyl 9,12-hexadecadienoate	$C_{18}H_{32}O_2$	280.4	0.45	18.825	
8	11-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296.5	3.22	18.910	
9	Stearic acid methyl ester	$C_{19}H_{38}O_2$	298.5	0.18	19.247	

ISSN: 2789-1895 online
ISSN: 2958-3101 print

10	**Benzoic acid, 3,5-dicyclohexyl-4-hydroxy-, methyl ester**	**$C_{20}H_{28}O_3$**	**316.4**	**2.44**	**27.414**	
11	**Isophytol, acetate**	**$C_{22}H_{42}O_2$**	**338.6**	**0.36**	**15.798**	
	Alkanes, Alkenes and Alkyl halides					
12	**2-Bromotetradecane**	**$C_{14}H_{29}Br$**	**277.28**	**0.61**	**15.275**	
13	**Eicosane**	**$C_{20}H_{42}$**	**282.5**	**0.33**	**20.257**	
14	**Eicosane, 10-methyl-**	**$C_{21}H_{44}$**	**296.6**	**0.41**	**22.792**	
15	**Erythro-9,10-Dibromopentacosane**	**$C_{25}H_{50}Br_2$**	**510.5**	**0.19**	**25.266**	
16	**Squalene**	**$C_{30}H_{50}$**	**410.7**	**2.87**	**27.755**	
	Alcohols (-OH)					
17	**2-Cis-Geranylgeraniol**	**$C_{20}H_{34}O$**	**290.5**	**2.81**	**19.993**	
18	**Dihydrophytol**	**$C_{23}H_{50}OSi$**	**370.7**	**0.80**	**20.158**	
	Carboxylic Acids (-COOH)					
19	**Acexamic acid**	**$C_8H_{15}NO_3$**	**173.21**	**4.68**	**22.442**	
	Amines and Amides (-NH_2 and -$CONH_2$)					
20	**Oleamide**	**$C_{18}H_{35}NO$**	**281.5**	**31.25**	**21.981**	

ISSN: 2789-1895 online
ISSN: 2958-3101 print

21	**Propylneopentylamine**	**$C_8H_{19}N$**	**129.24**	**5.41**	**19.860**	
	Nitrile group (-CN)					
22	**Oleic acid nitrile**	**$C_{18}H_{33}N$**	**263.5**	**3.54**	**18.601**	

Conclusion: The study reveals that oil from tiger nut seed is useful when applied in the production of body creams and has possible uses in the production of antibacterial ointments.

References

1. Lukić M, Pantelić I, Savić, SD (2021) Towards optimal ph of the skin and topical formulations: From the current state of the art to tailored products. Cosmetics. 8 (3): 69. doi: 10.3390/cosmetics8030069
2. Muhammad N, Bamishaiye E, Bamishaiye O, Usman L, Salawu MO, Nafiu MO, Oloyede O (2011) Physicochemical properties and fatty acid composition of cyperus esculentus (Tiger Nut) Tuber Oil. Bioresearch Bulletin. 5: 51-54. doi: Nil.
3. Sánchez-Zapata E, Fernández-López J, Pérez-Alvarez JA (2012) Tiger nut (*Cyperus esculentus*) commercialization: health aspects, composition, properties, and food applications. Comprehensive Reviews in Food Science and Food Safety. 11 (4): 366-377. doi: 10.1111/j.1541-4337.2012.00190.x
4. Coşkuner Y, Ercan R, Karababa E, Nazlıcan AN (2002) Physical and chemical properties of chufa (*Cyperus esculentus L*) tubers grown in the Çukurova region of Turkey. Journal of the Science of Food and Agriculture. 82 (6): 625-631. doi: 10.1002/jsfa.1091
5. Bamishaiye EI, Bamishaiye OM (2011) Tiger nut: as a plant, its derivatives and benefits. African Journal of Food, Agriculture, Nutrition and Development. 11 (5): 5157-5170. doi: 10.4314/ajfand.v11i5.70443
6. Bamgbose AM, Eruvbetine D, Dada W (2003) Utilisation of tiger nuts (*Cyperus rotundus L.)* meal in diets for cockerel starters. Bioresource Technology. 89 (3): 245-248. doi: 10.1016/s0960-8524(03)00074-9
7. Nwobosi PNU, Isu NR, Agarry OO (2013) Influence of pasteurization and use of natural tropical preservatives on the quality attributes of tiger nuts drink during storage. International Journal of Food and Nutrition Science. 2 (1): 27-31. doi: Nil.
8. Wakil SM, Ayenuro OT, Oyinlola, KA (2014) Microbiological and nutritional assessment of starter-developed fermented tiger nuts milk. Food and Nutrition Sciences. 5 (6): 495-506. doi: 10.4236/fns.2014.56059
9. Okorie SU, Nwanekezi EC (2014) Evaluation of proximate composition and antinutritional factors of *Cyperus esculentus* (tiger nuts) as influenced by boiling. IOSR Journal of Environmental Sciences, Toxicology and Food Technology.8 (7): 70-73. Doi: 10.9790/2402-08727073
10. Ogunlade I, Bilikis A, Olanrewaju A (2015) Chemical compositions, antioxidant capacity of tiger nuts (*Cyperus esculentus*) and potential health benefits. European Scientific Journal. 11 (10): 217-224. Corpus ID: 42048603.
11. Hassan HA (2007) Effect of dietary supplementation with tiger nuts tubers on streptozotocin-induced diabetic rats. The Egyptian Journal of Hospital Medicine. 29 (1): 475-485. doi: 10.21608/EJHM.2007.17694
12. Ahmed ZS, Hussein AM (2014) Exploring the suitability of incorporating tiger nut flour as novel ingredient in gluten-free biscuit. Polish Journal of Food and Nutrition Sciences. 64 (1): 27-33. doi: 10.2478/v10222-012-0087-z
13. Imam TS, Aliyu FG, Umar HF (2013) Preliminary phytochemical screening, elemental and proximate composition of two varieties of *Cyperus esculentus* (Tiger nut). Nigerian Journal of Basic and Applied Sciences. 21 (4): 247-251. doi: 10.4314/njbas.v21i4.1
14. Belewu MA, Abodunrin OA (2006) Preparation of Kunnu from unexploited rich food source: Tiger nut (*Cyperus esculentus*). World Journal of Dairy and Food Sciences. 1 (1): 19-21. doi: 10.3923/PJN.2008.109.111
15. Aremu MO, Ibrahim H, Aremu SO (2016) Lipid composition of black variety of raw and boiled tiger nuts (*Cyperus esculentus L.*) grown in North-East Nigeria. Pakistan Journal of Nutrition. 15 (5): 427-438. doi: 10.3923/pjn.2016.427.438

ISSN: 2789-1895 online
ISSN: 2958-3101 print

16. Linssen JP, Kielman GM, Cozijnsen JL, Pilnik W (1988) Comparison of chufa and olive oils. Food Chemistry. 28 (4): 279-285. doi: 10.1016/0308-8146(88)90103-3
17. Ezeh O, Gordon MH, Niranjan K (2016) Enhancing the recovery of tiger nut (*Cyperus esculentus*) oil by mechanical pressing: Moisture content, particle size, high pressure and enzymatic pre-treatment effects. Food Chemistry. 194: 354-361. doi: 10.1016/j.foodchem.2015.07.151
18. Segger D, Aßmus U, Brock M, Erasmy J, Finkel P, Fitzner A, Heuss H, Kortemeier U, Munke S, Rheinländer T, Schmidt-Lewerkühne H (2008) Multicenter study on measurement of the natural pH of the skin surface. International Journal of Cosmetic Science. 30 (1): 75-75. doi: 10.1111/j.1468-2494.2007.00403_1.x
19. Ismail BP (2017) Ash content determination. Food Analysis Laboratory Manual. Springer International Publishing. doi: 10.1007/978-3-319-44127-6_11
20. Pearson D (1991) Fats and oil: composition and analysis of food. Ed. 9th, 480-497. Longman Scientific and Technical Publisher, Harlow. ISBN: 9780470216934,047021693X.
21. Alimentarius C (1999) Codex standard for fats and oils from vegetable sources. doi: Nil.
22. Oderinde RA, Ajayi IA, Adewuyi A (2009) Characterization of seed and seed oil of Hura crepitans and the kinetics of degradation of the oil during heating. Electronic Journal of Environmental, Agriculture and Food Chemistry. 8 (3): 201-208. doi: Nil.
23. Ejoh RA, Djomdi D, Ndjouenkeu R (2006) Characteristics of tiger nuts (*Cyperus esculentus*) tubers and their performance in the production of a milky drink. Journal of Food Process Preservations. 30: 145-163. doi: 10.1111/j.1745-4549.2006.00056.x
24. Dosumu MI, Ochu C (1995) Physicochemical properties and fatty acid composition of lipids extracted from some Nigeria fruits and seeds. Global Journal of Pure and Applied Science. 1: 45-47. doi: Nil.
25. Ashford RD (2011) Ashford's dictionary of industrial chemicals. 3rd ed., Wavelength. ISBN: 0952267438, 9780952267430.
26. Rossoff IS (1975) Handbook of veterinary drugs. A compendium for research and clinical use. Springer Publishing Co. ISBN-13: 978-0826115300.
27. O'Neil MJ (2013) The Merck index: An encyclopedia of chemicals, drugs, and biologicals. Journal of Medicinal Chemistry. 50 (3): 590. doi: 10.1021/jm068049o
28. Hawley GG (1977) Condensed chemical dictionary. 13th ed., Van Nostrand Reinhold Company Inc., New York. ISBN-13: 978-0442232405.
29. Kelly GS (1999) Squalene and its potential clinical uses. Alternative Medicine Review. 4 (1): 29-36. PMID: 9988781.
30. Wisthaler A, Weschler CJ (2010) Reactions of ozone with human skin lipids: sources of carbonyls, dicarbonyls, and hydroxycarbonyls in indoor air. Proceedings of the National Academy of Sciences of the United States of America. 107 (15): 6568-6575. doi: 10.1073/pnas. 0904498106

Authors' Contribution: OKO conceived and designed the study and COJ-A collected and performed data analysis and interpretation. COJ-A & DOA drafted and reviewed the manuscript. All authors contributed to the data analysis and approved the final version of the manuscript and agreed to be accountable for its contents.
Conflict of interest: The authors declare the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
Ethical issues: The authors completely observed ethical issues including plagiarism, informed consent, data fabrication or falsification, and double publication or submission.
Data availability statement: The raw data that support the findings of this article are available from the corresponding author upon reasonable request.
Author declarations: The authors confirm that they have followed all relevant ethical guidelines and obtained any necessary IRB and/or ethics committee approvals.