Effects of Process Modification on the Nutrient Composition and Sensory Value of Tiger Nut Milk

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ABSTRACT

This study evaluated the effects of processing methods on the proximate composition, vitamin content, and sensory properties of tiger nut milk extracts. Four samples were prepared: sprouted (STNM), roasted (RTNM), fermented (FTNM), and control (CTNM). Standard analytical methods were used for nutrient determination, and sensory evaluation was conducted. Results showed significant ($p < 0.05$) differences among samples. Moisture content ranged from 75.25% (RTNM) to 78.95% (FTNM). Protein was highest in FTNM (4.80%) and lowest in CTNM (3.22%). Fat and ash contents were highest in RTNM (4.19% and 1.22%, respectively), while crude fiber ranged from 1.35% (FTNM) to 1.74% (RTNM). Carbohydrate content was highest in CTNM (14.94%) and lowest in FTNM (11.09%). Vitamin C was significantly higher in FTNM (17.87 mg/100 g), whereas vitamin A was highest in CTNM (2.28 µg/100 g).Sensory evaluation also showed significant differences, with CTNM having the highest scores in appearance (8.40), taste (8.00), aroma (7.90), and overall acceptability (8.10). RTNM was moderately accepted, while FTNM recorded the lowest sensory ratings.The study demonstrates that processing methods significantly improved the nutritional value, but reduced the sensory qualities of tiger nut milk. Fermentation enhanced protein and vitamin C, roasting improved fat and mineral content, while germination showed moderate effects. These methods can be utilized to improve the nutritional value ,while process optimization should be employed to enhance consumer acceptability of tiger nut milk for an improved food and nutrition security.

Keywords: Tiger nut milk; processing methods; nutrient value, sensory evaluation

INTRODUCTION

Tiger nut (*Cyperus esculentus* L.) is an ancient tuber crop widely cultivated in Africa and the Mediterranean region, yet it remains largely classified as an under-utilized food resource despite its rich nutritional and functional potential (Yuchen , Qihui , Guohua, & Fayin (2024).It is commonly known as earth almond, *chufa, chew-fa, attadew* and *Zulu* nuts. It is known in Nigeria as *Ayaya* in Hausa, *Ofio* in Yoruba an *Akiausa* in Igbo where three varieties (black,brown and,yellow) Recent reviews highlight that tiger nut contains appreciable amounts of lipids (22–45%), starch (23–48%), dietary fibre, protein, minerals, vitamins, and diverse bio-active compounds, positioning it as a valuable raw material for functional foods and plant-based beverages such as tiger nut milk (Yuchen , Qihui,Guohua, & Fayin, 2024). In particular, tiger nut milk (locally consumed in many parts of Nigeria and globally known as "horchata de chufa") has gained increasing attention as a lactose-free alternative beverage with promising nutritional and health benefits.

Despite its long history of consumption, contemporary authors emphasize that tiger nut remains under-exploited compared with major oil-seeds and legumes, largely due to limited research on optimized processing and value addition (Yu, Lu, Zhang, Zhao, Guan, Pu, Gao, 2022). Recent systematic and review studies (2022–2025) further stress that the crop holds strong potential for sustainable food systems, owing to its high energy value, bio-active profile, and adaptability, but requires improved processing strategies to enhance its utilization and acceptability (Fabrice , Catherine , Hilaire , Denise , Annick , Stephano & Tuba, 2022).

Processing plays a critical role in determining both the nutrient composition and sensory quality of tiger nut milk (Aremu *et al*., 2015; Sánchez-Zapata *et al*., 2012). Current literature shows that methods such as soaking, roasting, germination, fermentation, drying, and enzymatic treatment significantly influence nutrient availability, physicochemical properties, and consumer acceptability (Nwosu, 2011; Adebayo-Oyetoro *et al.*, 2017; Madaki *et al*., 2018). Variations in extraction and processing techniques have been shown to alter protein content, starch digestibility, lipid profile, and bioactive compounds, as well as sensory attributes such as taste, aroma, colour, and mouthfeel (Chukwuma *et al.*, 2010; Okorie & Nwanekezi, 2014). Similarly, recent studies on processing modifications demonstrate that structural and compositional changes directly affect both functional and sensory properties of derived products (Codina-Torrella *et al*., 2015; Roselló-Soto *et al*., 2019; Li,, Yan, , Niu, Gong, , Bai, , Qu, & Wei, 2025; Ogodo, Benjamin , and Chrinius, 2025; Opurum, Achinehwu, Barber , Obinna-Echem, (2025).

Consequently, there is a growing research interest in process modification as a means of improving the nutritional quality and consumer acceptability of tiger nut milk. Understanding how different processing techniques influence nutrient retention and sensory characteristics is essential for promoting the wider utilization of this under-valued crop and for developing high-quality, acceptable plant-based beverages.

Statement of the Problem

Food insecurity remains a major challenge in low-income countries, driven by factors such as poor food processing and storage, high food prices, inadequate infrastructure, poverty, and climatic variations (Abbey, 2018). Despite the need for sustainable nutritional solutions, tiger nut—an underutilized crop in Nigeria—is largely consumed as a snack and not fully explored for its nutritional and economic potential.

Evidence shows that tiger nut possesses valuable nutrients and health-promoting properties, including support for digestion, cardiovascular health, and immune function (Yeboah, 2012; Samuel, 2016; Aude, 2015). However, its potential contribution to addressing malnutrition and food insecurity remains under-exploited.

Therefore, there is a need to enhance the utilization of tiger nut through processing techniques such as fermentation, germination, and roasting, particularly in the production of tiger nut milk, to improve its nutritional value and broaden its application in promoting food and nutrition security.

Purpose of the study

The main purpose of this study is to investigate the effect of modification on the proximate composition, some vitamin contents and sensory value of tiger nut milk. Specifically, the study intends to;

1. modify the processing of tiger nut through sprouting (germinating), mild roasting and fermentation (solid substrate), to achieve three products, and then the control sample.

2. determine the proximate compositions of the modified samples of tiger nut milk.

3. determine the vitamins C and A contents of the modified samples of tiger nut milk.

4. assess the organoleptic properties and general acceptability of the modified samples of tiger nut milk.

Design of the Study

This study adopted the experimental research design in carrying out the work. Experimental research design is a blueprint procedure that enables, the researcher to test the hypothesis by reaching valid conclusion about relationship between independent and dependent variables (Tapsoba, 2015).

Area of the Study

The study was carried out in the Food Laboratory of the Department of Home Economics and Hospitality Management, Alvan Ikoku Federal University of Education (AIFUE), Owerri, Imo State. AIFUE was named after a leading educationist then in the person of "AlvanIkoku. Presently, the school is located along Akwakuma-Amakohia/Orlu road just before the Federal Medical Centre Owerri.

Sample Preparation

Fresh tiger nuts were used for all treatments. The nuts were sorted to remove defective tubers, washed thoroughly, and divided into portions for different processing methods.

Production of Fresh Tiger Nut Milk (Control) [CTNM]

Selected tiger nuts (1 kg) were washed, drained, and blended (electric blender Philips blender 1000w (hr3573/91) with 200 ml of water to form a paste. The slurry was filtered using a 0.5 mm sieve (mesh). The filtrate was collected in sterilized bottles and stored in a freezer (- 18°C) prior to analysis.

Production of Fermented (Solid-Substrate) Tiger Nut Milk [FTNM]

The sorted tiger nuts (1kg) were thoroughly washed with potable water. The cleaned tubers were soaked in distilled water at ambient temperature (30±3 °C) for 24 hours to soften the tissues and initiate natural microbial activity. After soaking, the water was drained, and the hydrated tubers were coarsely milled to increase the surface area for fermentation.

The resulting mash was transferred into sterile shallow plastic trays and adjusted to a moisture content of approximately 60%, ensuring a moist but non-waterlogged substrate suitable for solid-substrate fermentation. No starter culture was added, allowing natural fermentation by indigenous micro-flora present on the tiger nut and in the environment.

Fermentation was carried out under ambient dry-season conditions typical of tropical environments, with temperature ranging 30±3 °C and relative humidity of approximately 45–55%. The substrate was loosely covered with sterile muslin cloth to prevent contamination while allowing aeration. The mash was fermented for 48 hours, during which it was manually turned at 12-hour intervals to ensure uniform fermentation and to prevent localized heat buildup.

During the fermentation period, a gradual decrease in pH from approximately 6.4 to 4.3 was observed, accompanied by the development of a mildly sour aroma characteristic of lactic acid fermentation. The temperature of the fermenting mass increased slightly (by about 2–3 °C above ambient) due to microbial metabolic activity.

At the end of the fermentation period, the fermented mash was immediately processed into milk. Potable water was added to the fermented substrate in a ratio of 1:3 (w/v), and the mixture was homogenized using a laboratory blender (electric blender Philips blender 1000w (hr3573/91). The slurry was then filtered through a double-layer muslin cloth (coarse pore size, (100-500 micrometer; 0.5mm mesh size) to obtain the fermented tiger nut milk.

Production of Germinated (Sprouted) Tiger Nut Milk [STNM]

Tiger nuts (1 kg) were washed and soaked in potable water (1:3 w/v), then spread on moist jute cloth and allowed to sprout for 48 hours at room temperature (30 ± 2 °C). The sprouted nuts were blended (electric blender Philips blender 1000w (hr3573/91) with 200 ml water, filtered, bottled and stored in a freezer (- 18°C).

Production of Roasted Tiger Nut Milk [RTNM]

Cleaned and dried tiger nuts (1kg) were subjected to roasting. Prior to roasting, the tubers were washed and air-dried for 24 hours to a moisture content of 10%. The process was carried out using an open pan under controlled conditions. The tiger nuts were spread in a single layer and roasted at a temperature of 120–150 °C for 30 minutes, until golden brown. During roasting, the samples were stirred intermittently (every 5 minutes) to ensure uniform heat distribution and to prevent charring.The roasted samples were then removed from the heat source and allowed to cool at ambient temperature (30±3 °C). After cooling, the roasted nuts were blended (electric blender Philips blender 1000w (hr3573/91) with 200 ml water, filtered, and the extract was stored in sterilized bottles in the freezer (-18°C).

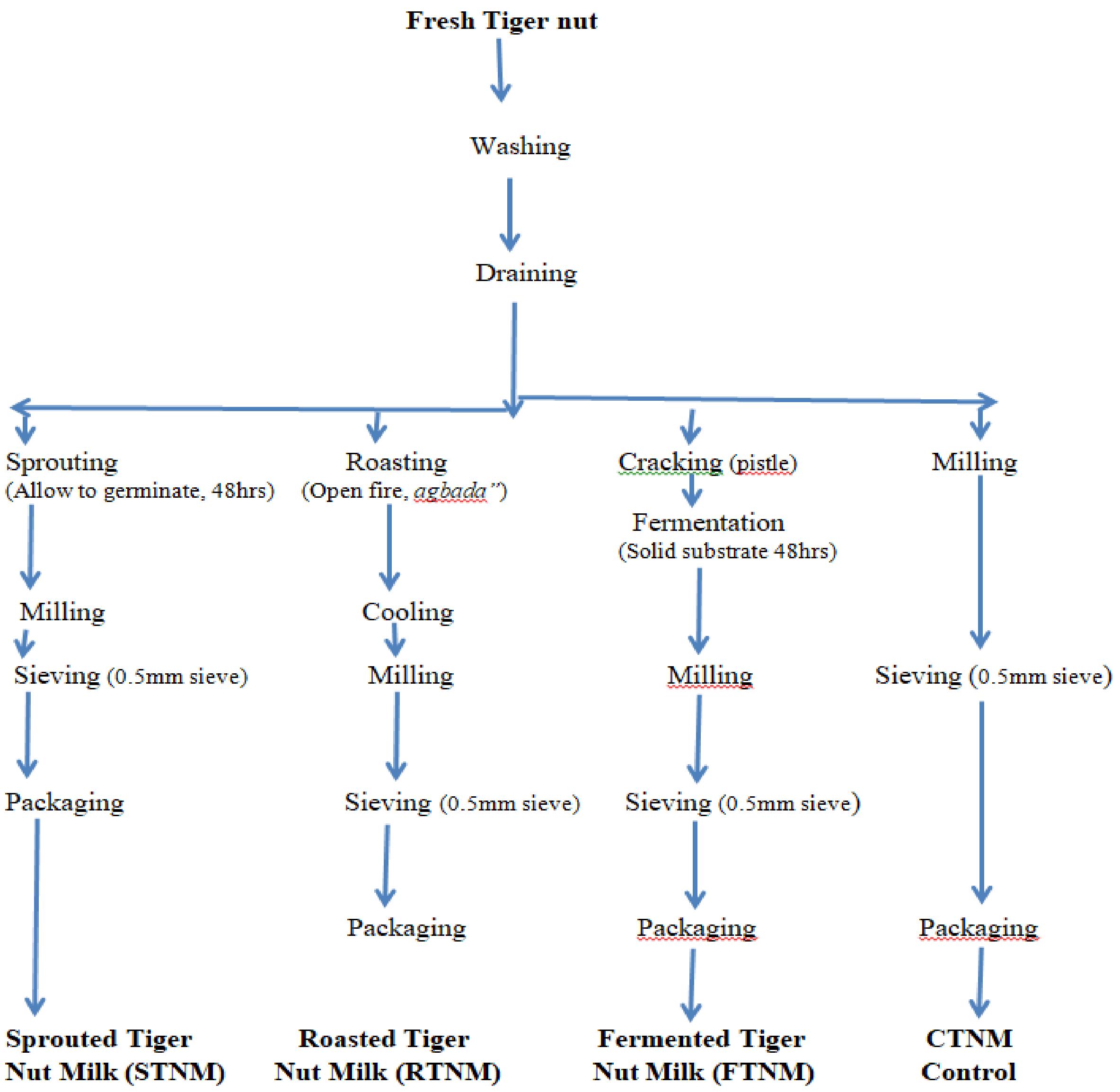

Fig 1: Flow diagram for production of modified Tiger nut milk

Proximate composition analysis

Proximate analysis of samples was carried out in triplicate determination using standard methods (AOAC, 2010).

Vitamin Analysis

Vitamin A Determination

Vitamin A determination was determined using Awolu *et al* (2013), the sample (1 ml) was measured into the test-tube I (centrifugal) with a tight stopper and 1 ml of the KOH solution was added, the tube was plugged and shake vigorously for 1 minute. The tube was heated in a water bath (60°C, 20 minutes), and was then cooled down in cold water. About 1 ml of xylene was added, the tube was plugged and shaken vigorously again for 1 minute. The tube was centrifuged (1500×g, 10 minutes), the whole of the separated extract (upper layer) was collected and transferred into the test tube II made of “soft” (sodium) glass. The absorbance A1 of the obtained extract was measured at 335 nm against xylene. The extract in the test tube II was irradiated to the UV light for 30 minutes, then the absorbance A2 was measured. The concentration Cx of vitamin A (µg/g) in the analyzed liquid was calculated, using equation.

$$Cx \text{ (as } \beta\text{-carotene)} = A1 - A2 \times 22.23$$

Where: 22.23 is the multiplier received on basis of the absorption coefficient of 1% solution of vitamin A (as the retinol form) in xylene at 335 nm in a measuring cuvette, 1 cm thickness.

Vitamin C Determination

Vitamin C content was determined by the spectrophotometric method using ascorbic acid as a reference compound. About 10ml of the juice sample was weighed into 10ml of water and mixed together. The extract (200µl) was pipetted and mixed with 300µl of 13.3% of trichloro-acetic acid (TCA) and 75µl (0.075ml) of Dinitrophenylhydrazyl (DNPH). The mixture was incubated in water bath at 37°C for 3 hours. After 3 hours, 500µl of 65% sulphuric acid was added and the absorbance was read with the spectrophotometer at 520nm. The concentration of vitamin C was calculated (Awolu *et al*. 2013).

$$\text{Vitamin C} = \frac{\text{Absorbance of standard}}{\text{Concentration of standard}} = \frac{\text{Absorbance of sample}}{\text{Concentration of sample}}$$

Sensory Evaluation

The sensory evaluation of the tiger nut milk samples was conducted using a panel of ten (10) trained and semi-trained assessors, comprising lecturers and students of Alvan Ikoku Federal University of Education, Owerri. The panelists were randomly selected based on their availability, willingness to participate, and absence of any known allergies or intolerance to plant-based milk products.

Training of Panelists

Prior to the evaluation, the assessors underwent a brief training session aimed at familiarizing them with the sensory attributes to be evaluated and the use of the hedonic scale. The training involved:

- ✓ Explanation of key quality attributes such as appearance, colour, aroma, taste, mouthfeel, and texture
- ✓ Orientation on the 9-point hedonic scale and how to score samples objectively
- ✓ Practice session using similar beverage samples to calibrate responses and improve consistency among panelists
- ✓ Guidance on avoiding bias, including not discussing scores during evaluation

Both trained (experienced) and semi-trained (naïve but oriented) panelists were included to reflect a balance between expert judgment and consumer perception.

Sample Preparation and Presentation

The samples were prepared, packaged, and presented under hygienic conditions. Each sample was placed in identical, transparent, and sealed containers and coded as follows:Sprouted tiger nut milk (STNM); Roasted tiger nut milk (RTNM); Fermented (solid-substrate) tiger nut milk (FTNM); Control tiger nut milk (CTNM). The samples were arranged on a clean table and presented to panelists in a randomized order to minimize positional bias. Each sample was served at ambient temperature (30±2 °C).To further reduce bias, samples were presented sequentially at different time intervals, and panelists were instructed to rinse their mouths with clean water between evaluations.

Evaluation Procedure

A structured questionnaire was administered to each panelist to assess the samples based on the following attributes:Appearance; Colour; Aroma; Taste; Mouthfeel; Texture; Overall acceptability. Each attribute was rated using a 9-point hedonic scale, where: 9 = Like extremely, 8 = Like very much ,7 = Like moderately ,6 = Like slightly,5 = Neither like nor dislike , 4 = Dislike slightly , 3 = Dislike moderately , 2 = Dislike very much , 1 = Dislike extremely

Bias Control Measures

To ensure reliability of results: ; Samples were coded to conceal identity; Panelists evaluated samples independently; Order of presentation was randomized; Interaction among panelists during evaluation was discouraged.

Statistical Data Analysis

The statistical package for service solution (SPSS) version (21) was used to analyze the data- proximate composition, vitamins C and A, and sensory evaluation). The analyzed data were expressed using one-way (one factor) analysis of variance (ANOVA). Duncan's multiple range was used to separate/compare the means obtained after each experiment. Difference was considered significant when P= 0.05.

RESULTS AND DISCUSSION

Table 1: Proximate and vitamins content of tiger nut milk extracts

Sample	Moisture %	Protein %	Fat %	Ash %	Crude fiber	Carbohydrate %	Vitamin C mg/100g	Vitamin A µg/100g
STNM	$78.10^{b}\pm0.01$	$4.26^{b}\pm0.16$	$2.94^{c}\pm0.02$	$1.18^{a}\pm0.0$	$1.62^{ab}\pm0.0$	$11.88^{c}\pm0.15$	$13.73^{b}\pm0.02$	$1.64^{c}\pm0.0$
RTNM	$75.25^{d}\pm0.03$	$3.67^{c}\pm0.01$	$4.19^{a}\pm0.01$	$1.22^{b}\pm0.01$	$1.74^{a}\pm0.0$	$13.90^{b}\pm0.01$	$6.25^{d}\pm0.01$	$2.01^{b}\pm0.0$
FTNM	$78.95^{a}\pm0.04$	$4.80^{a}\pm0.03$	$2.71^{d}\pm0.02$	$1.06^{c}\pm0.0$	$1.35^{b}\pm0.20$	$11.09^{c}\pm0.39$	$17.87^{a}\pm0.0$	$1.58^{d}\pm0.0$
CTNM	$75.99^{c}\pm0.01$	$3.22^{d}\pm0.0$	$3.13^{b}\pm0.01$	$1.02^{d}\pm0.01$	$1.67^{ab}\pm0.0$	$14.94^{a}\pm0.03$	$10.65^{c}\pm0.01$	$2.28^{a}\pm0.0$
LSD	0.02211	0.06038	0.02018	0.00955	0.13834	0.21156	0.01650	0.00345

Mean of duplicate and standard analysis. Mean value with different superscript along column are significant ($p<0.05$). LSD-Least Significant Different.

Key:

STNM- Sprouted tiger nut milk extract sample
RTNM- Roasted tiger nut milk extract sample
FTNM- Substrate fermented tiger nut milk extract sample
CTNM- Control tiger nut milk extract sample

RESULTS AND DISCUSSION

Nutrient Composition of Tiger Nut Milk

The proximate composition and vitamin contents of tiger nut milk samples processed through sprouting (STNM), roasting (RTNM), fermentation (FTNM), and untreated control (CTNM) are presented in Table 1.

Significant differences ($p < 0.05$) were observed across all parameters, indicating that processing methods markedly influenced nutrient composition.

Moisture content ranged from 75.25% (RTNM) to 78.95% (FTNM). The relatively high moisture levels observed across all samples are consistent with previous reports, although slightly lower than the 85.79–89.93% reported by earlier authors (Okorie & Nwanekezi, 2004; Udeozor, 2020; Ntukidem *et al*., 2019). The lower values obtained in this study may be attributed to variations in extraction efficiency and processing conditions. High moisture content suggests a greater susceptibility to microbial spoilage, thus necessitating preservation methods such as refrigeration or pasteurization.

Crude protein content showed a clear improvement with processing, increasing from 3.22% in CTNM to 3.67% (RTNM), 4.26% (STNM), and 4.80% (FTNM). The highest protein value (4.80%) recorded in FTNM agrees with findings by Li *et al.* (2025), who reported a 27–35% increase in crude protein following solid-state fermentation of tiger nut substrates. Similarly, Ogodo *et al*. (2025) documented enhanced protein and amino acid profiles in fermented tiger nut milk. They reported that laboratory fermentation of tiger nut milk led to a significant increase in crude protein content from approximately 3.10% in the un-fermented sample to about 4.45–4.72% after fermentation, representing an increase of roughly 35–50%. The increase observed in this study (approximately 49% increase from control to FTNM) is therefore consistent with these reports and can be attributed to microbial biomass synthesis, enzymatic hydrolysis, and increased nitrogen availability.

RTNM (3.67%) showed higher protein than CTNM (3.22%), although lower than STNM and FTNM. This indicates that roasting moderately improves protein concentration, likely due to moisture loss and enhanced extractability, but is less effective than biological processes such as fermentation and germination. Similar trends were reported by Olapade *et al.* (2021), who observed increases in protein content from 2.69% in the raw (control) sample to as high as 18.65% in processed samples (fermented, germinated, and roasted) following thermal and biochemical processing of tiger nut,indicating a substantial enhancement due to combined thermal and biochemical treatments.The magnitude of increase observed by Olapade *et al.* (2021) was much higher;the difference may be attributed to variation in sample form (flour vs. milk extract), processing intensity, and analytical basis (dry vs. liquid matrix).

The increase in protein content across processed samples can also be explained by degradation of anti-nutritional factors such as phytates and tannins, which bind proteins and reduce their detectability. Olapade *et al.* (2021) reported significant reductions in these compounds alongside improved protein availability, while Sotongui *et al*. (2025) confirmed enhanced nutrient bio-availability in fermented tiger nut products (reducing sugars increased from 2.48 to 4.05 g/100 g; protein content increased from 29.33 to 34.00 mg/100 g**),** increasing soluble and reducing sugars (improving digestibility) and reducing anti-nutritional factors that limit nutrient absorption.

Fat content varied significantly, with the highest value observed in RTNM (4.19%), compared to 2.94% (STNM), 2.71% (FTNM), and 3.13% (CTNM). The increase in roasted samples may be due to concentration effects following moisture loss. Conversely, the lower fat content in FTNM suggests microbial utilization of lipids during fermentation, as supported by Ogodo *et al.* (2025), who reported reductions in fat content during fermentation processes.Specifically, their study showed that crude fat content decreased significantly ($p < 0.05$) after fermentation (spontaneously fermented,11.72%; lab-fermented,10.23%) compared to the un-fermented control (11.84%). The reduction in fat content reported by Ogodo *et al*. (2025) is attributed to: microbial lipolytic activity, where microorganisms hydrolyze lipids,utilization of fatty acids as energy sources during fermentation, and conversion of lipids into metabolic intermediates.

Ash content ranged from 1.02% (CTNM) to 1.22% (RTNM), indicating that processing slightly improved mineral content. This supports Onyeka (2008), who described ash as an index of mineral composition, and suggests that processing does not adversely affect mineral retention.

Crude fibre values were relatively close (1.35–1.74%), although FTNM (1.35%) was lower than other samples, likely due to enzymatic breakdown of fibre during fermentation. Ntukidem *et al.* (2019) similarly reported fibre degradation following processing. Specifically,they reported that crude fibre content was highest in fresh tiger nut milk (0.12%) but decreased significantly ($p < 0.05$) in sprouted (0.10%) and roasted samples (0.11%), indicating fibre degradation during processing, which supports the lower fibre value (1.35%) observed in the fermented sample (FTNM) in the present study.

Carbohydrate content was highest in CTNM (14.94%) and lowest in FTNM (11.09%), reflecting carbohydrate utilization during fermentation. This agrees with previous quantitative findings where fermentation reduced carbohydrate levels to about 9.60%, representing an estimated 20–35% decrease compared to un-fermented samples. Similarly, total sugars have been reported to decline by approximately 10–11% during fermentation due to microbial metabolism, with reductions becoming more pronounced as fermentation time increases (Adebo *et al.,* 2022; Sotongui et al., 2025; Ogodo *et al*., 2025).

Vitamin C content showed marked variation, with FTNM recording the highest value (17.87 mg/100 g), compared to 13.73 mg/100 g (STNM), 10.65 mg/100 g (CTNM), and 6.25 mg/100 g (RTNM). This increase in FTNM is consistent with Li *et al*. (2025), who reported an increase in vitamin C from approximately 8.40 to 15.20 mg/100 g (~80% increase) following fermentation, and Ogodo *et al.* (2025), who observed a rise from about 9.50 to 14.60 mg/100 g (~55% increase). The significantly lower value in RTNM confirms the heat sensitivity of vitamin C, as thermal processing leads to degradation.

Vitamin A content, however, was highest in the control sample (2.28 µg/100 g) and lower in processed samples (1.58–2.01 µg/100 g), suggesting losses during processing. This may be linked to the fat-soluble nature of vitamin A and its susceptibility to oxidation and heat. Madaki *et al*. (2018) reported that raw tiger nut contains approximately 24.0–28.5% fat, indicating a high lipid matrix that supports fat-soluble vitamins; thus, processing-induced fat losses may account for the observed reduction in vitamin A content.

Table 2: Sensory properties content of tigernut milk samples

Sample	**Appearance**	**Mouth-feel**	**Aftertaste**	**Aroma**	**Taste**	**Overall acceptability**
STNM	$7.80^{a}\pm1.31$	$5.70^{a}\pm0.59$	$6.50^{ab}\pm0.63$	$5.80^{b}\pm0.44$	$4.70^{b}\pm0.57$	$5.40^{bc}\pm0.54$
RTNM	$7.40^{a}\pm0.84$	$6.70^{a}\pm0.39$	$6.50^{ab}\pm0.56$	$6.80^{ab}\pm0.48$	$7.0^{a}\pm0.49$	$6.90^{ab}\pm0.45$
FTNM	$5.40^{b}\pm1.50$	$4.40^{c}\pm0.61$	$4.50^{b}\pm0.73$	$5.10^{b}\pm0.62$	$3.40^{b}\pm0.70$	$3.80^{c}\pm0.59$
CTNM	$8.40^{a}\pm0.51$	$7.50^{a}\pm0.34$	$7.90^{a}\pm0.10$	$7.90^{a}\pm0.23$	$8.0^{a}\pm0.25$	$8.10^{a}\pm0.17$
LSD	0.66999	0.71141	0.79722	0.75462	0.75462	0.66583

Mean of duplicate and standard analysis. Mean value with different superscript along column are significant ($p<0.05$). LSD-Least Significant Different.

Key:

STNM- Sprouted tiger nut milk extract sample

RTNM- Roasted tiger nut milk extract sample

FTNM- Substrate fermented tiger nut milk extract sample

CTNM- Control tiger nut milk extract sample

Sensory Properties of Tiger Nut Milk samples

The sensory evaluation results (Table 2 above) revealed significant differences ($p < 0.05$) among samples across all attributes.The control sample (CTNM) consistently recorded the highest scores in appearance (8.40), mouth-feel (7.50), aftertaste (7.90), aroma (7.90), taste (8.00), and overall acceptability (8.10), indicating that it was the most preferred by panelists. In contrast, FTNM recorded the lowest overall acceptability score (3.80), despite its superior nutritional profile.

Although STNM and RTNM showed moderate acceptability (5.40 and 6.90, respectively), they were still significantly lower than the control. This suggests that while processing improves nutritional quality, it may adversely affect sensory attributes, particularly in fermented samples. The lower scores for FTNM may be attributed to the development of strong acidic or fermented flavours, which are less acceptable to consumers unfamiliar with such profiles.

The findings highlight a trade-off between nutritional enhancement and sensory acceptability. While fermentation significantly improved protein (4.80%) and vitamin C (17.87 mg/100 g), it resulted in poorer sensory ratings. This agrees with Ogodo *et al.* (2025), who reported that protein increased from approximately 3.20% to 7.44% and vitamin C from 9.50 to 14.60 mg/100 g following fermentation, while taste and aroma scores declined from about 7.20 to 5.10 and 7.00 to 5.00, respectively, indicating a 25–30% reduction in overall acceptability.

CONCLUSION

The results clearly demonstrate that processing methods significantly influence both the nutritional and sensory properties of tiger nut milk. Fermentation produced the highest improvements in protein (4.80%) and vitamin C (17.87 mg/100 g), consistent with recent literature (Li *et al.*, 2025; Ogodo et al., 2025). Sprouting also improved protein content (4.26%), while roasting moderately enhanced protein (3.67%) compared to the control (3.22%).

However, despite these nutritional improvements, the control sample remained the most preferred overall (8.10), indicating that processing negatively affected sensory attributes, particularly in fermented samples. Therefore, future studies should focus on optimizing processing conditions to achieve a balance between improved nutritional quality and consumer acceptability.

RECOMMENDATIONS

1. Future research should focus on optimizing processing conditions, particularly fermentation parameters (time, temperature, and starter cultures), to achieve a balance between enhanced nutritional quality and improved sensory acceptability. The use of flavour-masking strategies and natural additives should be explored to enhance consumer preference.

2. Studies should also investigate combined processing techniques (e.g., sprouting and fermentation) and optimize sprouting conditions to maximize nutrient retention while maintaining acceptable sensory properties. In addition, efforts should be made to minimize losses of heat-sensitive vitamins through controlled thermal processing.

3. Further research is needed on shelf-life stability, microbial safety, and packaging for large-scale production. Finally, comprehensive evaluation of nutrient bio-availability and functional properties is recommended to support the development of tiger nut milk as a nutritionally enhanced and consumer-acceptable functional beverage.

REFERENCES

1. Abbey, C. N. D. (2018). Microbial and Sensory Properties of Canned Tiger nut Milk. Kwame Nkrumah University of Science and Technology, Kumasi.
2. Adebo, J. A., Njobeh, P. B., Gbashi, S., Oyedeji, A. B., Ogundele, O. M., Oyeyinka, S. A., & Adebo, O. A. (2022). Fermentation of cereals and legumes: Impact on nutritional constituents and nutrient bioavailability**.** Fermentation, 8(2), 63. https://doi.org/10.3390/fermentation8020063

3. Akerele, D., Ayinde, A. F. O., Alabi, K. J., Ogunmola, O. O., & Ibrahim, S. B. (2020). Tigernut consumption in Ogun State, Nigeria: socioeconomic drivers and implications for consumer marketing. Nigerian Journal of Agricultural Economics, 10(1), 29–39.
4. AOAC (2005) Official Methods of Analysis, Association of Official Analytical Chemists, 16th ed. Washington DC
5. Asare, P. A., Kpankpari, R., Adu, M. O., Afutu, E., &Adewumi, A. S. (2020). Phenotypic Characterization of Tiger Nuts (Cyperus esculentus L.) from Major Growing Areas in Ghana. Scientific World Journal, 7232591, 1–11. https://doi.org/10.1155/2020/7232591
6. Awolu, O. O., Omoba, O. S., Olawoye, O., & Dairo, M. (2013).Optimization of the production and quality evaluation of maize-based snack supplemented with soybean and tiger nut flour**.**Food Science & Nutrition, 1(5), 1–8.https://doi.org/10.1002/fsn3.45
7. Bazine, T., & Arslanoğlu, Ş. F. (2020). Tiger Nut (Cyperus esculentus); Morphology, Products, Uses and Health Benefits. Black Sea Journal of Agriculture, 3(4), 324–328. https://dergipark.org.tr/tr/pub/bsagriculture/issue/56447/703m 497
8. Bolarinwa, O. O., Onifade, D. A., Nwose, A. M., &Adesokan, I. A. (2021). Effect of Storage on Mycology, Functional properties and Sensory attributes of Tiger nut Flour. Nature and Science, 19(1), 57–63. https://doi.org/10.7537/marsnsj190121.08.Key
9. Emurigho, T. A., Kabuo, C. O., &Ifegbo, A. N. (2020). Determination of physical and engineering properties of tiger nut (Cyperus esculentus) relevant to its mechanization. International Journal of Engineering Applied Sciences and Technology, 5(8), 82–90. https://doi.org/10.33564/ijeast.2020.v05i08.012
10. Evbuomwan, B. O., & Alabi, S. O. (2020). Comparative study of the physico-chemical, structural and proximate analysis of yellow and brown tiger nut (Cyperus esculentus). Journal of Multidisciplinary Engineering Science and Technology, 7(2), 11546–11549.
11. Ezeh, O., Niranjan, K., & Gordon, M. H. (2016). Effect of Enzyme Pre-treatments on Bioactive Compounds in Extracted Tiger Nut Oil and Sugars in Residual Meals. Journal of the American Oil Chemists' Society, 93(11), 1541– 1549. https://doi.org/10.1007/s11746-016-2883-9
12. Gasparre, N., & Rosell, C. M. (2019). Role of hydrocolloids in gluten free noodles made with tiger nut flour as non-conventional powder. Food Hydrocolloids, 97, 1–8. https://doi.org/10.1016/j.foodhyd.2019.105194
13. Ibrahim, S. G., Umar, R. A., Isa, S. A., &Farouq, A. A. (2017). Influence of preservation methods on ph and microbiological quality of tiger nut (Cyperus esculentus) milk. Bayero Journal of Pure and Applied Sciences, 9(2), 234. https://doi.org/10.4314/bajopas.v9i2.41
14. Ihenetu, S. C., Ibe, F. C., &Inyamah, P. C. (2021). Comparative study of the properties of yellow and brown Cyperus esculentus L. World News of Natural Sciences, 35, 25–37.
15. Li, C., Yan, Z., Niu, W., Gong, X., Bai, Y., Qu, L., & Wei, Y. (2025). Enhancing the nutritional values of tiger nut meal through solid-state fermentation. Biotechnology & Biotechnological Equipment, 39(1). https://doi.org/10.1080/13102818.2025.2580670
16. Madaki, Y. S., Binta, B. P., & Abubakar, S. (2018).Effect of processing methods on the nutritional composition of tiger nut (Cyperus esculentus) milk**.**International Journal of Food Science and Nutrition Engineering, 8(2), 23–29.
17. Madaki, F. M., Kabir, J., Musa, J. A., & Kolo, S. M. (2018).Effect of processing methods on the nutritional composition of tigernut (Cyperus esculentus) milk. Nigerian Journal of Nutritional Sciences, 39(2), 45–52.
18. Maduka, N. (2017). Physico-chemical Properties of Spicy Lactic Fermented Tiger nut-milk Drink Monitored during Ambient and Refrigeration Temperature Storage. Microbiology Research Journal International, 22(3), 1–9. https://doi.org/10.9734/mrji/2017/37698
19. Maduka, N.,& Ire, F. (2018). Tiger nut Plant and Useful Application of Tiger nut Tubers (Cyperus esculentus) – AReview. Current Journal of Applied Science and Technology, 29(3), 1–23. https://doi.org/10.9734/cjast/2018/43551
20. Mohdaly, A. A. (2019). Tiger Nut (Cyperusesculentus L.) Oil. In A. A. Mohdaly (Ed.), Fruit Oils: Chemistry and Functionality (pp. 243–269). Springer Nature Switzerland. https://doi.org/10.1007/978-3-030-12473-1_11

21. Muhammad, A. I., Chen, W., Liao, X., Xiang, Q., Liu, D., Ye, X., & Ding, T. (2019). Effects of Plasma-Activated Water and Blanching on Microbial and Physico-chemical Properties of Tiger Nuts. Food and Bioprocess Technology, 12(10), 1721–1732. https://doi.org/10.1007/s11947-019-02323-w
22. Ntukidem, V. E., Asuquo, A. E., & Enidiok, S. E. (2019).Evaluation of the nutritional and sensory properties of tiger nut (Cyperus esculentus) milk treated with different processing techniques.Asian Food Science Journal, 9(2), 1–10.https://doi.org/10.9734/afsj/2019/v9i230016
23. Ogodo, Alloysius Chibuike, Benjamin Nanisi Daniel, and Chrinius Hammuel (2025). "Assessment of Nutritional and Biochemical Properties of Tiger Nut Milk Fermented With Strains of Lactic Acid Bacteria". Asian Basic and Applied Research Journal 7 (1):539-55. https://doi.org/10.56557/abaarj/2025/v7i1197.
24. Okafor, U., Mordi, B., Ozumba, G., Solomon, B.O. & Olatunji, G (2013) . Assessing the Suitability of Tiger Nut Fibre for Structural Applications. Journal of Renewable Energy and Mechanics (REM), 3(01), 32–38. https://doi.org/10.25299/rem.2020.vol3.no01.4417
25. Okorie, S. U., & Nwanekezi, E. C. (2004).Effect of processing methods on the quality characteristics of tiger nut milk.Nigerian Food Journal, 22(1), 83–88.
26. Olapade AA, Obomeghei AA, Ebabhamiegbebho PA, Oluwafunmilola O. The influence of processing conditions on proximate, mineral and phytochemical properties of tiger nut (Cyperus esculentus) flour. Med. res. chronicles [Internet]. 2021 Oct. 14 [cited 2026 Mar. 20];8(5):428-3. Available from: https://medrech.com/index.php/medrech/article/view/532
27. Opurum, Peace C , Achinehwu, S. C , Barber, L.I , Obinna-Echem P C (2025).Effect Of Germination on the Physico-chemical, Proximate, Amino Acid and Sensory Properties of Soybean and Tiger Nut Yoghurt Research Journal of Food Science and Quality Control (RJFSQC) E-ISSN 2756-5483 P-ISSN 2695-2459 Vol 11. No. 2 www.iiardjournals.org online version
28. Owuama, C. I., & Owuama, P. M. (2020). Assessment of diastatic, proteolytic and lipolytic activities of yellow and brown varieties of cyperus esculentus (Tigernuts) extracts.mFood Research, 5(1), 91–98.https://doi.org/10.26656/fr.2017.5(1).257Marsili, 2013).
29. Roselló-Soto, E., Garcia, C., Fessard, A., Barba, F. J., Munekata, P. E. S., Lorenzo, J. M., &Remize, F. (2019). Nutritional and microbiological quality of tiger nut tubers (cyperusesculentus), derived plant-based and lactic fermented beverages. Fermentation, 5(1), 1–13. https://doi.org/10.3390/fermentation5010003
30. Sabah, M. S., Shaker, M. A., Abbas, M. S., & Moursy, F. I. (2019). Nutritional Value of Tiger Nut (Cyperusesculentus L.) Tubers and Its Products. Journal of Biological, Chemical and Environmental Sciences, 14(1), 301–318.
31. Samuel, A. B. (2016). Tigernuts: Benefits and negative health implications. University of Nigeria, Enugu Campus
32. Sotongui NDa Amenan Richemonde and Ngoran-AW Essan Bla Zita (2025**)**; Biochemical composition of soy-enriched fermented tiger nut milk, Int. J. of Adv. Res., 13 (02), 972-976, ISSN 2320-5407. DOI URL: https://dx.doi.org/10.21474/IJAR01/20454
33. Tapsoba, A. R. (2015). Enzymatic hydrolysis of starch in tigernut (Cyperus esculentus L.) milk using two enzymes and its sensorial effects. Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana.
34. Udeozor, L. O. (2020).Tiger nut-soy milk drink: Preparation, proximate composition and sensory qualities.International Journal of Food Science and Biotechnology, 5(2), 45–52.
35. Usman, D. D., Adanu, E. O., Jahun, B. G., & Ibrahim, K. (2019). Effect of moisture content variation on thermo-physical properties of brown variety tiger nut (Cyperus esculentus). Arid Zone Journal of Engineering, Technology and Environment, 15(3), 714–724.
36. Yeboah, S. (2012). Physico-chemical and nutritional profiling of fermented tiger nut-cereal-based symbiotic dairy drink. The University of Ghana,