Effect of Different Preprocessing Methods on the Proximate Composition of Bottled Tigernut (*Cyperus esculentus*) Milk Varieties

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ABSTRACT

This study was carried out to observe the proximate composition of tigernut milk extract from the yellow and brown varieties of tigernut. The tigernut tubers were subjected to different preprocessing operations (boiling, malting, and soaking) before extraction. The proximate composition of the tigernut tubers and drinks were determined. The result showed that the yellow variety recorded high moisture content (39.16%) compared to the brown variety which recorded (9.17%). Values obtained for the tigernut tubers and tigernut milk were significantly different except crude fibre content (0.00%) which recorded no trace of fibre in the extract. The moisture content of the tigernut milk slightly increased after sterilization except for the malted yellow sample, there was a decrease in the carbohydrate, crude fibre, and fat contents after sterilization. However, the protein, ash and fat content of the malted brown variety were not affected. There were significant differences $p<0.05$ between the processing methods and the varieties. The study showed that there was varietal difference in the nutrient composition of tigernut tuber and also the effect of processing and sterilization on tigernut milk. This study highlights the need to increase utilization of tigernut for commercialization in Nigeria and beyond.

INTRODUCTION

Over the past decade, the primary research emphasis on food product development has been to address the changing needs and meet the present demands of consumers by creating newer alternatives to healthy foods. In today's world, beverages are no longer considered simply as thirst quenchers; consumers seek specific functionality in these drinks, which forms a lifestyle. These changes and developments have recently led to newer products in the beverages sector. One such primary functional requirement is milk alternatives to mitigate problems of cow milk allergy, lactose intolerance, calorie concern, and prevalence of hypercholesterolemia (Valencia-Flores *et al.,* 2013). It is important to note that veganism and a healthy lifestyle rule the health charts as a trend. Companies are studying the consumption patterns of different people and maximizing the sales of different beverages by offering combinations of milk and energy drinks. Thus, the future of plant-based beverages is bright. The growing interest in promoting healthy living is expected to create a significant opportunity for a plant-based milk that would cater to the demand of a growing population. Tigernut milk beverages are one of the most appreciated plant-based beverages obtained from the aqueous extract of tigernut tubers (*Cyperus esculentus*) (Coşkuner *et al.,* 2002). These beverages are rich in carbohydrates (50%), unsaturated 55 fatty acids (75% in oleic and ~10% in linoleic acids, of total fat) and dietary fibre (~1%). There are three cultivars of tigernut; yellow, brown and black cultivars. The cultivars possessed different physicochemical properties (Nina *et al.,* 2019; Ayaşan *et al.,* 2021) and functional properties (Nina *et al.,* 2019; Ismaila *et al.,* 2020). The major factors that account for the chemical variation in tigernut are genetic makeup, production location, environment and growing conditions (Ihenetu *et al.,* 2021).

Furthermore, there is a dire need for increased utilization of homegrown crops, highlighted at national and international seminars, conferences, and workshops. Tigernuts have been reported to be a healthy source of nutrients like carbohydrates, protein, and fat with no allergy-causing components, yet they are vastly underutilized. The findings of this research will provide baseline data on tigernut milk thereby diversifying its use and increased production as a valuable means to fight food insecurity. The main objective of this study is to investigate the nutrient composition of tigernut milk and improve its commercial value.

MATERIALS AND METHODS

Sources of raw material

Tigernut tubers (brown and yellow varieties) were purchased from farmers in Jalingo Taraba State. The 26mm crown corks used were produced by Pellconi Company in Italy and successfully delivered through a courier service (DHL). The capping machine manufactured by Officine Pesce bottling system Italy with the model number PG 93/C was purchased from Canada and successfully shipped to Nigeria and was used for capping. Vitamilk bottles were reused for bottling, the bottles were washed with water, sterilized using an autoclave with the model number *ST3028E*.

Sample preparation

Fresh tigernuts were used for the preparation of tigernut extract. Fresh tigernuts were visually inspected. Defective tubers were manually removed and discarded. Hence, only mature, healthy tigernut tubers were selected. Tigernuts were weighed in portions, washed thoroughly in two changes of clean water, and drained before use for all the studies. The tigernut tubers were processed with different methods before extraction.

Boiling method

The method of Asante *et al*. (2014a) with modification was used. Fresh tiger nut (200g) was boiled at 100ºCfor 5 minutes until the tuber became soft for easy extraction. The boiled tiger nut was ground using Omniblend V model TM 800. A portion of 500 mL of distilled water was used together during the blending and slurring process. The slurry was filtered with a clean, damp muslin cloth (pore size 2 mm), and the filtrate obtained was boiled at 70ºC for 15 minutes to avoid curdling before bottling and capping for further studies.

Malting method

The method described by Ndubisi (2009) with slight modification was used. Fresh tigernut was visually selected. A portion of 200g of tigernut was soaked in a vessel for 24 hours and drained out. The soaked tigernuts were washed, drained every 6 hours and was placed in a jute bag at room temperature. Water was sprinkled twice a day to soften the tubers. After five days, it germinated, giving out shoots and roots. After sprouting, the tigernut tubers were cleaned, washed, drained, blended into a paste using Omniblend V model TM 800 blender, and slurred. A portion of 500 mL of water was used during the blending and slurring process. The slurry was filtered with a clean muslin cloth (pore size 2 mm), and the filtrate obtained was boiled at 70ºC for 15 minutes to avoid curdling before bottling and capping for further studies.

Soaking method

The method described by Ndubisi, 2009 with slight modification was used A portion of tigernut (200g) was washed in water, drained, and soaked in 600mL of water for 12 hours. The water was discarded, and the tubers were milled into a paste using Omniblend V model TM 800 blender, and slurred. A portion of 500 mL of distilled water was used during the blending and slurring process. The slurry was filtered with a clean muslin cloth (pore size 2 mm), and the filtrate obtained was boiled at 70ºC for 15 minutes to avoid curdling before bottling and capping for further studies.

Plate 1:

Yellow tigernut

Plate 2

Brown tigernut

Plate 3

Yellow malted tigernut

Plate 4

Brown malted tigernut

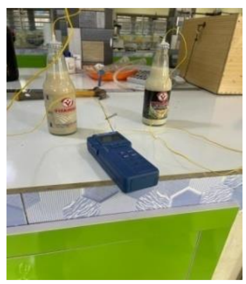
Heat penetration studies

Before sterilization, heat penetration was carried out on the different varieties and different processing methods of the tiger nut milk extract. A Nicetymeter thermocouple with the model number DT1311/DT1312 was inserted at the center of the bottle and sealed airtight, then connected to a temperature reading instrument. The initial temperature was noted, and the autoclave temperature was set at 121ºC. Temperature was recorded until the tiger nut extract got to 121ºC. Based on the observation recorded, the F_0 value was determined. F_0 value is the equivalent exposure time at 121ºC of the actual exposure time at a variable temperature. The F_0 was determined at 12 minutes.

Plate 5

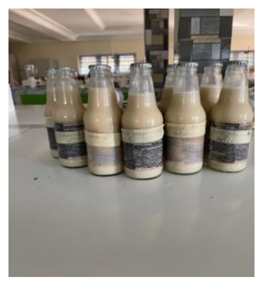
Bottling process

Plate 6



Heat penetration studies

Plate 7



Bottled tigernut milk

Sterilization of tigernut milk extract

The bottled milk extracts were sterilized after capping using an autoclave. Sterilization was carried out in batches after production and allowed to cool before analysis.

Proximate Analysis

The proximate components of fresh, soaked, boiled and malted tigernut tubers and tigernut milk were determined by the method of Association of Official Analytical Chemist (AOAC 2016).

Statistical analysis

The mean and standard deviation of the result data from the experiment was calculated and analyzed using single factor ANOVA Software (SPSS version12. 0.1 for windows). The Duncan‟s New Multiple Range Test was used to determine the significant difference between mean values. MINITAB version 19.0 was used to show interaction.

RESULTS AND DISCUSSIONS

Proximate composition of tigernut tubers

The proximate composition of the tigernut tubers is shown in Table 4.1. The yellow variety recorded a high value of moisture (39.16%) compared to the brown variety which recorded (9.17%). The high moisture indicated they may be easily susceptible to spoilage if not well preserved. Moisture content influences food's taste, texture, weight, appearance, and shelf life (AOAC, 2005). Even a little deviation from a defined standard can adversely impact the properties of a food material. Hence, obtaining an optimal analytical value for moisture is of great economic importance to a manufacturer (Pearson, 1976). The ash content was recorded at 1.51% for the yellow variety, while the brown variety had a higher value of 2.66%; the tiger nut was within the range reported for other starchy roots and tubers such as yam (1.5%) cassava (2.3%), and potatoes (1.0%). The ash value was similar to the value reported by Temple *et al.* (1998) at (1.86%) but higher than the values reported by Suleiman *et al.* (2018) at 1.18%. However, values reported by Umerie *et al.* (1997) on tigernuts had significantly higher values (2.48% and 6.70% dry weight, respectively). The value obtained showed that the three species are rich in minerals. Generally, ash content, being a micronutrient, varies between 1-2%, a reasonably high value indicating the presence of an adulterant (Ndubuisi, 2009). The crude fibre content recorded 11.54% for the yellow variety and 12.65% for the brown variety. Tigernut fibre values from the findings align with the report of Umerie *et al.*, 1997 which is 12.88 %. Conversely, Temple *et al.(1998)* reported a lower fibre value (5.50%). With about 100 g of tigernuts, the fibre content could be essential in reducing the pressure and transit time of food through the body, aiding digestion (Temple *et al.*, 1998). Fibre aids in the alleviation of flatulence problems. Thus, tiger nut fibre could be explored in formulating diets for treating indigestion, constipation, and non-communicable diseases such as colon cancer, obesity, and coronary heart disease (Wardlaw and Kessel, 2002).

The protein content recorded was 1.74 % for the yellow variety and 2.72% for the brown variety. These values are slightly lower than the results of Oguche and Musa, 2022 who reported 7.98% for yellow variety and 5.17% for brown variety. The protein content of tigernuts is higher than most starchy roots crops such as cassava (0.7%), sweet potatoes(1%) and yams(1.5%) (Sanchez-Zapata *et al.*, 2012). Tigernut's protein content was in comparison with that of cereals such as rice and sorghum (Ndubuisi, 2009). The fat content recorded was 22.49% for the yellow variety and 36.13% for the brown variety. The fat content of tigernuts is relatively similar to that of nuts and seeds (30%- 26%) but is higher than that of wheat (1.9%), rice (2.2%), maize (4.9%) and compares well with that of soya beans (28.20%) (Sanchez-Zapata *et al.*, 2012). Tigernuts, in comparison to other starchy roots and tubers such as sweet potatoes, cassava, and yam, have significantly higher fat content and could contribute more than 73% of fat to a child's daily fat need and more than 49% of fat to an adult daily fat requirement (FAO/WHO, 2002). The carbohydrate content of the tiger nut varieties recorded was 23.58% for the yellow variety and 36.69% for the brown variety. The values obtained for the carbohydrate content of the two varieties are higher than the values obtained by Oguche and Musa, 2022 which recorded 4.39% and 27.17%, respectively, for the yellow and brown varieties, but lower when compared to the values of the results obtained by Waoguikpe (2010) (yellow 46.99% and brown 41.22%). Of their high nutrients, tiger nuts could be eaten fresh as snacks by young children, adults, and pregnant and lactating mothers. These nutrients could contribute to the metabolic processes of the body. Consequently, consuming 100 g of tiger nuts could contribute 40 % of carbohydrates to a child's (4-9 yrs) daily carbohydrate requirement and above 32 % of carbohydrate to an adult's daily carbohydrate need (FAO/WHO, 2002). The actual sourced location and varietal difference may have affected the differences between the two varieties.

Table 4.1: Proximate composition of tigernut tubers

Component	Yellow variety	Brown variety
Moisture (%)	39.16**±0.13	9.17±0.23
Ash (%)	1.51**±0.01	2.66±0.15
Crude fibre (%)	11.54*±0.32	12.65±0.09
Protein (%)	1.74*±0.00	2.72±0.21
Fat (%)	22.49**±0.52	36.13±0.52
Carbohydrate (%)	23.58**±0.05	36.69±0.25

Values are mean ± standard deviation of duplicate determinations.
**: Means in the same row are significantly different at p<0.05.
*: Means in the same row are significantly different at p<0.01.

Proximate composition of tigernut milk

Table 4.1 shows the proximate composition of different varieties of fresh and sterilized tigernut milk. The moisture content ranged from 89.19% to 93.19%. Moisture content increased within the processing methods and varieties. The sterilized samples recorded higher moisture content; the boiled yellow sample had the highest moisture content of 93.19%, and fresh soaked brown recorded the lowest moisture content of 84.77%. There were significant differences $p<0.05$ between the processing methods and the varieties. The result showed that tigernut milk has a high moisture content, possibly because of the water used during the milling and extraction of milk from the tigernut. This could affect the stability and safety of food concerning microbial growth and proliferation.

The ash content ranged from 0.140% to 0.280%, with the malted samples recording the highest. The highest ash content was seen on the sterilized fresh yellow malted tiger nut, while the boiled sterilized sample had the most negligible ash content, 0.140%. The total ash recorded in various treatments was lower than the ash content of 1.5% recorded by Ukwuru *et al.* (2008). There was a significant difference ($p<0.05$) between the various processing methods and varieties.

The crude fibre content was 0.00% in all samples, and there was no trace of fibre recorded in the extract. The result shows that the crude fibre was lost during milk extraction from the tigernut tubers. Ayuba *et al.* (2020) also recorded similar observations for tiger nut milk.

The protein content ranged from 0.26% to 0.54%. There was a significant difference ($p<0.05$) between the processing methods and the different varieties of tiger nut tubers. The brown variety recorded the highest value, 0.54% and 0.49%, for fresh and sterilized samples, respectively, while the malted samples recorded the lowest value 0.26%. The differences in the sterilized sample could be attributed to the effect of heat treatment on the milk extract. Results showed that there was not much effect on the protein content of the tigernut milk after sterilization compared to its fresh state.

The fat content recorded values ranging from 5.13% to 9.17%. There was a significant difference ($p<0.05$) between the processing methods and the varieties. The highest fat content was recorded at 9.17% on the soaked brown fresh sample, while the least was seen on the malted sterilized yellow sample at 5.13%. The high-fat content recorded in fresh and sterilized soaked brown 9.17% and 9.01% were above the 8% for dairy milk (FAO/WHO 2002a,b), while the other samples were below the 8% standard. It has been reported that tigernut tubers are rich in fat (Belewu and Abdunrin, 2006). The fat level in the milk was higher than the 3% level required by the Codex Alimentarius Standard (Passmore and Eastwood, 1986). The results obtained are similar to the fat content of tiger nuts (7.8% -9.7 %), which Ayuba *et al.* (2022) recorded.

The carbohydrate content ranged from 0.04% to 6.83%. It was observed that the fresh malted brown recorded the highest carbohydrate (6.83%) while the soaked fresh yellow recorded the least (0.04%). Temple *et al.* (1990) showed that tiger nut tuber is a rich protein, fat, and carbohydrate source. The soaked samples recorded low carbohydrates except the fresh soaked brown with (5.12%); the low carbohydrate could be attributed to leaching during the soaking period. Also, the decrease in carbohydrates showed that sterilization affected the carbohydrate content of tigernuts. Decrease in carbohydrate content might be due to leaching of amylose during heating (Singh *et al*., 2006).

Table 2 Proximate composition of tigernut drinks

Pre-processing method	**Variety**	**Post-packaging**	**Moisture (%)**	**Ash (%)**	**Crude fibre (%)**	**Protein (%)**	**Fat (%)**	**Carbohydrate (%)**
Malting	Yellow	Fresh	$91.83^{b}\pm0.33$	$0.280^{a}\pm0.01$	0.00	$0.28^{fg}\pm0.00$	$5.69^{f}\pm0.11$	$1.93^{e}\pm0.23$
Malting	Yellow	Sterilized	$89.93^{c}\pm0.48$	$0.245^{bc}\pm0.01$	0.00	$0.26^{g}\pm0.01$	$5.13^{g}\pm0.6$	$4.44^{bc}\pm0.42$
Malting	Brown	Fresh	$85.45^{d}\pm0.72$	$0.275^{ab}\pm0.01$	0.00	$0.40^{c}\pm0.01$	$7.05^{c}\pm0.03$	$6.83^{a}\pm0.69$
Malting	Brown	Sterilized	$90.29^{c}\pm1.05$	$0.260^{ab}\pm0.01$	0.00	$0.40^{c}\pm0.00$	$7.06^{c}\pm0.02$	$2.00^{e}\pm1.02$
Soaking	Yellow	Fresh	$92.91^{ab}\pm0.18$	$0.200^{de}\pm0.00$	0.00	$0.34^{d}\pm0.01$	$6.53^{d}\pm0.21$	$0.04^{f}\pm0.01$
Soaking	Yellow	Sterilized	$93.05^{ab}\pm0.04$	$0.160^{fg}\pm0.01$	0.00	$0.30^{e}\pm0.01$	$6.15^{e}\pm0.06$	$0.35^{f}\pm0.03$
Soaking	Brown	Fresh	$84.77^{d}\pm0.86$	$0.25^{abc}\pm0.01$	0.00	$0.54^{a}\pm0.01$	$9.17^{a}\pm0.03$	$5.12^{b}\pm0.65$
Soaking	Brown	Sterilized	$89.84^{c}\pm0.30$	$0.170^{ef}\pm0.01$	0.00	$0.48^{b}\pm0.01$	$9.01^{b}\pm0.02$	$0.52^{f}\pm0.28$
Boiling	Yellow	Fresh	$92.94^{ab}\pm0.22$	$0.175^{ef}\pm0.02$	0.00	$0.33^{d}\pm0.01$	$6.20^{e}\pm0.04$	$3.47^{cd}\pm0.28$
Boiling	Yellow	Sterilized	$93.19^{a}\pm0.01$	$0.140^{g}\pm0.01$	0.00	$0.29^{ef}\pm0.01$	$6.13^{e}\pm0.01$	$0.26^{f}\pm0.02$
Boiling	Brown	Fresh	$89.19^{c}\pm0.92$	$0.225^{cd}\pm0.01$	0.00	$0.54^{a}\pm0.01$	$7.06^{c}\pm0.03$	$2.99^{de}\pm0.88$
Boiling	Brown	Sterilized	$89.57^{c}\pm0.25$	$0.190^{ef}\pm0.01$	0.00	$0.49^{b}\pm0.01$	$7.05^{c}\pm0.01$	$2.70^{de}\pm0.21$

Values are mean ± standard deviation of duplicate determinations. Means in the same column bearing different superscripts are significantly different at $p<0.05$.

CONCLUSION

The study showed that tigernut tubers can be processed into different products with various processing methods. Generally, processing treatment significantly affects the quality of the products. Variations in the chemical values of the samples were a function of the processing treatments. There was a significant difference in the proximate composition of the tiger nut tubers and a significant difference in the tigernut milk at different processing methods. Promoting tiger nut consumption will play an imperative role in many developing countries' health, nutrition, and economy. The study highlighted improvements in utilizing tigernut in order to massively drive the utilization and commercialization of tigernut tubers in Nigeria and beyond.

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Declaration of competing interest

The authors declare that they have no competing financial interest or personal relationship that could have appeared to influence the work.

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