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Evaluation of nutritional quality, physicochemical components and overall acceptability of milk produced from a blend of tiger nut and peanut

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Abstract

The tigernut and peanut milk (TNM-PNM) was produced by soaking methods, the formulations were in six different tigernut and peanut ratios: 90:10, 80:20, 70:30, 60:40, 50:50 and 100:0 (control) represented as M1, M2, M3, M4, M5 and M0 respectively. Nutritional and physicochemical analysis were carried out on the samples. The results showed that M1 had the highest protein and crude fibre contents with mean values of 3.77±0.02% and 0.06±0.00% respectively. M5had the highest ash content with a mean value of 1.77.03±0.08% while the M2 blend had the highest carbohydrate content of 7.07±0.74%. M0 had the highest moisture and fat contents of91.35±0.01%and 0.73±0.02%respectively, which were not significantly different from M1. The pH values of all formulations ranged from 4.79 to 5.57.M1had the highest total titratable acidity of 0.04±0.01% while the highest total soluble solids was observed in M4 and M5 with the value of 5.00±0.00. Highest mineral contents for calcium (263.04±8.54) mg/100mL, phosphorus (134.67±52.25)mg/100mL and Magnesium (171.04±0.95)mg/100mL were recorded in M5.The sensory evaluation revealed a notable variation in the aroma and overall acceptability in the six formulations. All the TNM-PNM formulations were acceptable as they contained most of the vital nutrients in milk from animal sources.

Keywords: Tiger nut milk; Peanut milk; Nutritional quality; Sensory evaluation

1 Introduction

Milk is a nutrient-dense dairy product that supplies energy and significant amounts of protein and micronutrients. It contains high-quality protein and significantly contribute to daily requirements for calcium, magnesium, selenium, riboflavin, vitamin B12, and pantothenic acid. It provides protein and other micronutrients such as potassium, zinc, vitamin A, and if fortified, vitamin D to the body [1].

Milk is usually obtained from the mammary gland of humans, cows, sheep, cattle, etc. However, commercial milk production from animal sources can be expensive and complex as their components interact with other elements and participate in various biological processes. Their complexity has been implicated in cardiovascular diseases and increased LDL cholesterol [2, 3]. It can be deduced from the highlighted studies that several factors need to be assessed before vouching for these postulations. Some of these factors are age, gender, health status, level of physical activity, and variations in the genetic blueprint of dairy products' nutrients. Interestingly, these factors may even vary between countries, depending on peculiarities like species and breeds of dairy animals [1].

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Animal milk products are high in lactose and may not be tolerated by all. Aside from these limitations, milk inclusion in the diet provides diversity and it is a good tool for tackling malnutrition due to its multiple nutrient values. Widespread consensus and substantial evidence showed that undernutrition during the first two years of life is a strong predictor of child mortality [1, 4].Early childhood malnutrition has long-term, severe health and developmental consequences among those who survive. Also, hidden hunger is a micronutrient deficiency in developing countries [5].

Cow milk which is the most common dairy source of dairy may not be sufficient due to the economic value and easy access to all and sundry. Therefore, in the advent to create a milk alternative and also to include milk as a significant fraction of functional foods that can be introduced in the various milk programme to combat malnutrition in developing countries, milk can be produced from plant food substances that are rich and nutrient-dense like peanut and tiger nut tubers.

Tiger nut (*Cyperus esculentus*) is known by different names depending on the ethnicity in Nigeria ,'Aya' (Hausa), 'Aki-Hausa' (Igbo), and 'Ofio' (Yoruba) [6, 7, 8]. Three varieties of the plant are grown in Nigeria - the brown, black, and yellow varieties. The yellow variety is larger, more attractive in colour, and fleshy[9]. This tasty tuberous plant can be consumed fresh or roasted. It can also be processed to obtain juice for beverage production and as animal feed [10,11]. The plant possesses a length of 1-2 cm, with an asymmetrical shape when dry and an oval or round shape when immersed in water [10,12].

In the past, tiger nut was underrated, but now, researchers have shown interest in the nutritious tuber as several studies confirmed that tiger nutsare rich inessential nutrients for good growth and development at the various stages of human life. Proximate composition analysis showed that tiger nut is packed with carbohydrates and fibre needed for proper digestion [7, 8, 10, 13,14]. In addition, all varieties of this plant are rich in essential minerals such as calcium, magnesium, sodium, phosphorous, and potassium required for various metabolic processes in the body [8]. It also contains vitamins A, C, and E and different amino acids [8, 10].Tiger nut tubers may be processed into one of several products such as milk, oil, flour, candies, etc. as the awareness of its different nutritional values has been exploited.

Tigernut milk is a traditional non-alcoholic beverage in West Africa, it is a good substitute for vegetarians and persons with lactose intolerance [15]. The tiger nut milk can be produced via water extraction in combination with other fruits like coconut, date, pineapple, sweet potato, cocoa, etc. [16, 17, 18, 19, 20, 21].

Infusion of natural herbs like cinnamon, cloves, coriander, ginger, rosemary, and black pepper with a low storage temperature of 4°C can increase the shelf life of tigernut milk by five days [22]. In addition [23] reported that pasteurization and addition of 0.02 % sodium azide extended the shelf stability of tigernut milk stored at 28 °C to 12 days without affecting its organoleptic properties. However, standard methods such as high-pressure processing, high-pressure homogenization, pulsed electric fields, and ultrasound can affect the processing and preservation of tigernut milk when used as a hurdle [24].

Peanuts, or "groundnuts" as they are called in some parts of the world, are the edible leguminous seeds cultivated worldwide. Peanut (*Arachis hypogaea*) is considered a pea and belongs to the family (*Fabaceae*) of bean/legume[25, 26].The seed crop is economical for oil production, besides oil, the by-products of peanuts contain a variety of other valuable substances that could be utilized as an active component in a variety of processed meals, including proteins, fiber, polyphenols, antioxidants, vitamins, and minerals. Recently it has also been identified that peanuts are excellent source of compounds like resveratrol, phenolic acids, flavonoids, and phyto-sterols that block cholesterol absorption from the diet. It also has all the 20 amino acids with the most arginine and it is a vital source of coenzyme Q10. These bioactive substances are considered to prolong life and have been shown to have the ability to prevent illnesses[27].

Peanuts have been developed into products like roasted peanuts, peanut butter, peanut oil, peanut paste, peanut sauce, peanut flour, peanut milk, peanut beverage, peanut snacks (salted and sweet bars), and peanut cheese analog. Raw peanuts are consumed all over the world while roasted peanuts are processed by heating the peanuts to 180 °C for 12–15 min or at 160 °C for 40–60 min, depending on the moisture content. Peanut skin significantly affects the products' antioxidant properties, fiber, and phenol content when consumed as reported by Yuanyuan*et al*. [28]in butter production.

Combining this highly nutritious product with another excellent product like tigernut will make an excellent functional food product. Such product combinations are specially formulated to eradicate malnutrition amongst vulnerable populationsin many African countries. In recent times, groundnut has majorly been used for these purposes[29].

Peanuts, is rich in various nutrients as a result it is used in the production of milk, which can be done using multiple methods like blanching, sprouting, and roasting [30]. All procedures had an appreciable amount of carbohydrate, protein, crude fat, ash, and crude fibre contents and had stable physicochemical properties with high pH and low titratable acidity concentration [30].

Milk production from animal sources can be expensive and complex as their components interact with other elements in biological processes which has led to various implications like increase risk of cardiovascular diseases and increased LDL-cholesterol, in addition cow milk which is the most common milk source may not be sufficient due to the economic value and easy access to all and sundry, therefore a need to create a milk alternative from plant which has led to this present study.

2 Materials and methods

2.1 Collection of samples

Fresh, raw, and wholesome peanut and brown dried tiger nut were purchased at a local market in Sagamu, Ogun State, Nigeria.

2.2 Preparation of samples

Peanut milk was produced according to the soaking method by[30] with little modifications. In this method, the peanut was shelled, sorted, weighed (500g), washed, then soaked with potable water at room temperature for 24 hoursand ground with water in ratio 1:2 (edible nuts to water). Next, the peanut ground mixture was filteredwith a clean muslin cloth to separate the milk from the shaft. Finally, the peanut milk was mixed thoroughly, then pasteurized (85ºC for 15 minutes) and cooled.

The tiger nut milk was produced by soaking method, 500g of dried tiger nuts were sorted and washed before being soaked in portable water for 24hours after which the brown dried tiger nut turned golden yellow and bigger. The water was changed every 8 hours during the soaking period to prevent a foul stench. After 24 hours, it was washed and milled. The mixture was sieved with a muslin cloth to separate milk from the bulk. Finally, the milk was homogenized and poured into a sterile glass jar.

2.3 Composite Milk blend Formulations

Five different composite milk blend samples were formulated from the tiger nut and peanut milk with the control sample M0 which was 100% tiger nut milk.

Table 1 Sample formulations of Fresh Milk from a blend of tiger nut and peanut

S/N	Samples	TNM %	PNM%
1	M0	100	0
2	M1	90	10
3	M2	80	20
4	M3	70	30
5	M4	60	40
6.	M5	50	50

TNM: Tiger nut milk; PNM:Peanut milk

2.4 Proximate Compositions

Crude protein and moisture were determined using [31] methods; fat was determined using the solvent extraction methodin a Soxhlet reflux apparatus as described by Pearson, 1991 [32]. The crude fibre was determined using Weende's method as described by Pearson, 1996 [33], ash content was determined using a process described by James, 1995[34]. The carbohydrate was also determined by difference as described by James, 1995[34].

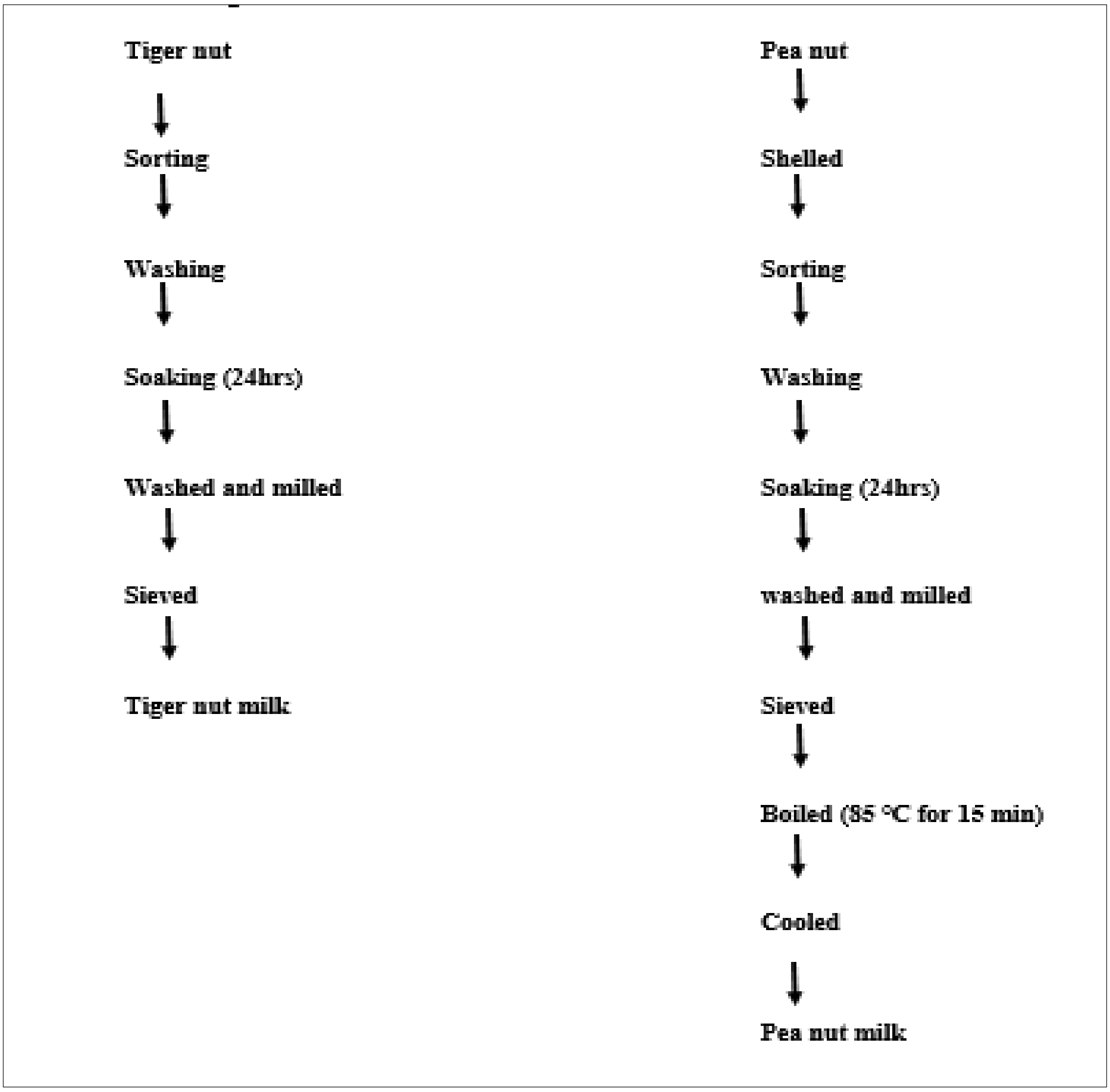

Figure 1 Formulation processes oftiger nut and peanut milk

2.5 Minerals and vitamin D evaluation of the composite milk

Calcium, phosphorus, and magnesium were determined using Atomic Absorption Spectrophotometer (AAS) [35] described by Shahidi*et al.,*1999[36].Vitamin D was determined spectrophotometrically using a standard method of [37].

2.6 Physicochemical evaluation of the composite milk

pH was evaluated usinga pH meter (JenwayModel) as described by Nielsen, 2003[38]. Total soluble solids (TSS) Brix was determined using a portable digital refractometer (ERMA, Japan) with a scale of 0–32°Brix (least count0.2°Brix) at room temperature (~30˚C).Also, the Titratable acidity was determined according to the AOAC official method 942.15 [37]. All chemical analysis were carried out at Boom Food Analytical Laboratory in Ibadan, Oyo State, Nigeria where all equipment and reagents used were also acquired.

2.7 Sensory evaluation of the composite milk

Organoleptic properties were determined using a semi-trained panelists consisting of 40 individuals. Appearance, colour, flavor, taste, and overall acceptability were the sensory attributes checked using a 9-point hedonic scale questionnaire.

The sensory evaluation was carried out at the Sensory Evaluation Laboratory of the Department of Food Technology, Gateway (ICT) Polytechnic, Saapade, Ogun State, Nigeria.

3 Results and discussion

Table 2 Proximate compositions of Fresh Milk produced from the blend of Tiger nut and Peanut

Sample	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Fibre(%)	CHO Content (%)
M0	91.35±0.01^{a}	2.14±0.01^{e}	0.82±0.03^{c}	0.73±0.02^{a}	0.04±0.00^{b}	4.91±0.06^{c}
M1	91.28±0.06^{a}	3.77±0.02^{a}	1.13±0.06^{b}	0.46±0.34^{a}	0.06±0.00^{a}	3.12±0.06^{d}
M2	89.00±0.69^{b}	2.33±0.02^{d}	1.17±0.06^{b}	0.40±0.00^{a}	0.03±0.00^{d}	7.07±0.74^{a}
M3	89.37±0.08^{b}	2.98±0.02^{b}	1.20±0.1^{b}	0.52±0.00^{a}	0.04±0.00^{b}	5.90±0.09^{b}
M4	89.50±0.56^{b}	2.64±0.02^{c}	1.27±0.12^{b}	0.46±0.00^{a}	0.04±0.00^{c}	6.09±0.49^{b}
M5	90.47±0.06^{a}	2.36±0.02^{d}	1.77±0.08^{a}	0.41±0.00^{a}	0.04±0.00^{d}	4.95±0.02^{c}

Values are mean ± standard deviations that were deduced in triplicates. Means on the same row and column with different sets of superscripts are significantly different ($p < 0.05$).

Table 2 showed the results of the proximate parameters - moisture, protein, ash, crude fibre, fat, and carbohydrate of the fresh milk produced from a blend of tiger nut and peanut. The protein and crude fiber contents were in their highest proportions in the composite blend of M1 with mean values (3.77±0.02 and 0.06±0.00) % respectively.However, the ash content was highest in the composite blend of M5 with a value of (1.77±0.08) %while the mixed blend of M2 had the highest carbohydrate content of (7.07±0.74)%.M0 had the highest moisture and fat contents (91.35±0.01and 0.73±0.02)% respectively, which were not significantly different from the composite blend of M1.

The milk blend from tiger nut and groundnut had high nutrient values of protein, ash, and carbohydrate. The ash content present in all the formulated tiger nut-peanut milk blends in this study were higher thanthose of whole milk (0.72 %) and skimmed milk (0.75 %)from animal sourcesas reported by FAO[1]from a secondary data analysis. The carbohydrate contents of M2, M3 and M4 from this study werehigher than the value of carbohydrate content as also reported by FAO[1] for wholemilk (4.65 %) and skimmed milk (4.96%) from animal sources, M0 and M5 were within the same range while M1 had lower carbohydrate content when compared with the reported values. Furthermore, comparingthe protein content of the whole milk (3.28 %) and skimmed milk (3.37 %) samples from the animal source with the protein content of the formulations in this study,the M1 blend was higher, while that of other formulations were lowerthan those from the whole milk and skimmed milk from animal source.

The protein, ash, and carbohydrate contents of all the formulated milks were higher than the values of (2.34, 1.17, and 4.33)% for protein, ashand carbohydrate respectively reported in raw tiger nut milk only by [39]except for protein and ash in M0, ash and carbohydrate in M1 with protein in M2 which were lower, while the ash in M2 was in the same range with the reported values. This revelation indicates that the milk formulation is an excellent alternative tobe introduced in the various milk programme to combat malnutrition, especially amongst low-income earners in developing countries.

As a result of high moisture content in the formulated milk, the shelf life might be shortened; therefore, it may need to be consumed in its fresh form or refrigerated to retain its properties.

Table 3 pH, Titratable acidity and Brix properties of fresh Milk produced from the blend of Tiger nut and Peanut

Parameters	M0	M1	M2	M3	M4	M5
pH	5.57±0.07^{a}	5.28±0.02^{b}	4.80±0.11^{c}	5.15±0.06^{b}	4.94±0.03^{c}	5.14±0.05^{b}
Titratable acidity (TTA)(mg/100mL)	0.03±0.01^{ab}	0.04±0.01a	0.03±0.00^{ab}	0.02±0.01^{bc}	0.01±0.00^{c}	0.01±0.00^{c}
Brix (TSS)	2.73±0.06^{e}	3.00±0.00^{d}	3.80±0.00^{c}	4.00±0.00^{b}	5.00±0.00^{a}	5.00±0.00^{a}

Values are mean ± standard deviations that are deduced in triplicates. Means on the same row and column with different sets of superscripts are significantly different ($p \leq 0.05$).

The results of the pH, as shown in Table 3 indicates that M0 has the highest pH(5.57) whileM2 has the lowest pH (4.80). The high pH value observed in the fresh milk produced which were slightly acidic may be attributed to the nature of the plants as legumes and nuts are acid-forming foods[40]. The pH values ofTNM-PNM in this study contradicted the value of 7.24 which was alkalinein nature asreported by [39] butlower than the value of fresh groundnut milk reported by [30]. The different processing methods in the two cited studies may be responsible for the observed variations. The highest value for total titratable acidity (TTA) was recorded in M1 (0.04±0.01 mg/100mL) while formulations of M4 and M5 had the leastTTA - 0.01±0.00mg/100mL. The TTA values observed in these formulations agreed with the assertion of Schmidt *et al.*, [41] that high quality raw milk always have low TTA when expressed as lactic acid.

For the total soluble solids, M4 and M5 had the highest value of 5.00±0.00% while M0 had the lowest total soluble solids of 2.73±0.06%reflecting from the Brix values. The values were low when compared to camel and raw cow milk with TSS of12.69±3.2% and 15.00±0.07%respectively as reported by[42]. Generally the values of TSS of the tiger nut milk and TNM-PNM blends in this study were lower than those reported byAyuba*et al.*,[43] which ranged between 8.0 and 9.7%.

Table 4 Vitamin D and mineral composition of fresh Milk produced from the blend of Tiger nut and Peanut

Sample	Vit. D (mg/100mL)	Calcium (mg/100mL)	Phosphorus (mg/100mL)	Magnesium (mg/100mL)
M0	0.01±0.00^{b}	122.67±2.74^{d}	80.67±1.61^{ab}	108.73±6.82^{d}
M1	0.01±0.00^{a}	130.59±4.27^{cd}	72.83±0.29^{b}	119.40±0.47^{d}
M2	0.01±0.00^{a}	125.00±4.27^{cd}	84.00±4.77^{ab}	137.71±7.82^{c}
M3	0.01±0.00^{a}	136.18±4.27^{c}	86.67±2.08^{ab}	142.08±3.41^{bc}
M4	0.01±0.00^{a}	154.82±2.80^{b}	93.33±5.25^{ab}	153.01±8.61^{b}
M5	0.01±0.00^{b}	263.04±8.54^{a}	134.67±52.25^{a}	171.04±0.95^{a}

Values are mean ± standard deviations that are deduced in triplicates. Means on the same row and column with different sets of superscripts are significantly different (p ≤ 0.05).

Vitamin D, calcium, magnesium, and phosphorus contents are shown in Table 4. It can be deduced that the M5 milk formulation had the highest mineral contents with calcium, phosphorus, and magnesium contents of (263.04±8.54, 134.67±52.25and 171.04±0.95) mg/100mL respectively with each value not significantly different (p>0.05) from one another. This result agrees with the reports of[38, 44,45, 46]thatboth tiger nut milk and groundnut milk are rich in nutrients, although with a higher content in tiger nut.Vitamin D content in all the formulations was 0.01±0.00 mg/mL. It could be deduced from this study that tiger nut might likely be the source of vitamin D in all the samples because the same value was observed for all the samples analyzed.Presence of vitamin D in milk enhancescalcium absorption [47].

Table 5 Sensory Evaluation of fresh Milk produced from the blend of Tiger nut and Peanut

Sample	Appearance	Texture	Mouthfeel	Aroma	Taste	Overall acceptability
M0	4.84^{a}	4.22^{a}	3.97^{a}	4.92^{a}	4.20^{a}	4.43^{a}
M1	4.85^{a}	4.20^{a}	3.98^{a}	4.95^{a}	4.23^{a}	4.44^{a}
M2	4.98^{a}	4.28^{a}	4.23^{a}	4.25^{b}	4.33^{a}	4.41^{a}
M3	4.90^{a}	4.25^{a}	4.38^{a}	4.38^{ab}	4.30^{a}	4.44^{a}
M4	5.00^{a}	4.55^{a}	4.15^{a}	4.30^{ab}	4.18^{a}	4.44^{a}
M5	5.05^{a}	4.35^{a}	4.33^{a}	4.25^{b}	4.08^{a}	4.42^{a}

Values are mean ± standard deviations that are deduced in triplicates. Means on the same row and column with different sets of superscripts are significantly different (p < 0.05).

For the sensory evaluation of the six milk samples, there was no significant difference in the appearance, texture, mouthfeel, and taste of all the samples. However, there was a significant difference in the aroma of the six evaluated formulations (p < 0.05). More specifically, the aroma of the M1 milk formulation had the highest evaluation of M = 4.95, SD = 0.88, p = 0.03). The mean score was not significantly different from that of M0 milk formulation but it was significantly higher than the milk formulation of M2 and M5 (M = 4.25, SD = 1.316, p = 0.03), which had similar interactions. Beside the marked variations observed in the aroma, no other significant difference wasobserved in the other assessed parameters. For example, the overall acceptability of formulationsM1, M3, and M5 had the highest overall acceptability of 4.44. On the other hand, the M5 formulation had the lowest value for overall acceptability (4.42) as shown in Table 5.

4 Conclusion

The result of this study revealed tha tall the tiger nut – peanut milk (TNM-PNM) formulations had appreciable amount of protein withM1 milk formulation having the highest protein content. Vitamin D was also present in all the TNM-PNM milk formulations. M5 milk formulation had the highest ash content and in turn having the highest calcium, magnesium, and phosphorus. Then utrient compositions of all the TNM-PNM milk were higher than that of tiger nut milk or peanut milk only. In addition, all formulations of the TNM-PNM were acceptable compared to only tiger nut milk.This acceptability was as a result of the presence of most of the vital nutrients in milk from animal sources. This study then concludes that the TNM-PNM blends of 50:50 and 90:10 were the best formulations and will be good for nourishing both young and old consumers.

Recommendations

- More research is needed to increase the shelf lives of the formulations in this study as they contained high moisture content and therefore, a need for preservative.
- They can be included in the milk fortification programme for eradication of malnutrition in vulnerable populations.
- Wastes gotten from TNM-PNM processing can be used in feed formulation

Contribution to knowledge

- Milk from plant source is rich in vital nutrients ranging from the macro nutrients to the micronutrients.
- Combination of tigernut and groundnut milk has higher nutrient contents than either of them in its single form with similar acceptability level.
- The milk from plants are more readily available and cost effective which is a good substitute for those having lactose intolerance.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors have declared that no competing interests exist

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