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**ORIGINAL RESEARCH PAPER**

# PHYSICAL AND CHEMICAL PROPERTIES OF TIGERNUT OIL AS INFLUENCED BY VARIETY AND METHOD OF EXTRACTION

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**Abstract**

This study was carried out to investigate the physical and chemical properties of tigernut oil as influenced by variety and methods of extraction. Oil was extracted from yellow and brown varieties of tigernut using mechanical screw press and N-hexane, and it was characterized for physical and chemical composition. The moisture content, acid value, free fatty acid, iodine value, saponification value and peroxide value for tigernut oil from extraction methods ranged from 2.97 to 3.30%, 0.28 to 0.56mgKOH/g, 0.55 to 1.12g/100g, 66.11 to 69.75gI/100g, 174.93 to 210.06mgKOHg and 0.27 to 0.56Mg$H_2O_2$, respectively. The range of values for specific gravity, percentage impurity, cloud point, smoke point and melting point are: 0.64 to 0.99g/ml, 0.15 to 0.24%, 9.00 to 25.5°C, 170.5 to 204.5°C and 18.0 to 28.5°C, respectively. However, the study showed that both the physical and chemical composition of tigernut oil were affected by the extraction methods used in this study.

**Keywords**: physical properties, chemical properties, tigernut oil, solvent assisted extraction, mechanical pressing

## Introduction

Tigernut (*Cyperus esculentus*), an emergent grass-like plant, which is a member of the sedge family known to be a universal perennial crop having matching genus as the papyrus plant that is usually seen in periodically overflowing marshlands (Oke *et al*., 2019). In Nigeria, three varieties of tigernut are cultivated (black, brown and yellow), namely Aya in Hausa, Ofio in Yoruba, and Akiausa in Igbo. However, only two of these cultivars are accessible in the market, i.e., the yellow and brown

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varieties. The milk produced by the yellow cultivar is more, has a reduced fat content and contains minimal antinutrients particularly some phenolic compounds (Okafor *et al*., 2003). Before now, tigernuts were known for their multifarious advantages health-wise in that, they contain high soluble glucose and oleic acid and also contain starch, fat, sugars and protein which are high in energy. Tigernuts are also copious in micronutrients that is, phosphorus, potassium, calcium and iron, which are germane for strong bones, tissue and muscle repair, blood stream and the general growth and development of the body. They are also plenteous in vitamin C and E (Adejuyitan, 2011). Tigernuts are obtainable in Nigeria markets in fresh, semi dried and dried forms and consumed by a large number of people, who are oblivious of its nutritional advantages and other products that could be developed from tigernuts. Other products resulting from tigernut include tigernut flour, tigernut oil and tigernut milk among many others (Bamishaiye and Bamishaiye, 2011). Tigernut can be ingested as either roasted, dried or baked snack. It can also be processed into healthy beverage. Tigernut milk, which is usually known as 'Kunnu Aya' in the Northern part of Nigeria, is a nutritionally fit beverage containing nutrients, such as vitamin C and E, minerals such as phosphorus, magnesium, potassium, calcium and iron (Belewu and Belewu, 2007; Oke *et al*., 2019; Bixquert-Jimenez, 2003; Oke *et al*., 2019). The tigernut flour is a gluten free product being a good alternative for wheat flour. It is considered a good supplement for the baking industry as it contains natural sugar which makes it suitable for diabetic patients as added sugars would be avoided (Anderson *et al*., 1994).

The oil from tigernut is of high quality, excerpted by a cold press so as to ascertain that it maintains the distinctive nutritional quality of the tigernut itself. The tigernut oil has a composition that is similar to olive oil and a rich mineral content, especially phosphorus and potassium; tiger nut oil is also cholesterol free and has very low sodium content. Tigernut oil has a golden colour and a nutty aroma. It is used in deep frying because of its resistant to chemical decomposition, when exposed to high temperature, and its low absorption in comparison to other frying oils (EL-Naggar, 2016). The tigernut oil contributes to the decrease of cholesterol, having also potential in reducing the risk of coronary heart diseases and atherosclerosis (EL-Naggar, 2016). The tigernut oil is much higher than soybean and corn oil in terms of oil yield (Bockisch, 1998; Adel *et al*., 2015), which can also replace these oils in periods of insufficiency (Jozef *et al*., 1988). However, tigernut oil is much higher in phytosterols. It has a relatively high oxidative stability as compared to other oils owing to its content of polyunsaturated fatty acids and oleic acid (Bamishaiye and Bamishaiye, 2011). The tigernut oil shares a similar fatty acid profile with olive, avocado and hazelnut oil. When compared to soybean oil, its phospholipids composition is higher (Bamishaiye and Bamishaiye, 2011).

Despite its similar physical and chemical properties, the utilization of tigernut oil in food companies is relatively low when juxtaposed with soyabean oil, olive oil or peanut oil (Ezeh *et al*., 2014). The tigernut oil has been reported to have increased oleic acid and reduced polyunsaturated fatty acid which is adequate for the daily minimum requirement for an adult. Also, it was found to have low acidity, making it excellent for skin care (Bamishaiye and Bamishaiye, 2011). It also has an elevated oxidative stability as compared to other oils as a result of the existence of gamma-tocoferol (El-Naggar, 2016). Several researchers, such as Sani (2015), reported the chemical properties of oil extracted from two varieties (brown and yellow) of *Cyperus esculentus*. Adel *et al*. (2015) also reported the chemical properties of brown variety of tigernut oil in Egypt, while Adejumo *et al*. (2018) also reported the chemical properties of brown variety of tigernut oil only. Thus, due to the rising awareness of tigernut oil nowadays, the present study aimed to investigate both the physical and chemical properties of yellow and brown variety of tigernut seed oil in order to provide useful information towards effective usage of these oils.

## Materials and methods

### *Materials*

Fresh raw tigernut tubers of yellow and brown varieties were purchased from Eleweran market, Abeokuta, Nigeria. The mechanical oil extracting machine was obtained from Isolu, Abeokuta, Ogun state, Nigeria. The Soxhlet extractor used was obtained from the Food Analytical and Chemistry Laboratory, Federal University of Agriculture, Abeokuta, Nigeria.

### *Sample Preparation*

Fresh tigernut (*Cyperus esculentus*) seeds were processed according to the method of Awulu *et al*. (2018). The seeds were dried by sun drying for several consecutive days and then stored in a high density polyethylene bags which were exposed to air and sunlight daily to prevent decay of tubers. Dry seeds were then stored in a covered plastic container for further use.

### *Extraction Methods*

The two extraction methods used in this study include solvent and mechanical pressing. As a result four oil samples were obtained (Table 1).

**Table 1**. Abbreviation of the samples used in the study.

| Obtained sample | Abbreviation |
|---|---|
| Yellow tigernut oil obtained by solvent extraction | YTS |
| Brown tigernut oil obtained by solvent extraction | BTS |
| Yellow tigernut oil obtained by mechanical extraction | YTM |
| Brown tigernut oil obtained by mechanical extraction | BTM |

*Chemical method of oil extraction from tigernut tubers*

The method described by Eze (2012) was used for chemical extraction of oil from tigernut tubers. The tubers were ground using mortar and pestle, then 100g of the powdered material was weighed and transferred into an extraction thimble (column). The extraction thimble was covered with cotton wool at the top and closed. N-hexane was poured into the extraction flask and the thimble was inserted in the extractor and all the extraction set-ups were connected. The extraction process was carried out at 50°C for one hour. After one hour the extraction set-up was disconnected and oil was recovered from the hexane and was dried using an oven at 70°C for 1hr and stored in bottle for further analysis

*Mechanical method of oil extraction from tigernut tubers*

A rotary oil mill was used for mechanical extraction of oil from tigernut tubers. The tigernut tubers sample was toasted (fried) at 150°C for 3 min using a gas cooker and was crushed using oil extracting machine and then tied in a cotton transparent cloth and was mounted on the mechanical press. Tigernut oil was extracted by continual pressing with a locally made hydraulic press. Pressure at 20-40MPa was exerted till the oil started dropping and also at the limitation of the strength of the cloth sieve materials used. The oil was subject to drying for an hour at 70°C and kept in bottle for further analysis.

***Chemical Properties***

*Moisture content determination*

Using the AOAC method 950.46B according to Association of official chemists' procedures (AOAC, 2005), the moisture content of the oil from tigernut was obtained. Five grams (5g) of tigernut oil was weighed into a dried moisture can and then subjected to oven heat at 105°C for an hour. The temperature of the dry sample was reduced in a desiccator which contained phosphorus peroxide and the weight was obtained. The process was replicated till the weight was constant.

*Determination of acid value*

The acid value was determined using the method described by Bereket and Alemayehu (2016). Oil samples (5g) were measured in a 250mL Erlenmeyer flasks and 30mLof newly neutralized ethyl alcohol (ethanol) was included in the samples and then properly jiggled shaken well to liquefy the sample. The dissolved sample was simmered for about five minutes and the temperature was reduced. 1mL of phenolphthalein indicator was added to the sample solution and treated with 1N sodium hydroxide solution until a constant light pink colour was seen.

*Assaying the free fatty acid value*

The free fatty acid (FFA) was carried out using the AOCS method Ca5a-40 as described by AOCS (1997). Into a 250ml conical flask containing 50ml of 95% neutralized ethanol was added 5g of oil sample. The temperature of the flask was raised to a boiling point on a hot plate and intensely shaken to release the free fatty acids present in the oil. The final solution temperature was lessened and titrated with 0.1N alcoholic KOH solution using phenolphthalein as indicator.

*Determination of iodine value*

The method described by the AOCS method cd 1-25 (1997) was used to determine the iodine value. Oil sample (0.2g) was weighed into a 500 ml flask and dissolved in 15 ml of $CCl_4$ and 25 ml of Wijs solution. A lid was placed on the flask, churned and kept in a dark place for 30 minutes. Thereafter, 20 ml of 10%KI solution and distilled water (150ml) was incorporated; 0.1N sodium thiosulphate solution was titrated with the mixture using 1.5ml starch indicator. A blank test was determined in the like manner but without oil.

*Determination of saponification value*

The saponification value of oil was determined to analyse the prospective industrial utilization for the oils as this variable is an indicator of the suitability of the oil to be used in soap making (Cuppett, 2001). Two grams (2g) of oil was liquefied in 25 ml of alcoholic potassium hydroxide solution. The mixture was boiled for 45 min and then cooled. Phenolphthalein indicator (1ml) was included and the sample solution was titrated using 0.5M HCl. A blank was determined as a test sample without oil.

*Determination of peroxide value*

The peroxide value was determined using the AOCS cd-8-53 as described by AOCS (1997). A quantity of the oil sample (5g) was measured into a 250ml Erlenmeyer glass with stopper containing a solution of 12ml of acetic acid-chloroform. The flask was meticulously warmed and stirred until the solution became homogenous. A volume of 0.5ml saturated potassium iodide (KI) solution was added using 1ml Mohr pipette. The stopper flask was then stirred for another minute, and 20ml of distilled water was added. The reaction mixture was intensely jiggled to release iodine from the chloroform layer. The resultant solution was carefully titrated with 0.1N sodium thiosulphate $Na_2S_2O_3$ till an amber colour was observed and 1ml of starch solution was used as indicator. Titration procedure progressed until a blue gray colour was no longer seen. A blank titration was done in parallel and the oil's peroxide value was determined.

***Physical Properties determination***

*Color determination*

Color measurement was performed by the method described by Feili *et al*. (2013), using a Minolta chromameter (CR-410, Japan) based on (CIE) L*a*b* scale. After calibrating the instrument by covering a zero calibration mask followed by white calibration plate. The samples were analyzed by pouring them inside a petri dish, and then the image was captured on the samples. The color attributes, such as lightness (L*), redness (a*) and yellowness (b*), were recorded.

*Determination of specific gravity by density bottle method*

According to Nagre *et al*. (2011), the specific gravity of oil was said to be a universal evaluation of the density of oil to water density. This is a fundamental indicator in the comparison and identification of oils. The specific gravity was obtained by employing the specific gravity bottle method. Equation 1 was used to evaluate the specific gravity of each oil.

$$Specific gravity = \frac{(weight of bottle + oil) - (weight of bottle)}{weight of water} \quad (1)$$

*Determination of percentage impurity in tigernut oil*

Each oil was evaluated for its level of impurities in the form of mesocarp fibers, insoluble materials, phosphatines, trace metals, and oxidation products, as an elevated level of these substances is outrightly forbidden under standard edible oils production (Watanapoon, 2004). In 500ml flask, two grams (2g) of oil was measured and 20 ml of a 1:1 solvent (petroleum ether and diethyl ether) was mixed with it. The content was intensely shaken, covered, and made to stand for 24 hours. The mixture was permeated using an 11 cm qualitative filter paper. The paper was then cleaned with 10 ml of the 1:1 solvent and kept in an oven at 103 ºC for one hour. The percentage impurity of each oil was evaluated using equation 2.

$$\%\ impurity = \frac{W2-W1}{W3} \qquad (2)$$

*Cloud point determination*

The method described by Awulu *et al*. (2018) was used to determine the cloud point of tigernut oil. Each of the oil samples was introduced to separate test tubes, with a thermometer inside and covered with a cork cover, then placed in the refrigerator so as to cool the oil samples. The test tubes were observed at specific intervals until they become cloudy. The temperature at which each oil sample became cloudy was recorded, respectively as the cloud point.

*Smoke point determination*

The smoke point was carried out using the method described by AOCS Cc 9a-48 of AOCS (2012) and Nancy *et al*. (2016) in the present study. A test portion of each oil was filled into a cup and heated until a continuous bluish smoke appeared.

***Statistical Analysis***

The data obtained were subject to statistical analysis. Means, Analysis of variance (ANOVA) were determined using SPSS Version 21.0 and the differences between the mean values were evaluated at $p \leq 0.05$ using Duncan's multiple range test.

## Results and discussion

***Chemical composition of obtained tigernut oil samples***

The chemical composition of tigernut oil is presented in Table 2. Significant differences ($p<0.05$) were observed in the moisture content of the obtained varieties of tigernut oil. The moisture content of the varieties of tigernut oil ranged from 2.54 to 4.43%. BTS oil sample had the highest moisture content while YTM oil sample had the lowest moisture content. In this respect, Sanni *et al*. (2006) reported that the lower the moisture content of a particular food product, the enhanced the shelf life of such product. This implies that the obtained tigernut oil samples will have good storage stability. Significant differences ($p<0.05$) were obtained also in the acid value of the obtained varieties of tigernut oil ranging from 0.28 to 0.56 mgKOH/g. The BTM oil sample had the highest acid value while BTS oil sample had the lowest acid value. The low acid values in BTS sample could mean that the triglycerides present in the oil were not hydrolyzed - an indication that the oil is less susceptible to lipase action. Also, based on the acid values obtained from BTS oil sample, it may be more suitable for consumption due to its lower acid value. The low acid value of oil obtained in this study shows that the oil can be stored for an elongated time interval and guard against rancidity and peroxidation. The 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 (Onwuka, 2005). The free fatty acid values of the obtained varieties of tigernut oil ranged from 0.55 to 1.12g/100g. The free fatty acid value reflects the amount of fatty acid hydrolyzed from triacylglycerols. Keefe *et al*. (2010) reported that the free fatty acid is the percentage by weight of a specific fatty acid. The BTM oil sample presented the highest free fatty acid value while BTS oil sample had the lowest free fatty acid value. This might be due to the nature of the tigernut tubers and of the used technology for tigernut oil extraction. The lowest free fatty acid value obtained in the BTS oil sample indicates that the BTS oil sample had the highest quality, being suitable for a long storage period without losing its flavour. The results obtained in this study for free fatty acid value of the four tigernut oil varieties were lower when compared to the values of 67.68 and 75.20g/100g for tigernut oil samples obtained by Sani (2015).

Significant differences ($p<0.05$) were observed in the iodine value, the saponification value and peroxide value for the four oil types were obtained. The iodine value is an evaluation of the level of unsaturation in the oil, and it is a uniqueness characteristic of native oil (Eze, 2012). The iodine values ranged from 66.11 to 66.75gl/100g. BTM oil sample had the highest iodine value while BTS oil sample registered the least iodine value. The high iodine value obtained in BTM oil sample implies the oil could easily be prone to oxidation, which also indicates high level of unsaturation which can cause rancidity (Awulu *et al*., 2018)From the result obtained in the present work it can be concluded that tigernut oil from different extraction methods (mechanical and soxhlet) had a fairly amount of unsaturated fatty acids which indicates that the oils are proper for consumption and also could be used as non-drying oils in soap manufacturing. The iodine values obtained in this study are comparable to the groundnut seed oil, pumpkin oil and African bean oil reported by Eze (2012). The saponification value of the obtained varieties of tigernut oil ranged from 174.93 to 210.06mgKOH/g. The BTM oil sample had the highest saponification value while BTS oil sample had the lowest saponification value. Saponification value is described as the quantity of alkali needed to neutralize a given quantity of fat and oil (Eze, 2012). According to Ezeagu *et al.* (1998) and Mohammed and Hamza (2008), a saponification value of 200 mg KOH/g implies high proportion of fatty acids of low molecular weight. The high saponification value observed in the brown and yellow varieties of tigernut oils by mechanical extraction method might be due to high proportion of lower fatty acid in the oil (Muhammad *et al*., 2011). This implies brown and yellow varieties of tigernut oils by mechanical extraction contains high amount of long chain fatty acid. Thus, the high saponification value found in the brown and yellow varieties of tigernut oils obtained by mechanical extraction could be suitable for soap production and vegetable oil based ice creams. The saponification values obtained in this study were within the range of some other reports such as maize oil (189mgKOH/g) and sunflower (190mgKOH/g), as reported by Sani (2015).

The peroxide values of the obtained varieties of tigernut oils ranged from 0.27 to 0.56mg $H_2O_2$. The BTM oil sample had the highest peroxide value while the BTS oil sample had the lowest peroxide value. The peroxide value is used as a measure of the degree to which rancidity reactions can take place during storage (Eze, 2012; Sabbir *et al*., 2016). The higher the peroxide values of oil, the lower its storage ability (Sani, 2015). This implies that the oil obtained in BTM oil sample will have better storage ability. The low values of peroxide value obtained in this study suggest strong presence or high levels of antioxidant and may not easily be susceptible to deterioration (Eze, 2012; Rabia *et al*., 2014). Keefe *et al*. (2010) also reported that oil with low peroxide value is less prone to oxidation.

**Table 2.** Chemical Properties of Tigernut Oil Samples as Influenced by Botanical Variety Extraction Method.

| | YTS | BTS | YTM | BTM |
|---|---|---|---|---|
| MC (%) | 3.30±0.02[c] | 4.43±0.01[d] | 2.54±0.01[a] | 2.97±0.04[b] |
| AV (mgKOH/g) | 0.28±0.00[b] | 0.28±0.00[a] | 0.53±0.00[c] | 0.56±0.00[d] |
| FFA (g/100g) | 0.56±0.00[b] | 0.55±0.00[a] | 1.05±0.00[c] | 1.12±0.00[d] |
| Iodine Value (gI/100g) | 66.21±0.02[b] | 66.11±0.01[a] | 69.47±0.01[c] | 69.75±0.04[d] |
| SV (mgKOHg) | 180.42±0.03[b] | 174.93±0.04[a] | 206.13±0.04[c] | 210.06±0.01[d] |
| Peroxide Value ($mgH_2O_2$) | 0.29±0.00[b] | 0.27±0.00[a] | 0.51±0.00[c] | 0.56±0.00[d] |

Mean values with different superscripts within the same row are significantly different ($p<0.05$); MC- Moisture content, AV – Acid value, FFA- Free fatty acid, SV - Saponification value, YTS- Yellow tigernut oil obtained by solvent extraction, BTS-Brown tigernut oil obtained by solvent extraction, YTM-Yellow tigernut oil obtained by mechanical extraction, BTM-Brown tigernut oil obtained by mechanical extraction.

### *Physical properties of obtained tigernut oil samples*

The physical properties of tigernut oil varieties are presented in Table 3. Significant differences ($p<0.05$) were found for all parameters analyzed. The specific gravity of the tigernut oil samples ranged from 0.64 to 0.99g/ml. The BTS oil sample had the highest specific gravity while BTM oil sample registered the lowest values. The specific gravity of tigernut oil varieties obtained in this study are low, this implies that the oils are of good quality which could be used for commercial purpose (Adejumo and Salihu, 2018). Thus, higher specific gravity of oil could lead to hydrolytic and oxidative rancidity, which are indications of low-quality oils (Ukom *et al*., 2018). Specific gravity refers to the ratio of the oil density to the density of water, which helps in the determination of the oil characteristics compared to a standard, usually water at a specific temperature (Nagre *et al*., 2011). The specific gravity obtained in this study is very close to the range of 0.87 to 0.91g/ml reported by Ukom *et al*. (2018) for selected branded vegetable oils. The impurity percentages of the obtained tigernut oil samples ranged from 0.15 to 0.24%. The YTM oil sample had the highest percentage impurity while the YTS oil sample had the lowest values. The impurity percentage is an indication of the level of impurity in the oils (Nagre *et al*., 2011). The result obtained in this study shows that oil impurity percentage were higher than maximum limits of 0.05% stated by Codex Alimentarius Commission (CAC, 2009). This implies that high level of impurity percentages of varieties of tigernut oil obtained in this might cause oxidation and rancidity; thereby reducing the quality of the oil (Kamoul *et al*., 2019). The cloud point of the tigernut oil samples ranged from 9.0 to 25.5°C. BTS oil sample had the highest value of cloud point while the BTM oil sample had the lowest value. The cloud point is the temperature at which the oil phase separate and two phases appear, thus becoming cloudy, when chilled to a low temperature (Awulu *et al*., 2018). The high cloud point obtained in the BTS might be due to high content of saturated fatty acids in the oil sample (Sarin *et al*., 2009; Roiaini *et al*., 2015).

The smoke point of the tigernut oils ranged from 170.5 to 204.5°C. The BTM oil sample had the highest smoke point while the YTS oil sample had the lowest smoke point. The smoke point serves as an indicator of the capacity of the oil to withstand heat (Nagre *et al*., 2011). Oil with low smoking points is suited for lower temperatures. The smoke point values obtained in this study were in agreement with the maximum standard of 200°C for frying temperature as reported by SON (2000) and Ukom *et al*. (2018). This implies that tigernut oil extracted with both methods are suitable and healthy nourishment due to their high smoke point (Awulu *et al*., 2018) and can also resist ignition during frying operations of thermal stability (Nwabueze *et al*., 2008). The melting point of the tigernut oils ranged from 18.0 to 28.5°C. The BTM oil sample had the highest melting point while the BTS oil sample had the lowest melting point. The melting point of extracted oil observed in this study was within the range of 27-50°C as reported by SON (2000) and Ukom *et al*. (2018). This implies that the extracted oil samples can be kept liquid at room temperature.

**Table 3**. Physical composition of tigernut oil samples as influenced by botanical variety extraction method.

| Samples | Specific Gravity(g/ml) | Percentage Impurity (%) | Cloud Point(°C) | Smoke Point(°C) | Melting Point(°C) |
|---|---|---|---|---|---|
| YTS | 0.94±0.00$^{c}$ | 0.15±0.01$^{a}$ | 24.0±0.00$^{c}$ | 170.5±0.71$^{a}$ | 18.0±0.00$^{a}$ |
| BTS | 0.99±0.00$^{d}$ | 0.16±0.00$^{b}$ | 25.5±0.71$^{d}$ | 175.0±0.00$^{b}$ | 20.0±0.00$^{b}$ |
| YTM | 0.88±0.00$^{b}$ | 0.24±0.00$^{d}$ | 10.5±0.71$^{b}$ | 200.5±0.71$^{c}$ | 25.5±0.71$^{c}$ |
| BTM | 0.64±0.00$^{a}$ | 0.22±0.01$^{c}$ | 9.00±0.00$^{a}$ | 204.5±0.71$^{d}$ | 28.5±0.71$^{d}$ |

Mean values with different superscripts within the same column are significantly different ($p<0.05$); YTS- Yellow tigernut oil obtained by solvent extraction, BTS-Brown tigernut oil obtained by solvent extraction, YTM-Yellow tigernut oil obtained by mechanical extraction, BTM-Brown tigernut oil obtained by mechanical extraction.

### *Color attributes of obtained tigernut oil samples*

The color attributes of tigernut oil samples obtained in the present study are shown in Table 4. The color characteristics analyzed refers to lightness (L*), redness (a*), and yellowness (b*). Significant differences ($p<0.05$) were obtained for all three color parameters- lightness (L*), redness (a*) and yellowness (b*) in the case of all tigernut oil samples. For instance, the lightness ranged from 28.96 to 62.84. The BTS oil sample had the highest value of lightness while YTM oil sample had the lowest value of extraction. The high value of lightness makes the BTS more attractive than the other varieties of oils from this study. The redness ranged from -3.08 to 7.77; the YTM oil sample had the highest value of redness while the BTS oil sample had the lowest value of redness. The yellowness ranged from 4.72 to 23.82; the BTS oil sample had the highest value of yellowness while the YTS oil sample had the lowest value of yellowness. The BTS oil sample had the highest value of lightness and yellowness; this might be as a result of the brown colour of tigernut that was removed during the bleaching process, which makes it more attractive than other samples. This makes the oil suitable for salad making and shortenings (Muhammad *et al*., 2011; Katkade *et al*., 2018).

**Table 4**. Color attributes of tigernut oil samples as influenced by botanical variety extraction method.

| Samples | L* | a* | b* |
|---|---|---|---|
| YTS | 29.12±1.21[a] | 6.02±0.33[c] | 4.72±0.23[a] |
| BTS | 62.84±0.69[c] | -3.08±0.08[a] | 23.82±0.11[d] |
| YTM | 28.96±0.03[a] | 7.77±0.01[d] | 9.35±0.13[c] |
| BTM | 34.49±0.11[b] | 4.84±0.04[b] | 8.79±0.01[b] |

Mean values with different superscripts within the same column are significantly different ($p<0.05$); L*: Lightness, a*: Redness, b*: Yellowness, YTS- Yellow tigernut oil obtained by solvent extraction, BTS-Brown tigernut oil obtained by solvent extraction, YTM-Yellow tigernut oil obtained by mechanical extraction, BTM-Brown tigernut oil obtained by mechanical extraction

## Conclusions

This study showed that extraction of the tigernut oil by mechanical and chemical methods was significantly affected the physical and chemical composition of the yellow and brown varieties of tigernut. The colour attributes of the tigernut oil (lightness, yellowness and redness) were also significantly affected by the mechanical and chemical methods of extraction. However, the brown variety oil obtained by solvent extraction gave better physical and chemical properties in comparison to the other samples. Further studies should also be carried out on the storage effect of the yellow and brown variety of tigernut seed oil extracted from mechanical and chemical methods.

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