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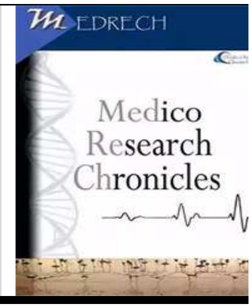


# THE INFLUENCE OF PROCESSING CONDITIONS ON PROXIMATE, MINERAL AND PHYTOCHEMICAL PROPERTIES OF TIGER NUT (Cyperus esculentus) FLOUR

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## ABSTRACT

**ORIGINAL RESEARCH ARTICLE**

Processing of agricultural produce is carried out to improve its nutritional value and consumer acceptability. Different processing operations are used to process cereals and legumes and these include fermentation, germination and roasting. These techniques are important in improving the nutritive values, palatability, digestibility and shelf life. Data on the influence of these processing conditions on nutrients and anti-nutrients of tiger-nut are scanty. The influence of these processing techniques on proximate composition, mineral and anti-nutritional contents of tiger nuts were determined using standard procedures. Fermentation germination and roasting caused significant ($p \leq 0.05$) increases in protein from 2.69% to 18.65%, sodium from 6 to 12 mg/100g, potassium from 402 to 517 mg/100g, calcium from 6 to 16 mg/100g and iron from 5 to 12 mg/100g and a significant ($p \leq 0.05$) decrease in ash contents. There were also significant decreases in tannin from 0.76 to 0.22 mg/g, phytate from 0.46 t0 0.15 mg/g, saponin from 2.04 to 1.18 mg/g and alkaloids from 1.93 to 1.29 mg/g in fermentation, 1.74mg/g in germination and 1.77 mg/g in roasting, but there occur marginal increases in alkaloids and saponin in freshly germinated and dry roasted samples. Increases or decreases were not observed in magnesium and zinc contents in any of the processing techniques.

# I INTRODUCTION

Tiger nut (Cyperus esculentus) is an edible perennial grass-like plant native to the Old World and is a lesser-known vegetable that produces sweet nut-like tubers known as "earth almonds".[1] The cultivation and utilization of tiger nut tubers is a practice known to have started with the Egyptians at about 5000 BC.[2,3] The tubers are believed to have been a source of food for those Paleo-Indians[4] It was an important food in ancient Egypt.[5] In those times in Egypt, Cyperus esculentus tubers were roasted and eaten as a sweetmeat. Nowadays, tiger nuts are also being cultivated in Northern Nigeria, Ghana, Togo, Niger, Mali, and Senegal where they are utilized mainly as an uncooked side dish. [6] Three varieties of tiger nut tubers exist namely yellow, brown and black varieties. The black variety is not common in Nigeria but the tubers are mainly available in Ghana[7] (Asante *et al*, 2014). The other two varieties of tiger nut tubers are commonly sold in local markets across many states in Nigeria. Generally, the yellow variety tiger nut tuber is preferable to the brown variety tiger nut tuber.[8] Tiger nut is not a real nut; despite its name, tiger nut is a tuber. But its chemical composition shares characteristics with both tubers and nuts. The main components of tiger nut are carbohydrates. The oil content is between 22.80 and 32.80%.[9,10,11,12, 1] The carbohydrate present in tiger nuts are composed mainly of starch and dietary fiber. Tiger nut tubers contain almost twice the quantity of starch as potato or sweet potato tubers.[1] However, comparing tiger nuts to real nuts, it will be observed that its fiber content is within the usual range for nuts.[13] Chukwuma *et al.*[14] have investigated the presence and phytochemical composition of the raw and roasted tiger nut tuber. The results of their experiments showed that a higher content of alkaloids, sterols, and resins than cyanogenic glycosides, saponins, and tannins were detected in raw tiger nut tubers. In the roasted tuber, only alkaloids, sterols, and resins were detected. Tiger nut can be eaten raw, roasted, fried, baked, or made into refreshing beverages or tiger nut milk.[15] Germination is a natural process that takes place during the growth period of cereals, legumes, seeds, and nuts. During the periods of germination reserves materials are degraded, commonly utilized for respiration and synthesis of new cells before developing an embryo.[16] Several studies on the effect of germination on legumes found that it increased protein content, dietary fiber, reduce tannin and phytate and increase mineral bioavailability.[17] Germination was also reported to influence an increase in vitamin concentration and bio-availability of trace elements and minerals.[18] Kaushik *et al.*[19] observed that germination improved calcium, copper, manganese, zinc, riboflavin, niacin, and ascorbic acid contents. Fermentation is a processing method used for plant produce to increase the nutritional quality and remove undesirable compounds. Fermentation involving lactic acid bacteria offers potentials for widespread application, particularly concerning the provision of safe, low-cost complementary foods for developing countries.[20] Fermentation most often leads to an improvement in the nutritional value of foods through the bio-enrichment with microbial protein, amino acids, lipids and vitamins.[21] Roasting is the application of dry heat to food produce. It is important in flavor development and for moisture reduction. Roasted tiger nut have been reported to have a characteristic flavor and aroma, as well as reduced moisture content[22] in nicotinic acid content of coffee beans in addition to the formation of furaldehyde.[23] Studies on proximate composition, amino acid composition, anti-nutrient and mineral content of tiger nut tubers have been reported extensively by researchers.[15] These parameters are influenced by the tiger nut variety, planting site, planting period as well as the method adopted in processing the tubers.[24,7] The chemical composition and functional properties of flours produced from two varieties (yellow and brown) of tiger nut have been studied.[25] Therefore, the objective of the study was to subject the yellow variety tiger nut to different processing conditions of germination, fermentation and roasting and determine their effects on proximate, mineral and anti-nutrient contents.

## II MATERIALS AND METHODS

### Materials

Yellow variety tiger nuts were purchased from a local merchant at Ojo market in Ibadan.

### Methods

**Germination and production of tiger nut flour.**

A modified method of Ade-Omowaye *et al.*[21] was used for germination of tiger nut tubers. The tubers (1 kg) were manually sorted, cleaned, and soaked in 3 L of water at room temperature (30±2$^0$C) for 16 hr. The nuts were then washed and kept in a clean container, covered with a piece of cheesecloth to allow passage of oxygen for the germinating tubers. The tubers were then allowed to germinate for 72 hr. at 37$^0$C with frequent watering. The sprouts were then rinsed with tap water and dried in a cabinet drier at 75$^0$C for 8 hrs. The dried germinated tubers were milled in an attrition mill through a 210µm sieve to obtain a fine powder. The flour was packaged in high-density polyethylene and placed in a covered plastic bucket and kept in a deep freezer (-10$^0$C) until required for further use.

**Roasting and production of tiger nut flour**

A modified method of Oladunmoye *et al.*[22] was used in the production of roasted tiger nut flour. The tiger nut tubers (1 kg) were sorted, cleaned, and washed. The tubers were dried at 75$^0$C for 8 hrs and the pan was roasted on a controlled gas stove, the non-luminous flame for 30 min. The roasted tubers were allowed to cool and then milled in an attrition mill. The flour was packaged in high-density polyethylene and placed in a covered plastic bucket and kept in a deep freezer (-10$^0$C) until required for further use.

**Production of fermented tiger nut flour**

A modified method of Adejuyitan *et al.*[26] was utilized in the production of fermented tiger nut flour. The tiger nut tubers were sorted, cleaned, washed, and soaked in water, and left to undergo natural fermentation for 48 hrs. The fermented tubers were drained and dried in a cabinet drier at 75$^0$C for 8 hrs. The dried tubers were milled in an attrition mill. The flour was packaged in high-density polyethylene and placed in a covered plastic bucket and kept in a deep freezer (-10$^0$C) until required for further use.

**Determination of proximate composition**

Moisture, protein, crude fat, crude fiber, and ash contents of all samples were determined using standard methods as described by AOAC[27] while the carbohydrate contents were estimated by difference.

**Determination of mineral contents.**

The ash obtained after the determination of ash content was first dissolved in 5 ml concentrated HCl (11.8M) and filtered into a 50 ml volumetric flask (modification of AOAC.[28] The concentrations of the minerals, Ca, Fe, Mg, and Zn in the samples were measured by atomic absorption spectrophotometer (Pye-Unicam, England). The amounts of K and Na in the samples were determined using Flame Photometry. At the end of the analysis, the output obtained was employed to determine the concentrations of the analytes in the actual samples using a standard calibration curve plotted for each mineral. The preparation of standards was based on AOAC.[28] The equations of the lines obtained from the graphs by interpolation and extrapolation were used to determine the concentrations of each of the analytes in the sample.

**Determination of anti-nutrient contents**

The anti-nutrients that were determined are Phytate, Tannin, Alkaloids, and Saponin.

Phytate was extracted from the flours by the method described in Harland and Oberleas.[29] The phytate content was estimated using the spectrophotometric analysis, with an absorbance (A) and wavelength at 640 nm.[28] The method described by Swain[30] was used to determine the tannin content. The alkaloids contents were measured using the alkaline precipitation gravimetric method as described by Harborne.[31] Saponin contents were determined as described by Obadoni and Ochuko.[32]

**Effect of processing conditions on proximate composition**

The results of the proximate composition obtained for different processing conditions on tiger nut flour are presented in Table 1. The ash contents ranged from 0.80±0.27 to 2.03±0.58%, fat from 17.27±1.85%, protein from 2.69±0.95 to 18.65±2.28%, moisture from 2.30±0.20 to 6.37±0.15%, fiber from3.90±0.61 to 40.98±4.07% and carbohydrate from 29.98±7.47 to 53.08±1.46%.

## III RESULTS

**Table 1.** Effect of processing conditions on proximate composition of tiger nut flour (%)

| Sample | Ash | Fat | Protein | Moisture | Fiber | Carbohydrate |
|---|---|---|---|---|---|---|
| FRT | 1.30±0.17$^{c}$ | 23.30±0.96$^{a}$ | 6.66±1.24$^{d}$ | 4.00±0.10$^{c}$ | 17.37±0.86$^{d}$ | 47.58±0.79$^{ab}$ |
| FFT | 2.00±0.00$^{a}$ | 20.80±2.08$^{ab}$ | 18.65±2.28$^{a}$ | 5.03±0.58$^{b}$ | 20.06±0.50$^{d}$ | 46.37±1.60$^{b}$ |
| DGT | 1.30±0.27$^{c}$ | 18.27±1.46$^{bc}$ | 15.55±0.57$^{b}$ | 2.87±0.31$^{d}$ | 35.37±0.55$^{b}$ | 29.98±7.47$^{c}$ |
| DFT | 0.80±0.27$^{d}$ | 20.80±1.13$^{ab}$ | 15.05±0.45$^{b}$ | 6.37±0.15$^{a}$ | 3.90±0.61$^{e}$ | 53.08±1.46$^{a}$ |
| DUT | 1.50±0.00$^{bc}$ | 19.97±1.45$^{c}$ | 5.93±0.41$^{c}$ | 2.53±0.58$^{e}$ | 28.06±2.68$^{c}$ | 31.28±1.85$^{c}$ |
| DRT | 1.93±0.12$^{a}$ | 17.27±1.85$^{c}$ | 8.23±1.65$^{d}$ | 5.07±0.58$^{b}$ | 19.60±0.99$^{d}$ | 47.91±2.22$^{b}$ |
| FUT | 2.03±0.58$^{a}$ | 21.07±1.05$^{a}$ | 2.69±0.95$^{e}$ | 2.30±0.20$^{e}$ | 40.98±4.07$^{a}$ | 30.93±4.69$^{c}$ |
| FGT | 1.80±0.27$^{ab}$ | 20.60±1.13$^{ab}$ | 11.12±1.34$^{c}$ | 5.03±0.06$^{b}$ | 19.59±1.12$^{d}$ | 41.87±2.13$^{b}$ |

Means with the same superscript along the same column are not significantly different from each other at p≤0.05. FRT = Fresh Roasted Tiger nut flour, FFT = Fresh Fermented Tiger nut flour, DGT = Dried Germinated Tiger nut flour, DFT = Dried Fermented Tiger nut flour, DUT = Dried Untreated Tiger nut flour, DRT = Dried Roasted Tiger nut flour, FUT = Fresh Untreated Tiger nut flour, FGT = Fresh Germinated Tiger nut flour.

**Effect of processing conditions on mineral composition:** The results of mineral content for fresh and processed tiger nut flours are presented in Table 2.

**Table 2.** Effect of processing conditions on mineral content of tiger nut flours (mg/ 100g).

| Sample | Potassium | Magnesium | Calcium | Zinc | Iron | Sodium |
|---|---|---|---|---|---|---|
| FRT | 475.00±0.06$^{b}$ | 9.00±0.00 | 7.00±0.01$^{cd}$ | 2.00±0.00 | 8.00±0.00$^{b}$ | 8.00±0.06$^{bc}$ |
| FFT | 503.00±0.03$^{a}$ | 9.00±0.00 | 11.00±0.00$^{b}$ | 2.00±0.00 | 4.00±0.00$^{e}$ | 12.00±0.00$^{ab}$ |
| DGT | 460.00±0.16$^{b}$ | 9.00±0.00 | 5.00±0.01$^{f}$ | 2.00±0.00 | 7.00±0.01$^{c}$ | 10.00±0.00$^{abc}$ |
| DFT | 517.00±0.14$^{a}$ | 9.00±0.00 | 11.00±0.01$^{b}$ | 2.00±0.00 | 7.00±0.01$^{c}$ | 9.00±0.00$^{abc}$ |
| DUT | 402.00±0.06$^{c}$ | 9.00±0.00 | 7.00±0.01$^{cd}$ | 2.00±0.00 | 7.00±0.00$^{c}$ | 6.00±0.00$^{c}$ |
| DRT | 521.00±0.85$^{c}$ | 9.00±0.00 | 16.00±0.01$^{a}$ | 2.00±0.00 | 12.00±0.01$^{a}$ | 10.00±0.00$^{abc}$ |
| FUT | 416.00±0.20$^{c}$ | 9.00±0.00 | 6.00±0.01$^{f}$ | 2.00±0.00 | 5.00±0.00$^{d}$ | 12.00±0.00$^{ab}$ |
| FGT | 456.00±0.90$^{b}$ | 9.00±0.00 | 8.00±0.02$^{c}$ | 2.00±0.00 | 5.00±0.00$^{d}$ | 13.00±0.00$^{a}$ |

Means with the same superscript along the same column are not significantly different from each other at p≤0.05

FRT = Fresh Roasted Tiger nut flour, FFT = Fresh Fermented Tiger nut flour, DGT = Dried Germinated Tiger nut flour, DFT = Dried Fermented Tiger nut flour, DUT = Dried Untreated Tiger nut flour, DRT = Dried Roasted Tiger nut flour, FUT = Fresh Untreated Tiger nut flour, FGT = Fresh Germinated Tiger nut flour

**Effect of processing conditions on phytochemical composition**

The phytochemical content of fresh and pre-treated tiger nut flours is presented in Table 3.

**Table 3.** Effect of processing conditions on phytochemical composition (mg/g)

| Sample | Tannin | Phytate | Saponin | Alkaloids |
|---|---|---|---|---|
| FRT | 0.38±0.13$^{bc}$ | 0.37±0.08$^{abc}$ | 1.18±0.04$^{e}$ | 1.77±0.00$^{f}$ |
| FFT | 0.75±0.10$^{a}$ | 0.31±0.89$^{bc}$ | 1.14±0.11$^{e}$ | 1.29±0.23$^{e}$ |
| DGT | 0.61±0.08$^{a}$ | 0.31±0.04$^{bc}$ | 1.16±0.01$^{e}$ | 1.74±0.10$^{d}$ |
| DFT | 0.76±0.10$^{a}$ | 0.30±0.07$^{c}$ | 1.50±0.04$^{d}$ | 1.96±0.15$^{d}$ |
| DUT | 0.73±0.09$^{a}$ | 0.29±0.06$^{c}$ | 0.40±0.04$^{f}$ | 1.41±0.20$^{e}$ |
| DRT | 0.22±0.06$^{c}$ | 0.43±0.07$^{ab}$ | 2.23±0.23$^{b}$ | 2.24±0.11$^{c}$ |
| FUT | 0.76±0.11$^{a}$ | 0.46±0.05$^{a}$ | 2.04±0.10$^{c}$ | 1.93±0.35$^{b}$ |
| FGT | 0.58±0.22$^{ab}$ | 0.15±0.03$^{a}$ | 3.40±0.04$^{a}$ | 2.47±0.20$^{a}$ |

Means with the same superscript along same column are not significantly different from each other at $p \leq 0.05$

FRT = Fresh Roasted Tiger nut flour, FFT = Fresh Fermented Tiger nut flour, DGT = Dried Germinated Tiger nut flour, DFT = Dried Fermented Tiger nut flour, DUT = Dried Untreated Tiger nut flour, DRT = Dried Roasted Tiger nut flour, FUT = Fresh Untreated Tiger nut flour FGT = Fresh Germinated Tiger nut flour

## IV DISCUSSION

For the proximate composition, the ash contents for fresh untreated tiger nut flour, fresh fermented tiger nut flour and dried roasted tiger nut flour had the highest values respectively. Significant differences ($p \leq 0.05$) do not exist among all the values. The dried fermented flour sample had the lowest value. The reduction in the ash content in this flour sample could have occurred as a result of the usage of minerals by inherent microorganisms for metabolic activities. The ash content is an index of the mineral elements present in the flour. A range 0f 1.79 – 2.68% was reported for dried untreated tiger nut.[33]

The fat contents ranged from 17.27% to 23.30% with the fresh-roasted (FRT) and dried roasted (DRT) having the highest and lowest values respectively. There were no significant differences ($p \leq 0.05$) among samples FRT, FFT, DFT, FUT, and FGT. But these were significantly higher than samples DUT and DRT. The fermented (fresh and dried) tiger nut had values of fat content that are lower than the values 32.13 – 35.40% reported for two varieties of fermented tiger nut flours.[25] The values obtained in this study are within the range of 8.94 – 35.43% reported by Nwaoguikpe[33] for three varieties of tiger nut flours. Germinated tiger nut flours exhibited a significant difference between the dried and fresh samples having 18.27% and 20.60% fat respectively. These values are lower than 22.53% reported by Okoye and Ene[34] for germinated tiger nut flour.

There was a general increase in protein contents for all samples. The crude protein content of the samples increased significantly ($p \leq 0.05$) through fermentation than germination. The increase in protein contents observed in the fermented tiger nut flours could be attributed to a decrease in carbohydrate that serves as a potential source of energy for fermentative microorganisms during fermentation. The values of protein obtained in this study are far higher than the 7.73%, 8.40% and 9.23% reported by Adejuyitan *et al.*[26] The fresh tiger nut flour had the lowest protein content. There was no significant difference between the fresh roasted, fresh fermented and dried roasted tiger nut flours in terms of protein content. The effect of fermentation on proteins has yielded inconsistent results probably as a result of different experimental designs, durations of study and differences in the initial protein contents of foods.[35] Many authors have reported increases[36,37,38] while others have reported decreases in protein as a result of fermentation.[39,38] Most of these effects may not reflect actual changes but rather relative changes due to loss of dry matter as a result of microorganisms hydrolyzing and metabolizing carbohydrates and fats as a source of energy.[35]

The moisture contents for fresh untreated and dried untreated tiger nut flours increased significantly in processing tiger nut flours. Oladele and Aina[25] reported values of 3.50% and 3.78% for untreated tiger nut flour from yellow and brown varieties respectively.

The crude fiber content of fresh untreated tiger nut flour was highest while that for germinated, fermented, roasted and dried tiger nut flours were lowest. The value for crude fiber was lowest in dried fermented and high in dried germinated samples. The decrease in crude fiber content of fermented tiger nut flour may be due to the enzymatic breakdown of fiber components by lactic acid bacteria for their nutrition during fermentation. The expected decrease in fiber content during fermentation could also be attributed to the partial solubilization of cellulose and hemicellulosic type of material by microbial enzymes.[40] A similar study reported a significant decrease of fat, ash, and fiber contents after four days of maize fermentation.[41]

Generally, the processed tiger nut flours had higher carbohydrate contents than the unprocessed tiger nut flours. There were significant differences ($p \leq 0.05$) between the treated and untreated tiger nut flours though the dried germinated flour had the lowest value.

**Effect of processing conditions on mineral composition**

The potassium contents increased significantly ($p \leq 0.05$) from 405 mg/ 100g of fresh germinated tiger nut flour to 520 mg/ 100g of dried roasted tiger nut flour. The values of potassium obtained in this study are lower than the range 556 – 845 mg/ 100g reported for flours of three types of tiger nuts.[42] Oladele and Aina[25] reported lower values of 216mg/ 100g and 255 mg/ 100g for unprocessed tiger nut flours for the yellow and brown varieties respectively. The increase in potassium contents of the fermented tiger flour could be as a result of the synthesis of the mineral element by fermentative microbial flora during fermentation.

Although the calcium contents increased in some of the treated tiger nuts flours significant differences do not exist between the dried and freshly fermented tiger nut flours. The dried roasted sample had the highest calcium content. The increase in calcium contents of the fermented flour could be said to be due to the increased activities by fermentative microorganisms involved in the fermentation.[43] The increase in mineral content might be due to the loss of dry matter during fermentation as microbes degrade carbohydrates and protein.[44] Oladele and Aina[25] reported values of 155 and 140mg/ 100g for the untreated yellow and brown varieties respectively while Bado *et al.*[42] reported a range 19.09 – 32.27 mg/ 100g.

There were no significant differences ($p \leq 0.05$) between all samples in terms of magnesium and zinc contents for both treated and untreated samples. Bado *et al.*[42] reported the ranges of 100.50 – 107.30 mg/ 100g and 1.88 – 2.70mg/ 100g for magnesium and zinc respectively for untreated tiger nut flours.

The iron content of fresh fermented tiger nut flour was lowest while dried roasted (DRT) tiger nut had the highest value which was significantly higher than all other samples followed by fresh roasted (FRT). Samples FUT (Fresh untreated) and FGT (Fresh Germinated) are not significantly different from each other but significantly higher than samples DGT (Dried Germinated), DFT (Dried Fermented) and DUT (Dried Untreated). The values obtained in this study are far higher than the values reported by Oladele and Aina[25] who reported values of 0.65mg/ 100g and 0.80mg/ 100g respectively for yellow untreated and brown untreated varieties. Also the values obtained in this study are within the range 3.57 – 11.44 mg/ 100g reported by Bado *et al.*[42] Chukwu *et al.*[45] reported higher values of 158.49mg/ 100g for dried tiger nut flour.

The sodium content of the fresh germinated (FGT) sample was the highest while dried untreated (DUT) was the lowest. There were no significant differences between sample FFT, FUT, FGT, DGT and DRT. Minerals from plant sources have very low bioavailability since they normally form complexes with non-digestible compounds like cell wall polysaccharides[46] as well as phytate. Potassium is an integral part of phytate molecules where it is covalently bonded thereby making it unavailable for use by digestive enzymes. These complexes in which these minerals are chelated and bonded are majorly responsible for their low bioavailability. Fermentation is one of the food processing methods that are used to dissolve these chelated or complexes and make minerals bioavailable.[47,38] According to Pranoto *et al.*[38] fermentation increases the magnesium, iron, calcium, and zinc content in some fermented foods that are associated with the decrease in the amount of phytates Fermentation also increases the bioavailability of calcium, phosphorous, and iron likely due to the degradation of oxalates and phytates that chelates the minerals thereby reducing their bioavailability.[48] There are different mechanisms by which fermentation increases mineral bioavailability. Firstly, fermentation reduces phytic acid that binds minerals making them free and more available.[47] But this effect is counteracted by release of tannins during fermentation especially in high-tannin cereals such as sorghum.[39,48]

**Effect of processing conditions on phytochemical composition**

The tannin content was highest in the dried fermented (DFT) and fresh untreated (FUT) tiger nut flours, while the dried roasted (DRT) tiger nut flour had the lowest value. There were no significant differences among samples FFT (Fresh Fermented), DGT (Dried Germinated), DFT (Dried Fermented), DUT (Dried Untreated), FUT (Fresh Untreated) and FGT (Fresh Germinated) in terms of tannin contents. The increase in tannin during fermentation was attributed to the hydrolysis of condensed tannins such as proanthocyanidin to phenols.[49,48] Tannins bind minerals and reduce their bioavailability[49] depending on the duration of fermentation. Prolonged fermentation decreases the tannin contents as a result of the enzyme phenyl oxidase activity.[49] The transformation of tannins to phenols which takes place during fermentation increases the phenol content that interacts with minerals leading to the hindrance of mineral bioavailability.48]

The fresh untreated (FUT) tiger nut flour had the highest value for phytate while the fresh germinated (FGT) tiger nut flour had the lowest value. The phytate values of Fresh untreated (FUT) and dried roasted (DRT) tiger nut flour are not significantly different ($p \leq 0.05$) from one another but are significantly higher than all other samples. The decrease in phytate content of the fermented samples may be due to increased microbial activities during fermentation. A wide range of microflora have been known to possess phytate activity, that may be partly responsible for the reduction in the phytate content of the fermented samples.[50] The fresh roasted (FRT), fresh fermented (FFT), and dried germinated (DGT) tiger nut flours had similar values of saponin contents. The fresh germinated (FGT) sample had the highest saponin value. The FGT (Fresh Germinated) sample had the highest value of alkaloids while the FFT (Fresh Fermented) sample had the lowest values.

## V CONCLUSION

The germination and fermentation pre-treatment operations affected the nutritional value of tiger nut flours. The higher crude protein, calcium, iron, potassium and sodium contents observed in the processed tiger nut flours showed significant improvement in their nutritional values compared to the untreated sample. There were significant decreases in the anti-nutrients tannin, phytate, and alkaloid contents in the germination and roasting pre-treatment operations. There were marginal decreases in the saponin contents in fermentation and germination pre-treatment processes. There is clear evidence indicating that fermented and germinated tiger nut are superior in nutrients compared to their unfermented and ungerminated samples as a result of the activation of endogenous enzymes that degrade anti-nutritional factors.

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