

Nutritional Values, Anti-Nutritional Factors and Molar Ratio of Minerals to Anti-Nutrients of Plant-Based Yoghurt from Bambaranut, Soybean and *Moringaoleifera* Seed Milks

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ABSTRACT

An evaluation into the quality characteristics of plant-based yoghurt from bambaranut, soy and moringa oleifera seed milks was carried out. Nutritional values, anti-nutritional factors and molar ratio of minerals to anti-nutrients of the plant-based yoghurt were studied. The study revealed that the nutritional content of the plant-based yoghurt was enhanced tremendously with increase in Moringa seed milk addition. There was significant increase ($p < 0.05$) in the proximate and mineral composition of the product with increasing level of Moringa seed milk. The ash content ranged from 0.36 – 0.74, the control sample (716) (100% cow milk) recorded the highest value 0.74 % followed by sample 577 (50% Soymilk + 35% Bambaranut + 15% Moringa seed milk) and Sample 985 (35% Soymilk + 50% Bambaranut + 15% Moringa seed milk) both had 0.69 % as value of ash content. The protein content ranged from 3.25 – 3.99 % with samples 577 and 985 having the highest values of 3.99 % and 3.85 % respectively. The calcium content ranged from 152.47–181.34 mg/ml, sample 985 has the highest value (181.34 mg/ml). Also potassium content ranged from 118.43-63-145.63 mg/ml, sample 577 recorded the highest value of Potassium (145.63 mg/ml). The anti-nutritional factors of these yoghurt products were significantly low; lectins ranged from 0.12-0.59 mg/100g, oxalate 0.16-0.62 mg/100g, phytate ranged from 2.37-8.78 mg/ml, saponins 0.86-3.75 mg/100g and tannins 1.11-3.53 mg/ml. Similarly, the molar ratios of minerals to anti-nutrient were below the critical values indicative of mineral bioavailability. The range is as follows: Phytate:Ca = 8.0×10^{-4} to 3.17×10^{-3} ; Phytate:K = 1.12×10^{-3} to 3.62×10^{-3} ; Phytate:Mg = 6.44×10^{-3} to 2.10×10^{-2} ; Phytate:P = 9.33×10^{-4} to 3.66×10^{-3} and Oxalate:Ca = 4.07×10^{-4} to $.85 \times 10^{-3}$.

Keywords: plant-based yoghurt, bambara nut, moringa seed milk, soymilk

INTRODUCTION

Interest in functional foods has recently increased among consumers due to a greater consciousness of health and nutrition; as well as the need to cure diseases and also the increasing scientific evidence of their effectiveness, thus making fermented food products to play a significant part of many indigenous diets (Opara *et al.*, 2013). One example of such fermented food is yoghurt. The word “yoghurt” is derived from Turkish “jugurt”, used to describe any fermented food with an acidic taste (Younus *et al.*, 2002). Yoghurt is a fermented milk product obtained from fermentation of lactose in milk of animal sources by the activities of *Streptococcus thermophilus* and *Lactobacillus bulgaricus* (Sanful, 2009). Yoghurt is known for its high nutritional and therapeutic properties; consequently the product has gained tremendous attention in recent times

in both developed and developing world (Karagulet *al.*, 2004). Moreover, yoghurt supplies good quality proteins, also an excellent source of calcium, phosphorus, potassium and contains significant quantities of general vitamins (Demott, 1985).

Recent developments in human nutrition call for sourcing cheap and abundant protein foods. Due to the high content of cholesterol-which has been implicated as the cause of coronary heart disease in animal proteins, alternatives have been consistently sought after in plant protein foods. Abundant proteins in legumes are thus, cheaper sources of proteins that would serve the purpose (Adebowale and Lawal, 2003). Several authors have reported on the functionality of legumes that are underutilized but are potential sources of cheap protein in developing countries (Chavan *et al.*, 2001; Chel-Guerrero *et al.*, 2002; Dzudie and Hardy, 1996). The affordability of

plant protein source relative to that of animal origin has led to the intensified development of legume processing as a means of enhancing the availability, palatability and diversity of leguminous source of dietary protein. In addition to legumes, nuts and seeds such as *moringa oleifera* seeds are beginning to gain more attention in food product development due to their known nutritional and therapeutic properties. The scarcity of milk supply in developing countries has led to the development of alternative milk sources from vegetable sources (Onweluzo and Nwakalor, 2009). Also, vegetable milks could be used as vegetarian nutrition or for medical reasons, in cases of milk allergies and galactosemia (Obizoba and Egbuna, 1992).

Bambaranut, also known as Bambara groundnut (*Vigna Subterranean*) is an indigenous African crop that is now grown across the continent from Senegal to Kenya and from the Sahara to South Africa (Atiku *et al.*, 2004). It originated in the Sahelian region of present day West Africa, which its name originating from the Bambara tribe who now live mainly in Mali (Nwana *et al.*, 2005). As the shortage of food continues to be a major problem in Africa, these legumes are being promoted more than before in order to help in combating malnutrition (Okafor *et al.*, 2003). Studies had revealed the detailed nutritional composition to be 16% crude protein, 9.7% moisture, 5.9% crude fat, 2.9% ash and 64.9% total carbohydrate (Aremu, 2006). It contains an appreciable amount of lysine and a minimum amount of trypsin and chymotrypsin as reported by Rachie (2000). Also, according to Yusuf *et al.* (2008) Bambaranut contains 7.3% moisture, 18 to 24% protein, 6.0 to 6.5% fat and 60 to 63% carbohydrates.

The Soybean (*Glycine max* L.), is one of the oldest crops of China, and has been used by Chinese and other Oriental cultures for centuries in many forms as one of the most important source of protein and oil (Wilson 1991). Soybean is one of the most important oil, protein, a good source of energy, vitamins and minerals crops of the world (Nwokolo, 1996; Islam *et al.*, 2007). Soybean has gained increase in its utilization as a staple crop due to its high nutritional and excellent functional properties (Ren *et al.*, 2006). It is rich in protein (39.4 %), carbohydrates (27.1 %) and oil (20.6 %) (Osundahunsi *et al.*, 2007).

Moringa oleifera belongs to a monogeneric family of shrubs and tree, *Moringaceae*.

Moringa is a multipurpose tree and it has a great potential to become one of the most economically important crops for the tropics and subtropics considering its use in many fields as a food (Pontualet *et al.*, 2012) because of its micronutrients which are beneficial to human for consumption; medicine because of its therapeutic value (Peixoto *et al.*, 2011; Anwar *et al.*, 2007). *Moringa oleifera* seeds contain more vitamin A than carrots, more calcium than milk, more vitamin C than oranges, and more potassium than bananas, 4 times the fibre in oats, 9 times the iron in spinach, and that the protein quality rivals that of milk and eggs (Khawaja *et al.*, 2010).

Utilization of Bambaranut, Soya bean and *Moringa oleifera* seed milks in the production of plant-based yoghurt would combat proteins and micronutrient malnutrition in both children and women since this combination would provide a dense nutrient profile product for these target population.

Therefore, the aim of this study was to investigate the nutritional values, anti-nutritional factors and molar ratio of minerals to anti-nutrient of plant-based yoghurt from Bambaranut, soybean and *moringaoleifera* seed milks.

MATERIALS AND METHODS

Procurement of Materials

Soybeans, Bambaranut, *Moringa oleifera* seeds and cow milk powder were purchased from North-bank market in Makurdi, Benue state. While Freeze dried lactic acid producing bacteria (mixed culture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus*) was purchased from Modern market also in Makurdi, Benue state.

SAMPLE PREPARATION

Preparation of Bambaranut Milk

Bambaranut seeds were manually sorted, cleaned with potable water and soaked in (4.1 w/v) potable water for 24hrs, while water used in soaking was changed at every 6hrs interval during the soaking duration. The seed coat of the nuts were dehulled after 24hrs of soaking by rubbing the seeds with the palm and the husks was sieved out of the water and subsequently wet milled using hammer mill. Cheese cloth was used in the extraction of milk from the bambaranut mash by triple filtered by folding the cheese cloth thrice.

Preparation of Soymilk

The method described by Udeozor (2012) with slight modification was used to prepare the soymilk. One kg of soybeans was soaked overnight for 18hrs in a3 L of warm potable water to give a bean: water ratio of 1:3. The beans were then drained, rinsed with potable water and blanched for 5min in boiling water. The blanched beans were drained, dehulled and ground with 750 ml of potable water using attrition mill. The resulting slurry was filtered through a muslin cloth and the extract (milk) was obtained.

Preparation of Moringa Oleifera Seed Milk

Moringa oleifera seeds were sorted, dehulled, 1 kg weighed, washed with potable water, soaked for 6hrs, drained, blanched for 10mins, wet milled and filtered to obtain *Moringa oleifera* seed milk.

Preparation of Mother Culture

Cow milk powder was reconstituted by dissolving 800 g in 3.5 litres of water as recommended by the manufacturer. The whole milk was heated to 95°C for 5min, then cooled rapidly to 45°C and inoculated with 0.2% (w/v) of freeze-dried culture. The inoculated mix was incubated for 6 hours at 40-45°C to develop proper acidity, then cooled and stored at 6°C.

Yoghurt Formulation

Eight yoghurt formulations were produced by varying the proportions of soymilk, Bambaranut milk and *Moringa oleifera* seed milk. Formulation 716 (100% cow milk) was used as control; The mixed samples were pasteurized at 95°C for 5min, then rapidly cooled to 45°C and inoculated with 15% (w/v) mother culture (figure 1). These samples were incubated at 40-45°C for 6hours and then cooled rapidly.

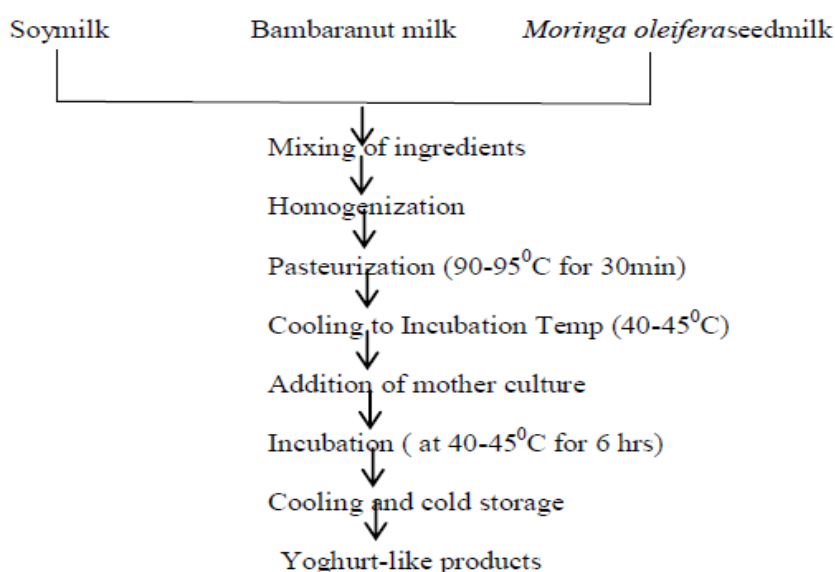


Figure1. Flow Chart for the Production of plant-based yoghurt from Bambaranut, Soy and Moringa Oleifera Seed Milks

Proximate Composition Analysis

The ash, crude protein, crude fat and moisture content of the samples were determined by using standard methods of AOAC (2012).Carbohydrate was determined by difference as reported by Ihekoronye and Ngoddy, (1985).

Mineral Determination

The mineral content of samples was determined using the method described by AOAC (2012). Two grams of samples were transferred into a crucible and ashed in a muffle furnace at 500°C for 3hours. The crucibles were removed after

the ashing was completed. After cooling, 10ml of 2M HCl acid was added and heated directly until boiling. The contents in each crucible were thereafter transferred into 50ml volumetric flask and then diluted to 50ml. The optical density of elements except phosphorus was determined using the Atomic Absorption Spectrophotometer (Model 2011-A). Phosphorus (P) was determined colorimetrically by vanadomolybdate procedure.

Determination of Antinutrients

Five grams of sample was weighed and extracted with hexane in a 50.0ml vial. The extract was filtered and the filtrate was then injected into a Buck scientific (USA) BLC10/11

High Performance Liquid Chromatography (HPLC) system fitted with a fluorescence detector (excitation at 295 nm and emission at 325 nm) and an analytical silica column (25 cm x 4.6mm ID, stainless steel, 5 µm). The mobile phase used was hexane: tetrahydrofuran: Iso-propanol (1000:60:4 v/v/v) at a flow rate of 1.0ml/min. Standards of each antinutrient was prepared. The prepared standards were treated and analyzed in the same manner as the samples using same method. Area of each peak from both samples and standards chromatograph were calculated and recorded. The concentration of the antinutrient was calculated using the following formula:

$$[\text{Conc. of Antinutrient}] = \frac{[\text{A SAMPLE} \times [\text{STD}] (\text{ppm}) \times \text{V HEX} (\text{ml})]}{[\text{A STD} \times \text{Wt SAMPLE} (\text{g})]}$$

Where;

[Conc. of antinutrient] = concentration of Antinutrient in ppm

[STD] = concentration of standard

A SAMPLE = peak area of sample

A STD = peak area of standard

V HEX = volume of hexane

Wt SAMPLE = weight of sample

Determination of Molar Ratio of Antinutrients To Minerals

The molar ratio between antinutrient and mineral was obtained after dividing the mole of antinutrient with the mole of minerals (Woldegiorgiset al., 2015).

Statistical Analysis

All data obtained from the experiments were statistically analysed using a one way Analysis of Variance (ANOVA) and means separated by Duncan's Multiple Test. The significant differences between means were determined by Least Significant Difference (LSD) test as described by Ihekoronye and Ngoddy (1985). Significant difference was accepted at 5% level of probability.

RESULT AND DISCUSSION

Proximate Composition of Plant-Based Yoghurt from Bambaranut, Soy and *Moringa Oliefera* Seed Milks (%).

The proximate composition of plant-based yoghurt produced from Soy, Bambaranut and *Moringaoleifera* seed milks is shown in Table 1.

There was significant difference ($p < 0.05$) in the proximate composition of all the products. The ash content ranged from 0.36 – 0.74. The control sample (716) (100% cow milk) recorded the highest value 0.74 % followed by sample 577 (50% Soymilk + 35% Bambaranut + 15% Moringa seed milk) and Sample 985 (35% Soymilk + 50% Bambaranut + 15% Moringa seed milk) both had 0.69 % as value of ash content. The high ash content recorded for sample 577 and 985 might be attributed to high proportion of Moringa seeds in the product. The amount of ash is an indication of the presence of minerals in food samples. *Moringa* seed is known for its high ash content (Khawaja *et al.*, 2010; Hassan and Galal, 2016). The ash content of the plant-based yoghurt products increased with increase in the level of substitution of the *Moringa* seeds milk. The trend obtained in this study was in corroboration with those reported by Eke *et al.* (2013) who reported that increasing the amount of baobab fruit pulp resulted in an increase in the ash content of a plant-based yoghurt. Other researchers reported higher ash content (0.89-1.13 %) of non-fat skimmed yoghurt (Mistry and Hassan, 1992). Similarly, Balogun *et al.* (2017) reported that addition of bambaranut to cow milk enhanced the ash content of yoghurt-like product from cow milk and bambaranut.

The carbohydrate content of plant-based yoghurt ranged from 7.38 – 10.34 %. The result is in line with those reported by Eke *et al.* (2013) who recorded carbohydrate content of 5.25-10.01% for the yoghurt-like product from Baobab (*Adansonia digitata*) Fruit Pulp Emulsion and the Micronutrient Content of Baobab Leaves. Similarly, Ukwo (2015) reported that substituting cow milk with soymilk up to a level of 70% had significant ($p < 0.05$) increase (5.02-5.19) on the carbohydrate contents of yoghurt-like product. The higher carbohydrate content recorded in this work might be attributed to the high carbohydrate content of bambaranut as reported by (Aremu, 2006; Yusuf *et al.*, 2008).

The protein content of plant-based yoghurt from soy, bambaranut and *Moringa* seed milks ranged from 3.25 – 3.99 % with samples 577 and 985 having the highest values of 3.99 % and 3.85 % respectively. The protein content of the plant-based yoghurts was higher than the control (100% cow milk yoghurt) and this might be attributable to high protein content of Bambaranut (Mune *et al.*, 2011), soybeans (Serrem *et al.*, 2011) and Moringa seeds (Aja *et*

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al., 2013). The protein content of the products increased with increasing level of substitution of *Moringa* seed milk. The result obtained was in line with those recorded by Oyeniyi *et al.*, 2014. The authors reported protein contents between 3.33-3.74 % in their work on “Effect of Flavorings on Quality and Consumer Acceptability of Soy-Yoghurt”.

The increase in the protein content of the products in this study is logical since bambaranut, soybeans and *Moringa* seeds are well known for their high protein content.

The fat content of the products ranged from 3.22 – 4.19 %. Sample 577 recorded the highest value of fat while the control sample (716) recorded the least value of fat. The fat content of plant-based yoghurt was higher than the control (100% cow milk yoghurt) and this might be attributed to high fat content of soybeans (Liu, 1997; Glami, 2002) and *Moringa* seeds (Hassan and Galal, (2016)). The results obtained were in agreement with those reported (3.29-4.00 %) by Sampson *et al.* (2017) in their work on

“Preparation of Semi-dairy Yoghurt from Soy bean”.

The moisture content of the yoghurt-like products ranged from 82.09 – 83.75 %. The result of the study revealed that increasing the substitution level of bambaranut resulted to decreasing level of the moisture content and this probably was due to higher reconstitution index of bambaranut compared to the composite milk used in the production of the yoghurt-like products (Falade *et al.*, 2014). However, the result of this study was lower than those reported by Eke *et al.* (2013). The authors reported moisture content of yoghurt-like product ranging from 83.73-90.76%. Ukwo (2015) reported moisture content ranging from 85.53- 88.32 % for yoghurt-like product from cow milk and soymilk which were higher than the finding of this study. Although, the finding of this study fell within the range of the acceptable standard for commercial yoghurt (80-85%)

Table1. Proximate Composition of Yoghurt-like Products Produced from Bambaranut, Soy and *Moringa* *olieifera* seed milks (%)

Samples	Ash	CHO	Protein	Fat	Moisture
716	0.74 ^a ± 0.00	9.50 ^c ± 0.07	3.25 ^c ± 0.00	3.22 ^d ± 0.02	83.29 ^c ± 0.01
424	0.36 ^f ± 0.03	9.30 ^c ± 0.07	3.47 ^c ± 0.24	3.79 ^c ± 0.00	83.08 ^d ± 0.00
839	0.57 ^d ± 0.02	10.34 ^a ± 0.02	3.35 ^c ± 0.00	3.24 ^d ± 0.03	82.47 ^f ± 0.03
746	0.36 ^f ± 0.00	8.79 ^d ± 0.01	3.40 ^c ± 0.07	3.85 ^c ± 0.42	83.60 ^b ± 0.02
958	0.62 ^c ± 0.00	9.95 ^b ± 0.07	3.42 ^c ± 0.01	3.92 ^{bc} ± 0.00	82.09 ^g ± 0.01
469	0.43 ^e ± 0.03	8.73 ^e ± 0.03	3.38 ^c ± 0.12	3.88 ^b ± 0.98	83.58 ^b ± 0.00
577	0.69 ^b ± 0.00	7.38 ^f ± 0.00	3.99 ^a ± 0.01	4.19 ^a ± 0.01	83.75 ^a ± 0.07
985	0.69 ^b ± 0.01	8.80 ^d ± 0.28	3.85 ^b ± 0.11	4.01 ^b ± 0.01	82.65 ^e ± 0.07
LSD	0.03	0.25	0.10	0.10	0.03

Values are means ± SD duplicate determinations

Values with different superscript within the same column are significantly different ($p < 0.05$)

Key: 716 = 100 % cow milk (control), 424= 95 % Soymilk + 5 % *Moringa* seed milk; 839= 95 % Bambaranut milk + 5 % *Moringa* seed milk; 746= 70 % Soymilk + 25 % Bambaranut milk + 5 % *Moringa* seed milk; 958= 30 % Soymilk + 60 % Bambaranut milk + 10 % *Moringa* seed milk; 469= 45 % Soymilk + 45 % Bambaranut milk + 10 % *Moringa* Seed milk; 577= 50 % Soymilk + 35 % Bambaranut milk + 15 % *Moringa* seed milk; 985 = 35 % Soymilk + 50 % Bambaranut milk + 15 % *Moringa* seed milk.

Mineral Composition of Plant-Based Yoghurt Produced from Bambaranut, Soybean and *Moringa* *Olieifera* Seed Milks.

As shown in Table 2, There was no significant difference ($p > 0.05$) in the calcium content of samples 716, 577 and 985, also samples 424, 746, 958 and 469 did not vary significantly ($p > 0.05$) in calcium content. The calcium content ranged from 152.47 – 181.34 (mg/100g) values. Sample 985 (35% Soymilk + 50% Bambaranut + 15% *Moringa* seed milk) had the highest value (181.34 mg/100g) while sample

746 (70% Soymilk + 25% Bambaranut + 5% *Moringa* seed milk) has the least value (152.47 mg/100g). The result revealed that the calcium content of the plant-based yoghurt increased with an increase in the substitution with *Moringa* seed milk. The high calcium content of sample 985 may be attributed to the high proportion of *Moringa* seed milk. The amount of calcium obtained in this study was higher than those reported by various authors: Moreno Rojas *et al.* (1993), 1525 mg / kg; Sanchez-Segarra *et al.* (2000) reported values of 990 mg / kg for a

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strawberry yoghurt, All the values obtained by these researchers were lower than those obtained in this study. However, Ihemeje *et al.* (2015), recorded higher calcium content (180.00-180.05 mg/g) in their work titled “Production and quality evaluation of flavored yoghurts using carrot, pineapple, and spiced yoghurts using ginger and pepper fruit”.

There was significant difference ($p < 0.05$) in the Potassium content of all the products. Sample 577 recorded the highest value of Potassium (145.63 mg/100g) while sample 839 recorded the least value of potassium (122.65 mg/100g). The high level of potassium in sample 577 might be attributed to increased proportion of *Moringa* seed milk coupled with high proportion of soymilk. Thus, it can be inferred that addition of *Moringa* seed milk and soymilk enhanced the potassium content of the plant-based yoghurt. The result of potassium for this study was higher than those reported by Amellal-Chibane and Benamara (2011).

There was no significant difference ($p > 0.05$) in the Magnesium content of all the products. The values of Magnesium ranged from 12.65 to 15.85 mg/100g . The result of Magnesium was

lower than those reported by Amellal-Chibane and Benamara (2011). The authors reported magnesium in the range of 132.16-267.85 mg/kg in yoghurt supplemented with date powder of three dry varieties. Similarly, Ihemeje *et al.* (2015) reported higher values for magnesium (170.00-170.14 mg/g). The values obtained in the present study were lower than those reported by those authors probably due to the food materials used in the formulation, Ihemeje *et al.* (2015) used fruits that are rich in mineral content.

The Phosphorous content ranged from 95.63 to 129.64 mg/ml. There was significant difference ($p < 0.05$) in the Phosphorous content of all the products. The findings of the study revealed that increasing both bambaranut milk and *Moringa* seed milk resulted to a proportionate increase in the phosphorus content the plant-based yoghurt. This increase probably was due to high quantity of phosphorus in both *Moringa* seed milk and bambaranut compared to soymilk. The findings of this study were lower than those reported by Ihemeje *et al.* (2015) who reported values ranging from 158.00-158.33 mg/g.

Table 2. Mineral Composition of plant-based yoghurt Produced from Bambara nut, Soy and *Moringa oliefera* seed milks (mg/100g)

Samples	Ca	K	Mg	P
716	178.54 ^a ±2.85	124.63 ^{dc} ±2.82	13.55 ^a ±0.01	119.35 ^a ^{bc} ±3.25
424	157.65 ^c ± 2.89	134.47 ^{bc} ± 2.83	14.53 ^a ±2.82	105.65 ^{bc} ±0.00
839	166.25 ^b ±2.83	122.65 ^{de} ±2.82	14.76 ^a ±2.82	112.39 ^{bc} ±1.41
746	152.47 ^c ±2.82	137.03 ^b ±2.82	14.63 ^a ±2.83	95.63 ^c ±2.83
958	155.51 ^c ±2.83	118.43 ^c ±2.83	15.08 ^a ±4.24	121.56 ^a ±1.48
469	156.26 ^c ±4.28	127.46 ^{cd} ±2.83	12.65 ^a ±2.86	124.34 ^a ±5.71
577	179.83 ^a ±2.87	145.63 ^a ±7.11	15.85 ^a ±2.89	115.43 ^{bc} ±7.11
985	181.34 ^a ±1.47	142.66 ^{ab} ±2.8	15.66 ^a ±3.53	129.64 ^a ±1.41
LSD	6.79	8.43	6.87	27.71

Values are means ± SD duplicate determinations

Values with different superscript within the same column are significantly different ($p < 0.05$)

Key: 716 = 100 % cow milk (control), 424= 95 % Soymilk + 5 % *Moringa* seed milk; 839= 95 % Bambaranut milk + 5 % *Moringa* seed milk; 746= 70 % Soymilk + 25 % Bambaranut milk + 5 % *Moringa* seed milk; 958= 30 % Soymilk + 60 % Bambaranut milk +10 % *Moringa* seed milk; 469= 45 % Soymilk + 45 % Bambaranut milk + 10 % *Moringa* Seed milk; 577= 50 % Soymilk +35 % Bambaranut milk + 15 % *Moringa* seed milk; 985 = 35 % Soymilk + 50 % Bambaranut milk +15 % *Moringa* seed milk

Anti-Nutritional Content of Plant-Based Yoghurt Produced from Bambaranut, Soybean and *Moringa Oliefera* Seed Milks (Mg/100g)

Table 3 shows the anti-nutritional content of yoghurt and plant-based yoghurt from Bambaranut milk, Soymilk and *Moringa oliefera* seed milk. There was significant difference ($p < 0.05$) in the anti-nutritional

content of the yoghurt samples. The lectins ranged from 0.12 to 0.59 mg/100g. The amount of lectin detected in this study is negligible, thus it can be inferred that the plant-based yoghurt were safe for consumption. The values of lectin obtained in this study were in accordance with the values reported by Omoikhoje *et al.* (2006). The authors recorded lectin contents ranging from 0.17 to 0.77mg/100g in their work on Raw,

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Soaked, Dehulled and Germinated Bambara groundnut seeds”.

The oxalate content of samples ranged from 0.16 to 0.62 mg/100g with sample 716 (100% cow milk) had lowest value (0.16 mg/100g) while sample 746 (70% Soymilk + 25% Bambaranut milk + 5% Moringa seed milk) had the highest value (0.62 mg/100g). The higher oxalate content of the samples might be attributed to the fact that plants have higher amount of oxalate compared to animals food sources. Mba *et al.* (2012) reported higher oxalate values (2.52 to 3.58mg/100g) in their work on *Moringa Oleifera* seeds”. The lower values reported in this study might be attributed to the processing techniques employed in this study.

The phytic acid content ranged from 2.37 to 8.78 mg/100g. Sample 716 recorded the lowest phytate value (2.37 mg/100g) while sample 577 (50% Soymilk +35% Bamabara milk + 15% Moringa seed milk) had highest phytate value (8.78 mg/100g). Similar results were obtained by Pele *et al.* (2016) who reported phytate values of 5.45 to 8.05 % in their work on “Effects of Processing Methods on the Nutritional and Anti-Nutritional Properties of Soybeans (*Glycine max*)”. Mba *et al.* (2012) recorded higher phytate values (3.28 to 11.70 mg/100g) than the ones obtained in this study. The lower phytic value recorded for sample 716 might be attributable to the fact that phytic acid is mostly found in plant food sources. Generally, the results of this study showed that plant-based

yoghurt have low amount of phytic acid and this might be attributed to the processing techniques used.

The saponins content ranged from 0.86 to 3.75 mg/100g. Sample 577 (50% Soymilk +35% Bamabara milk + 15% Moringa seed milk) had highest saponin value (3.75 mg/100g) while sample 716 (100% cow milk) recorded lowest value (0.86 mg/100g). The saponins content were higher than the value recorded for the control sample probably due to the fact that this anti-nutrient is commonly found in plant food materials. Oluwole *et al.* (2013) reported higher (7.50 to 8.00 mg/100g) saponin values than the result obtained in this study. The values of saponin obtained in the work were actually higher than the ones reported by Mba *et al.* (2012), and this might be attributed to the high quantity of saponin in soybean.

The tannins content of the products ranged from 1.11 to 3.53 mg/100g. Sample 716 (100% cow milk) recorded the lowest value (1.11 mg/100g) while sample 424 recorded the highest value (3.53 mg/100g). Pele *et al.* (2016) and Mba *et al.* (2012) reported higher tannin contents of 19.23 – 25.23 mg/100g and 1.23 – 9.83 mg/100g respectively. Although, Omoikhoje *et al.* (2006) reported lower values for tannins content ranging from (0.03 to 0.11 mg/100g). The variations between the values of tannins recorded in this study might be attributed to difference in type and proportion of raw materials used.

Table3. Anti-nutrients of Yoghurt-like Products Produced from Bambaranut, Soybean and *Moringa oliefera* seed milks (mg/100g).

Samples	Lectins	Oxalates	Phytates	Saponins	Tannins
716	0.12 ^c ±0.03	0.16 ^a ±0.02	2.37 ^a ±0.03	0.86 ^d ±0.04	1.11 ^d ±0.00
424	0.28 ^{cd} ±0.06	0.33 ^{cd} ±0.04	8.24 ^a ±0.05	3.62 ^a ±0.03	3.53 ^a ±0.14
839	0.47 ^b ±0.03	0.36 ^{cd} ±0.08	5.47 ^c ±0.04	2.72 ^c ±0.03	2.36 ^{bc} ±0.18
746	0.59 ^a ±0.01	0.62 ^a ±0.03	5.13 ^c ±0.00	2.65 ^c ±0.07	2.51 ^{bc} ±1.55
958	0.43 ^b ±0.04	0.39 ^c ±0.06	6.12 ^b ±0.03	3.11 ^b ±0.01	2.43 ^{bc} ±0.28
469	0.25 ^d ±0.00	0.43 ^{bc} ±0.04	6.33 ^{bc} ±0.04	3.53 ^a ±0.04	2.65 ^b ±0.17
577	0.24 ^d ±0.03	0.52 ^{ab} ±0.03	8.78 ^a ±0.15	3.75 ^a ±0.31	2.76 ^b ±0.30
985	0.35 ^c ±0.03	0.29 ^d ±0.01	7.05 ^b ±1.43	2.81 ^c ±0.14	2.16 ^c ±0.18
LSD	0.07	0.10	1.17	0.29	0.46

Values are means ± SD duplicate determinations

Values with different superscript within the same column are significantly different ($p < 0.05$)

Key:716 = 100 % cow milk (control), **424**= 95 % Soymilk + 5 % Moring seed milk;

839= 95 % Bambaranut milk + 5 % Moringa seed milk; **746**= 70 % Soymilk + 25 % Bambaranut milk + 5 % Moringa seed milk; **958**= 30 % Soymilk + 60 % Bambaranut milk +10 % Moringa seed milk; **469**= 45 % Soymilk + 45 % Bambaranut milk + 10 % Moringa Seed milk; **577**= 50 % Soymilk +35 % Bambaranut milk + 15 % Moringa seed milk; **985** = 35 % Soymilk + 50 % Bambaranut milk +15 % Moringa seed milk

Molar Ratios of Minerals to Anti-Nutrients in Yoghurt-Like Products Produced from Bambaranut, Soy and Moringa Oleifera Seed Milks.

The molar ratios of phytate to calcium, potassium, magnesium phosphorous and oxalate to calcium of the plant-based yoghurt to predict their bioavailability is as shown in Table 4. The phytate: Calcium molar ratio was higher in samples from bambaranut milk, soymilk and moringa seed milk compared to whole cow milk yoghurt. Phytate: Calcium molar ratios >0.24, indicative of poor calcium available. But as shown in this study, the ratios of Phytate: Calcium in all the samples was less than the critical value of 0.24 indicative of bioavailability of calcium in the products. Although, higher calcium bioavailability was observed in sample 716 (100% cow milk).

The phytate : Potassium molar ratio was highest in sample 424 and lowest in sample 716

respectively. Phytate:Potassium molar ratios >0.5, indicates poor bioavailability of potassium. Phytate: potassium molar ratio is considered as a better indicator of potassium bioavailability than total dietary phytate levels alone. The lower phytate: Mineral ratios from cow milk may be partly ascribed to the decreased content of phytic acid in animal food sources. For all the samples, the phytate: potassium molar ratio is less than 0.5 which means there would be no interference in availability of potassium. Joung *et al.* (2004) reported increase in bioavailability of minerals in grain legumes by decreasing phytic acid as a result of the action of phytase synthesized by micro-organism.

It was generally observed that molar ratios of minerals to antinutrients in yoghurt and yoghurt-like products produced in this study were lower than the critical values, indicative of bioavailability of these minerals.

Table4. Molar Ratios of Minerals to Anti-nutrients in Yoghurt-like Products Produced from Bambaranut, Soy and Moringa oleifera seed milks

Samples	Phytate:Ca	Phytate:K	Phytate:Mg	Phytate:P	Oxalate:Ca
716	8.0 x 10 ⁻⁴	1.12 x 10 ⁻³	6.44 x 10 ⁻³	9.33 x 10 ⁻⁴	4.07 x 10 ⁻⁴
424	3.17 x 10 ⁻³	3.62 x 10 ⁻³	2.10 x 10 ⁻²	3.66 x 10 ⁻³	9.51 x 10 ⁻⁴
839	1.99 x 10 ⁻³	2.64 x 10 ⁻³	1.40 x 10 ⁻²	2.29 x 10 ⁻³	9.83 x 10 ⁻⁴
746	2.04 x 10 ⁻³	2.21 x 10 ⁻³	1.30 x 10 ⁻²	2.52 x 10 ⁻³	1.85 x 10 ⁻³
958	2.39 x 10 ⁻³	3.05 x 10 ⁻³	1.50 x 10 ⁻²	2.36 x 10 ⁻³	1.14 x 10 ⁻³
469	2.46 x 10 ⁻³	2.93 x 10 ⁻³	1.80 x 10 ⁻²	2.39 x 10 ⁻³	1.25 x 10 ⁻³
577	2.96 x 10 ⁻³	3.56 x 10 ⁻³	2.00 x 10 ⁻²	3.57 x 10 ⁻³	1.31 x 10 ⁻³
985	2.36 x 10 ⁻³	2.92 x 10 ⁻³	1.70 x 10 ⁻²	2.55 x 10 ⁻³	7.27 x 10 ⁻⁴
CV	>0.24	>0.50	>1.00	>0.50	>1.00

Values are means ± SD duplicate determinations

Values with different superscript within the same column are significantly different (p<0.05)

Key:716 = 100 % cow milk (control), 424= 95 % Soymilk + 5 % Moring seed milk; 839= 95 % Bambaranut milk + 5 % Moringa seed milk; 746= 70 % Soymilk + 25 % Bambaranut milk + 5 % Moringa seed milk; 958= 30 % Soymilk + 60 % Bambaranut milk +10 % Moringa seed milk; 469= 45 % Soymilk + 45 % Bambaranut milk + 10 % Moringa Seed milk; 577= 50 % Soymilk +35 % Bambaranut milk + 15 % Moringa seed milk; 985 = 35 % Soymilk + 50 % Bambaranut milk +15 % Moringa seed milk

CONCLUSION

This study revealed that combination of bambaranut milk, soymilk and *Moringa oleifera* seed milk in yoghurt production yielded highly nutritious products with increased protein and mineral contents. *Moringa oleifera* seed milk enhanced the proximate and mineral contents of yoghurt-like products from Bambaranut milk and soybean milk. Thus it can be inferred that *Moringa seed* milk is a rich source of protein and mineral supplement and this makes it suitable for use in food product development for both adults and infants. It was observed that the

anti-nutritional factors of the plant-based yoghurt were within the acceptable standards, indicative of bioavailability of these minerals when consumed. Similarly, Molar Ratios of Minerals to Anti-nutrients in the plant-based yoghurt were below the critical values indicative of mineral bioavailability.

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Citation: Edith Ani, Bibiana Igbabul, Julius Ikya and Julius Amove, "Nutritional Values, Anti-Nutritional Factors and Molar Ratio of Minerals to Anti-Nutrients of Plant-Based Yoghurt from Bambaranut, Soybean and *Moringaoleifera* Seed Milks", *Research Journal of Food and Nutrition*, 3(4), 2019, pp. 18-28.

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