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EFFECT OF FRESHLY HARVESTED *MORINGA OLEIFERA* SEEDS ON THE PROXIMATE COMPOSITION AND SENSORY QUALITIES OF TIGER-NUT MILK

Elochukwu, Chinwe U.*, Okpata, E. C.

Department of Food Technology, Federal Polytechnic Oko, P.M.B. 021, Anambra State.

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***Corresponding Author: Elochukwu, Chinwe. U**
Department of Food Technology, Federal Polytechnic Oko, P.M.B. 021, Anambra State.

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ABSTRACT

The proximate composition and sensory acceptability of tiger-nut milk as influenced by addition of freshly harvested *Moringa oleifera* seeds was investigated. 1.5 gram (5 seeds), 3 grams (10 seeds) and 6 grams (20 seeds) of freshly harvested moringa seeds were washed and milled with soaked, washed tiger nuts (200 g) respectively. Water (500 ml) was added respectively during milling. The slurries were sieved using clean sieving cloth to extract the milk. The filtrates were homogenized and corked respectively in 30 ml sterilized bottles. These corked blends of tiger-nut/moringa milk were pasteurized at 72°C for 15 s. The control sample (no *moringa* seed) was also prepared. The samples were labelled TM1 (control), TM2, TM3 and TM4 respectively. The samples were subjected to proximate analysis using standard analytical methods while the sensory acceptability of the products was evaluated using a 9-Point Hedonic Scale. The results obtained showed that addition of freshly harvested moringa seeds had significant ($p<0.05$) effect on the proximate composition of tiger-nut milk. There was significant increase in the moisture (88.20–89.10%), ash (2.83–4.93%), fibre (0.12–0.97%), fat (1.01–1.98%) and protein (0.93–1.98%) contents while the carbohydrate content of the samples decreased from 6.82% in TM1 to 1.15% in TM4. Sensory evaluation showed that increasing *Moringa oleifera* seed addition improved aroma but significantly reduced taste and overall acceptability. The appearance, colour, and consistency were unaffected across all treatments.

KEYWORDS: Moringa, Tigernut, Proximate, Sensory, Seed.

INTRODUCTION

Plant-based "milk" refers to water extracts obtained by grinding or mashing plant materials such as seeds, nuts, legumes, oil seeds, cereals, or pseudocereals with water and subsequently filtering the liquid to obtain a product that resembles cow's milk in appearance and consistency (Ziarno and Cichonska, 2021). The global interest in plant-based beverages has grown considerably over the past two decades, driven by increasing concerns about lactose intolerance, milk protein allergies, ethical and environmental considerations associated with animal husbandry, and the rising demand for functional and health-promoting foods (Sethi *et al.,* 2016). These beverages have been recognized not only as alternatives to conventional dairy milk but also as vehicles for delivering essential nutrients to populations that are vulnerable to micronutrient deficiencies, particularly in developing countries (Belewu and Belewu, *2007*).

A wide variety of traditional plant-based beverages exists across the world. Notable examples include Horchata (tiger-nut milk) in Spain, Sikhye (a beverage made from cooked rice, malt extract, and sugar) in Korea, and traditional soy milk originating from China (Kim *et al.,* 2012). In West Africa, plant-based drinks derived from groundnut, soybean, bambara nut, and tiger-nut are widely consumed and are increasingly being evaluated for their nutritional adequacy and functional properties (Adebayo-Oyetoro *et al.,* 2019). Researchers have shown strong interest in these milk sources due to their high nutritional values and economic potentials; plant-based milk sources are seen as a radiating hope and an ally in the fight against hidden hunger (Belewu and Belewu, 2007).

Tiger-nut (*Cyperus esculentus* L.) is a perennial sedge belonging to the family Cyperaceae. It grows primarily in tropical and subtropical regions, including sub-Saharan Africa and parts of the Mediterranean (Adebayo *et al.,* 2014). The edible portion consists of small underground tubers that are sweet, nutty-flavoured, and highly nutritious. Tiger-nuts have been reported to contain significant quantities of protein, carbohydrates, sugars, oils, and dietary fibre (Osaloni *et al.,* 2019). They are also rich in minerals such as potassium, calcium, and phosphorus, as well as vitamins C and E (Umelo *et al.,* 2014). Tiger-nut can be consumed raw, dried, roasted, or grated and used as flour in the formulation of value-added food products. Studies have demonstrated that tiger-nut is useful for enhancing blood circulation, preventing heart diseases, and reducing the risk of colon cancer due to its high unsaturated fatty acid and dietary fibre content (Adebayo *et al.,* 2014).

Tiger-nut milk, a popular beverage extracted from tiger-nut tubers, is a highly nutritive energy drink consumed across various age groups. It is commercially known as 'Horchata de chufa' in Spain and 'Kunu aya' in Nigeria (Lasekan *et al., 2013*). According to Umelo *et al. (2014)*, tiger-nut milk contains high levels of starch, glucose, potassium, phosphorus, and vitamins C and E. Despite its nutritional merits, tiger-nut milk has been noted to have relatively low protein content compared to cow's milk, which limits its potential as a complete nutritional substitute. This nutritional gap underscores the need for fortification strategies to improve its overall nutrient profile (Adebayo-Oyetoro *et al.*, 2019).

Moringa oleifera Lam., commonly referred to as the 'miracle tree' or 'tree of life,' is one of the most nutritionally dense plants known to food and nutrition science. Its seeds, leaves, pods, and roots have all been utilized in food, pharmaceutical, and cosmetic applications across many cultures (Bolarinwa *et al.*, 2017). Moringa seeds are particularly rich in protein of high biological value, essential amino acids, vitamins, and minerals such as calcium, magnesium, potassium, and zinc. They also contain bioactive phytochemical compounds including isothiocyanates, phenolics, and flavonoids which have been reported to exhibit antioxidant, anti-inflammatory, and antimicrobial properties (Fahey, *2003*). The oil extracted from moringa seeds (ben oil) has a long shelf-life due to its high content of oleic acid and natural antioxidants, making it valuable for food preservation (Anwar *et al., 2007*).

Nutritional enhancement through food-to-food fortification has gained increasing attention as a cost-effective and sustainable approach to tackling malnutrition in developing countries. Recent studies have demonstrated that blending two or more indigenous plant materials can significantly improve the nutrient density of food products while maintaining acceptability among consumers (Adebayo-Oyetoro *et al., 2019*). The combination of tiger-nut and moringa seed is particularly promising given their complementary nutritional compositions: tiger-nut provides energy-dense carbohydrates and healthy fats, while moringa seeds contribute high-quality protein, minerals, and bioactive compounds (Osaloni *et al., 2019*). Prior research by Osaloni *et al. (2019)* explored the fortification of tiger-nut milk with moringa seed powder and reported significant improvements in protein, ash, and fat contents. However, limited information is available on the use of freshly harvested moringa seeds as an additive during the milling of tiger-nut milk, which may offer a more practical and accessible approach for rural food processors.

The advocacy for improved health and nutritional wellbeing has necessitated a search for healthy foods with balanced nutrient profiles required for various metabolic and physiological demands (*Adebayo-Oyetoro et al., 2019*). In line with this, the present study seeks to investigate the feasibility of producing an acceptable and nutritionally improved beverage by incorporating different numbers of freshly harvested moringa seeds into tiger-nut milk during the milling process. The specific objectives of the study are: (i) determination of the proximate composition of tiger-nut milk enriched with different levels of moringa seeds; and (ii) evaluate the sensory acceptability of the enriched tiger-nut milk products.

MATERIALS AND METHODS

Source of Raw Materials

The tiger-nut tubers used in this study were procured from Eke-Ekwuluobia Market in Aguata Local Government Area while moringa seeds were obtained from a local farm in Oko community of Orumba North Local Government Area, both in Anambra State, Nigeria.

Preparation of Tiger-nut Milk Enriched with Moringa Seeds

The methods described by Osaloni *et al. (2019)* with slight modifications were used to produce the tiger-nut milk. Two hundred grams (200 g) of fresh tiger-nuts were sorted, washed, and soaked in water for 12 hours with constant change of water at three-hour intervals. The soaked tiger-nuts were washed, drained, and mixed with 1.5 g (5 seeds), 3 g (10 seeds), and 6 g (20 seeds) of freshly harvested moringa seeds respectively. The mixtures were milled with a Q-Link auto electric blender using 500 ml of clean water. The slurry obtained was filtered with the aid of clean muslin cloth. 350 ml of tigernut/moringa milk was generated for samples TM1, M2, TM3 and TM4.These samples were transferred into sterilized bottles, corked, pasteurized at 72°C for 15 seconds, and refrigerated until needed for analysis.

Proximate Analysis

The moisture, ash, protein, crude fat, and crude fibre content of the samples were determined using the official methods of AOAC (2012) while carbohydrate was calculated by difference.

Sensory Evaluation

The sensory characteristics of the product such as colour, taste, aroma, mouth-feel, and general acceptability were examined by a team of twenty semi-trained panelists drawn from students of the polytechnic who are familiar with milk products. Sample presentation was randomized and presented to each panelist at the same time using identical containers. A sensory booth was fitted with lighting that supported visual judgment on colour attributes. Each panelist was asked to score each coded sample based on a nine-point hedonic scale where 9 represented "extremely liked" and 1 represented "extremely disliked" (Iwe, *2010*).

Statistical Analysis

The data obtained were subjected to various statistical analyses which include simple descriptive mean, standard deviation, and Analysis of Variance (ANOVA), while Duncan's Multiple Range Test was used to separate the means using version 25.0 of SPSS Software (SPSS Inc., Chicago, IL, USA).

RESULTS

Table 1: Proximate composition (%) of tiger-nut milk enriched with freshly harvested moringa seeds.

Samples	Moisture	Ash	Fibre	Fats	Protein	Carbohydrates
TM1	88.20d±0.01	2.83d±0.02	0.12d±0.02	1.01d±0.02	0.93c±0.07	6.82a±0.03
TM2	88.40c±0.01	3.00c±0.00	0.33c±0.03	1.65c±0.05	1.53b±0.05	5.09b±0.01
TM3	88.70b±0.07	4.57b±0.01	0.85b±0.03	1.80b±0.01	1.92a±0.02	2.18c±0.02
TM4	89.10a±0.17	4.93a±0.03	0.97a±0.01	1.89a±0.01	1.98a±0.01	1.15d±0.01

*Values are means ± standard deviation of triplicate determinations. Means with the same superscript in the same column are not significantly different ($p<0.05$);

TM1 = Tiger-nut milk enriched with 0 pieces of moringa seed; TM2 = Tiger-nut milk enriched with 5 pieces of moringa seed; TM3 = Tiger-nut milk enriched with 10 pieces of moringa seed; TM4 = Tiger-nut milk enriched with 20 pieces of moringa seed.

Table 2: Sensory Properties of tiger-nut milk enriched with freshly harvested moringa seeds.

Sensory tribute	TM1	TM2	TM3	TM4
Appearance	8.65a ± 0.20	8.40a ± 0.15	8.10a ± 0.12	8.23a ± 0.01
Colour	6.10a ± 0.03	6.15a ± 0.05	6.18a ± 0.04	6.22a ± 0.01
Aroma	4.51cd ± 0.01	4.65c ± 0.02	4.80b ± 0.01	4.98a ± 0.00
Taste	7.50a ± 0.10	6.80b ± 0.08	6.10c ± 0.05	5.50d ± 0.00
Consistency	7.00a ± 0.01	6.90a ± 0.02	6.80a ± 0.01	6.70a ± 0.00
Overall acceptability	7.15a ± 0.05	7.10ab ± 0.04	7.00b ± 0.03	5.76c ± 0.01

*Values are mean ± SD (n = 3). TM1 = control (no Moringa seed); TM2 = 1.5 g (5 seeds); TM3 = 3.0 g (10 seeds); TM4 = 6.0 g (20 seeds) of freshly harvested Moringa oleifera seeds.

Superscripts [a, b, c] — means with different letters in the same row are significantly different ($p<0.05$); means with the same letter are not significantly different ($p>0.05$).

DISCUSSION

Proximate Composition

The results of the proximate composition of tiger-nut milk enriched with different numbers of moringa seeds are presented in Table 1. The moisture content of the samples ranged from 88.20% in the control (TM1) to 89.10% in the sample containing 20 pieces of moringa seeds (TM4). There was a significant difference ($p<0.05$) in the moisture content of the samples, with values slightly increasing with increasing addition of moringa seeds. These results are consistent with the findings of Osaloni *et al. (2019)*, who recorded a similar trend in tiger-nut milk fortified with moringa seed powder. The relatively high moisture contents across all samples are characteristic of plant-based beverages, which inherently have high water activity due to their liquid nature. The generally high moisture content observed suggests that these beverages will be prone to microbial proliferation if not stored under refrigeration or subjected to adequate preservation treatments (Belewu *and* Belewu, *2007*). This is consistent with the findings of Lasekan *et al. (2013),* who also noted the susceptibility of tiger-nut milk to spoilage at ambient temperatures.

The ash content of the samples increased significantly ($p<0.05$) from 2.83% in TM1 to 4.93% in TM4 with increasing addition of moringa seeds. Ash content serves as an index of the total mineral content of a food product. The progressive increase in ash content suggests that moringa seeds contributed substantially to the mineral composition of the enriched milk, which is in agreement with previous reports on the high mineral content of moringa seeds (*Fahey, 2003*; *Anwar et al., 2007*). Moringa seeds are rich in essential minerals including calcium, potassium, phosphorus, magnesium, zinc, and iron (Bolarinwa *et al., 2017*), all of which would contribute to the elevated ash values recorded in this study. Higher ash content in food products is desirable as it reflects improved mineral density, which is particularly important for addressing micronutrient deficiencies prevalent in sub-Saharan Africa (Adebayo-Oyetoro *et al., 2019*).

Similar increasing trends were observed for the crude fibre and fat contents of the enriched tiger-nut milk. Crude fibre values ranged from 0.12% in TM1 to 0.97% in TM4, while fat content ranged from 1.01% in TM1 to 1.89% in TM4, with significant differences ($p<0.05$) existing among the samples. The increased fibre content observed with the addition of moringa seeds can be attributed to the fibrous nature of whole moringa seeds, which contain both soluble and insoluble dietary fibres (Fahey, *2003*). Dietary fibre plays a critical role in preventing constipation, reducing blood cholesterol levels, and lowering the risk of colorectal cancer (Adebayo *et al., 2014*). The increased fat content is similarly attributable to the oil-rich nature of moringa seeds. Moringa seed oil (ben oil) contains approximately 73% oleic acid and has been reported to be one of the most stable vegetable oils due to its high antioxidant content (Anwar *et al., 2007*). The presence of healthy unsaturated fatty acids in the enriched tiger-nut milk may protect the heart and blood vessels.

The protein content of the samples ranged from 0.93% in the control (TM1) to 1.98% in TM4, revealing a steady increase with increasing moringa seed addition. No significant difference ($p>0.05$) existed between the protein contents of samples TM3 and TM4, but these samples significantly differed ($p<0.05$) from the control and TM2. The low protein content of the control is consistent with earlier reports on tiger-nut milk, which generally has a lower protein content compared to soy milk or cow's milk (Umelo *et al., 2014*). The enrichment with moringa seeds improved the protein content of the milk, which is in line with the well-documented high protein quality of moringa seeds. Moringa seeds contain all essential amino acids and have a protein efficiency ratio that is comparable to casein (Fahey, *2003*). Osaloni *et al. (2019)* recorded a higher protein value of 2.97% for tiger-nut milk fortified with moringa seed powder, suggesting that grinding moringa seeds to powder before incorporation may result in more efficient protein extraction compared to using whole seeds, as was the case in the present study. The differences in formulation ratios, seed-to-liquid ratios, and the particle size of the moringa seeds used may also account for the variability in protein values between studies.

The carbohydrate content of the products decreased significantly with increasing addition of moringa seeds, ranging from 6.82% in TM1 to 1.15% in TM4. Since carbohydrate was calculated by difference, this decrease is a reflection of the increases recorded in the other proximate components (moisture, ash, fibre, fat, and protein). Although moringa seeds contain some carbohydrates, their contribution to the total carbohydrate pool is lower relative to that of the tiger-nuts themselves, which are known for their high starch and sugar content (Umelo *et al., 2014*). The reduction in carbohydrate content may be beneficial for consumers who require low-glycemic index foods, such as diabetic patients (Sethi *et al., 2016*).

Sensory Evaluation

The results presented in Table 2 revealed that the appearance scores of tiger-nut milk samples ranged from 8.10 (TM3) to 8.65 (TM1), with no significant difference (p>0.05) observed among all treatment levels. The control sample (TM1) recorded the highest appearance score, while TM3 (3.0 g; 10 seeds) recorded the lowest. The non-significant difference in appearance across all treatments suggests that the addition of freshly harvested *Moringa oleifera* seeds at the levels used in this study did not substantially alter the visual appeal of the tiger-nut milk. The colour scores of the tiger-nut milk samples ranged from 6.10 ± 0.03 (TM1) to 6.22 ± 0.01 (TM4), and no significant difference (p>0.05) recorded among the treatments. The aroma scores increased progressively from 4.51 ± 0.01 in TM1 (control) to 4.98 ± 0.00 in TM4, with a significant difference (p<0.05) observed between them. The gradual increase in aroma scores with increasing moringa seed inclusion levels of freshly harvested moringa seeds, which are are known to contain glucosinolates and isothiocyanates, which upon hydrolysis release pungent volatile compounds that can enhance the aroma profile of food products (Fahey *et al.*, 2001). The taste scores of the tiger-nut milk samples showed a significant decline (p<0.05) with increasing levels of *Moringa oleifera* seed addition, ranging from 7.50 in TM1 to 5.50 in TM4. The control sample (TM1) recorded the highest taste score and was significantly different from TM4. This declining trend in taste acceptability with increasing moringa seed inclusion is not unexpected, as *Moringa oleifera* seeds has mild, slightly, pea-like taste. The consistency scores of the tiger-nut milk samples ranged from 6.70 ± 0.00 (TM4) to 7.00 ± 0.01 (TM1), with no significant difference (p>0.05) observed among all treatment levels. Although a slight downward trend in consistency was observed with increasing Moringa seed addition, the differences were not statistically significant. This suggests that the addition of freshly harvested *Moringa oleifera* seeds at the levels used in this study did not significantly alter the texture or body of the tiger-nut milk. The overall acceptability scores of the tiger-nut milk samples ranged from 5.76 ± 0.01 (TM4) to 7.15 ± 0.05 (TM1), with a significant difference (p<0.05) observed between the control and the highest Moringa seed inclusion level. The control (TM1) and TM2 recorded the highest acceptability scores of 7.15 and 7.10 respectively, both of which were significantly higher than TM4 (5.76). These results suggest that fortification of tiger-nut milk with freshly harvested *Moringa oleifera* seeds is most acceptable at inclusion levels up to 3.0 g (10 seeds), beyond which the sensory quality, particularly taste, may be compromised.

CONCLUSION

The findings of this study have demonstrated that the addition of freshly harvested moringa seeds at varying levels to tiger-nut milk significantly improved its proximate composition, resulting in increased moisture, ash, crude fibre, fat, and protein contents, while reducing the carbohydrate content. The sensory evaluation showed that increasing *Moringa oleifera* seed addition progressively improved aroma but significantly reduced taste and overall acceptability at the highest inclusion level (6.0 g), while appearance, colour, and consistency were unaffected across all treatments ($p>0.05$). It is recommended that further studies be conducted to evaluate the micronutrient profile and microbial safety of the product.

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