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Full Length Research Article

MINERAL COMPOSITION AND ANTI-NUTRITIONAL FACTOR PROFILING IN FERMENTED DAIRY AND PLANT-BASED YOGHURTS: A COMPARATIVE STUDY

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ABSTRACT
This research determined the mineral contents and the anti-nutritional elements in the fermented dairy products of goat milk, cow milk, and plant-based yoghurt such as soy yoghurt, tiger nut yoghurt and coconut yoghurt. The study reveal that the fermentation improve the bioavailability of minerals in the plant-based yoghurt by mortifying phytates, cyanide, oxalate and Saponin content in the products. The plant based yoghurts have various levels of anti-nutritional factor values for SMY have highest phytate content of 18.99 ± 0.09 mg/100g and coconut milk yoghurt (CNY) have the lowest content 1.96 ± 0.07 mg/100g, CNY 90.29±1.21 mg/100g with highest content of cyanide and SMY 7.70 ± 0.40 mg/100g with lowest content, CNY 90.29 ± 1.22 mg/100g with highest value of oxalate and soy milk yoghurt (SMY) with lowest value of 0.03±0.01 mg/100g . For saponin CNY 67.51±0.47 mg/100g with highest value and TNY with least value of 0.05±0.01 mg/100g while for dairy yoghurt anti-nutritional factors value cow milk yoghurt (CMY) values is higher than goat milk yoghurt (GMY) values. The findings reveal that plant-based and animal based yoghurts have differing levels of mineral content in which certain samples like CMY, GMY and SMY are having high levels of calcium 16.05 ± 0.02 mg/100g, magnesium 12.62 ± 0.06 mg/100g and potassium 192 ± 4.55 mg/100g content.

Keywords: Dairy yoghurt, plant-based yoghurt, Anti-nutrition factor and Minerals.

INTRODUCTION
Yoghurt is a widely consumed fermented dairy products by activity of microorganisms like *Lactobacillus bulgaricus* and *Streptococcus thermophiles* that provide vital nutrients like minerals example calcium, vitamins and proteins that contribute to healthy living of human beings (Weerathilake *et al*., 2014). Lactose in milk, is converted to lactic acid during milk fermentation by microorganisms action that make the yoghurt easily digestible than milk, so those who are lactose tolerance or who cannot tolerate milk because of the protein allergy can consume yoghurt easily (Priyanka Aswal, 2012). There are different reasons for development of plant-based milk yoghurt which involve varying consumer's needs, product ingredients, opportunities in market, new technology and desire to feed world increasing population with sustainable and quality fermented foods (Bristone *et al*., 2015). The food industry presently, may be interested in evolving varieties of plant-based milk beverages that can serve as substitute for those that are lactose intolerance, vegetarians, and have allergy to cow milk (Badau *et al*., 2015). Because, several consumers desire to reduce use of animal products like bovine milk, cow milk, camel milk, goat milk etc. as a result of their health, ethical issues and environmental condition.
The plant-based product like tiger nut yoghurt, soy milk yoghurt, coconut yoghurt and corn yoghurt. The soy bean (*Glycine max*) protein is least expensive sources of dietary protein with their nutritional composition compare to animal protein which is taken as good alternative for animal protein, the protein of soy bean have vital amino acids for human and animal nutrition (Jiang *et al*., 2013). The quantity of protein, niacin, iron, and unsaturated fatty acid are high in soy milk but low in quantity of carbohydrates, calcium and fat compared to goat milk, cow milk and human milk. The monounsaturated and polyunsaturated fats of soy milk does not result to fat accumulation in blood vessels comprising those vessels in heart which does not result to heart diseases (Mazumder and Hongsprabhas, 2016).
Tiger nuts are tubers of plant *Cyperus esculenttus* with great food qualities, perfect nutritional balance and also rich in nutrients that keep the entire body healthy (Bristone *et al*., 2015). Tiger nut dietary fiber can control diabetes in line with first benefit, the vast healthy contribution and fiber balance delivered by tiger-nuts does not increase glucose levels of blood. So, these food is exceptional for fighting and preventing diabetes (Gambo and Da'u, 2014).
The coconut (*Cocus nucifera L.*) is nutritious and rich in minerals, dietary fibers and vitamins like vitamin C and E, consumption of milk from coconut have health benefits because of its antibacterial, anti-carcinogenic, antiviral and anti-microbial effects. Milk from coconut have cooling properties that aids in digestion and also maintain skin elasticity (Sethi *et al*., 2016). Milk of coconut haves medium fatty acids chain majorly lauric acid that is found in milk of human which have been connected to improvement of brain, cholesterol positive impact, improving immune system, body mass, insulin sensitivity, consumption of energy, waist circumference, blood vessels elasticity and general adiposity.

MATERIALS AND METHODS

Collection of Samples
Soybean (Glycine max) variety TGX-923-2E, tiger nut *Cyperus esculentus var. esculentus* and coconut variety East coast tall all was purchased from Kure market in Minna, Niger State.
Four liters of fresh cow milk and goat milk each were purchased directly from Fulani herders' farms. The fresh milk samples were collected in containers and transported under ice container to the laboratory for processing within 30 minutes of collection.

Preparation of Samples
The soy bean and tiger nuts were sorted, and cleaned to remove foreign materials and soaked for 8hrs. Coco nut shell and brown back were removed using dull knife, and washed with portal water.

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Processing of plant based milk for yoghurt production

All the plant raw materials were wet milled with Silver crest (SC-2023) Multifunctional industrial blender at 32000 RPM, on weight basis soy bean 4:1 w/v, tiger nut 3:1 w/v and coconut 3:1 w/v. The soybean, tiger nut and coconut slurry was filtered with cheese cloth and re-filtered with mesh sieve 160 to get the soy milk, tiger nut milk and Coconut milk. Five milk type samples was pasteurized separately at 80 °C for 15min in clean pot. The separately, pasteurized milk was placed in a water bath to cool down to 40-45 °C, for inoculation with the starter culture as described by (Collins *et al*., 1991). The cooled milk type was inoculated with the commercial starter culture by 50:50 pure culture of mixed strains of *Lactobacillus bulgaricus* and *Streptococcus thermophillus* 0.1 % (w/v) was used to inoculate 100 ml of the sterile each milk type to start fermentation. All sterile milk samples were poured into sterile plastic cups with cover then inoculated and incubated at 40 °C to ferment for 6 hours. After incubation period, the samples were stirred, cooled and stored in a refrigerator at 4 °C for further evaluation of mineral and Anti-nutritional (Mustafa *et al*., 2020).

Milk (Soy bean seed, tiger nut, coconut, goat and cow)
↓
Pasteurization (at 80 °C for 15 mins)
↓
Sugar added
↓
Cooling (40-45 °C)
↓
Inoculation of starter culture 0.1 % /100ml
↓
Fermentation for 4-6hours at 40 °C
↓
Curd form and Mixing
↓
Filling into sterile bottles
↓
Refrigeration at 4-10 °C

Figure 1: Flow chart for yoghurt production

Determination of Minerals Composition

The calcium, zinc, iron, phosphorus, sodium, copper, potassium and magnesium composition of the yoghurt samples was determined by atomic absorption spectrometer according to method described by AOAC, (2005) with method number 999.01.

Heavy metals was done by flame Emission Spectrophotometer with model AA-6200(Shimadzu, Japan) by using an air acetylene flame with four standard solution at least for each heavy metal, Coefficient of variation (% CV) in all samples was less than 2.5 % in heavy metal determination (Ziarati *et al*.,2017).

Determination of Anti-nutrients factors

Anti-nutrients factors of the yogurt was determined following standard procedures.

The saponin content of samples was determined according to method described by (Oloyed, 2005) using spectrometer absorbance taken at 490 nm. Phytic acid content was determined using a modified indirect colorimetric method of Wheeler and Ferrel (1971). For cyanide content determination, the alkaline picrate method described by Onwuka, (2005) was adopted. Oxalate content of samples was determined by permanganate titrimetric method as described by Oke,(1966).

Statistical Analysis

Statistical package for social science (SPSS) version 24 was used to analyze data and $p< 0.05$ was consider to be statistically significant, and the results was express as in mean ± deviation using Analysis of Variance (ANOVA) and significant means was separated using Duncan's multiple range test.

RESULTS

The mineral content results is presented in Table 1 for fermented dairy yoghurts and plant-based yoghurt. Mineral compositions of two dairy yoghurt compare with three plant-based yoghurt. The calcium content of dairy product like cow milk yoghurt CMY (16.05 ± 0.02) and goat milk yoghurt GMY (9.61 ± 0.00) samples are higher than the plant-based yoghurts samples of soy milk yoghurt SMY (5.66 ± 0.05), tiger nut milk yoghurt TNY (4.50±0.50) and coconut milk yoghurt CNY (3.21±0.01). Magnesium content for GMY (12.62±0.06) have the higher value than SMY (6.88±0.54), CMY (4.40±0.01), TNY (3.86±0.45) and CNY with lower value of (3.46±0.05). Iron content of the plant-based samples CNY (3.60±0.05) is higher than others like CMY (3.05±0.07), GMY (2.93±0.05), TNY (1.94±0.05) and SMY with lower value of (0.80±0.05). The sodium values of plant-based samples SMY (5.85±0.55), TNY (2.77±0.37), CNY (2.20±0.10) were higher than dairy yoghurt samples of GMY (4.85±0.05) and CMY (4.75±0.05) where GMY and CMY indicated statistically significant difference at ($p < 0.05$). The potassium values in plant-based samples are SMY (192.85±4.55), TNY (72.88±0.28), CNY (17.20±0.10), GMY (82.90±0.40) and CMY (81.40±0.10) which indicate significant difference across the column at ($p < 0.05$). Phosphorus content of CNY (4.06±0.83) and GMY (3.18±0.05) samples have higher values than SMY (2.18±0.05), TNY (2.72±0.39) and CMY sample with lower value of (2.18±0.05); Copper content values for plant-based samples are SMY (0.35±0.05), GMY (0.02±0.00), CMY (0.02±0.00), TNY (0.01±0.00) and CNY (0.01±0.00) with significant difference at $p>0.05$. Zinc content values for dairy samples GMY (3.54±0.05) and CMY (3.54±0.05) values are higher than others of plant-based yoghurt CNY (2.89±0.19), TNY (1.94±0.09) and SMY (0.38±0.05) showing significant difference at $p>0.05$. Cadmium and Lead contents in samples SMY (0.62±0.45), TNY (0.00±0.00), CNY, GMY and CMY are below detectable limit. All the mineral content reveals that there was statistically significant difference in all the yoghurt samples of dairy and plant-based yoghurt.

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Table 1: Mineral Composition of Dairy Yoghurt and Plant Based Yoghurt (mg/100 g)

Sample code	Ca (X ± SD)	Mg (X ± SD)	Fe (X ± SD)	Na (X ± SD)	K (X ± SD)	P (X ± SD)	Cu (X ± SD)	Zn (X ± SD)	Cd (X ± SD)
SMY	5.66±0.05^{cd}	6.88±0.54^{efg}	0.80±0.05^{efg}	5.85±0.55^{bcd}	192.85±4.55^{a}	2.18±0.05^{a}	0.35±0.05^{abcdef}	0.38±0.05^{d}	0.62±0.45^{d}
TNY	4.50±0.50^{b}	3.86±0.45^{fg}	1.94±0.05^{d}	2.77±0.37^{a}	72.88±0.28^{bcde}	2.72±0.39^{a}	0.01±0.00^{d}	1.94±0.09^{bc}	0.00±0.00^{a}
CNY	3.21±0.01^{c}	3.46±0.05^{d}	3.60±0.05^{cd}	2.20±0.10^{a}	17.20±0.10^{d}	4.06±0.83^{a}	0.01±0.00^{ab}	2.89±0.19^{efg}	BDL
GMY	9.61±0.00^{k}	12.62±0.06^{b}	2.93±0.05^{defg}	4.85±0.05^{cd}	82.90±0.40^{ef}	3.18±0.05^{ab}	0.02±0.00^{ab}	3.54±0.05^{d}	BDL
CMY	16.05±0.02^{f}	4.40±0.01^{d}	3.05±0.07^{abc}	4.75±0.05^{cde}	81.40±0.10^{g}	2.18±0.05^{b}	0.02±0.00^{abc}	3.54±0.05^{d}	BDL

Keys: SMY- Soy milk yoghurt; TNY- Tiger nut milk yoghurt; CNY- Coconut milk yoghurt; GMY-Goat milk yoghurt; CMY- Cow milk yoghurt; Values bearing the same alphabets down group are no significantly different ($p<0.05$), BDL: Below Detection limit, Values are presented as Mean± SD at ($p<0.05$).

Table 2 reveal the Anti-nutrient composition of the dairy yoghurts and plant based yoghurt. The phytate content of plant based yoghurt for SMY (18.99 ± 0.09), TNY (2.87± 0.11), CNY (1.96±0.07) while dairy yoghurts values include CMY (10.01± 0.12) and GMY (5.41± 0.29) which exhibited significant difference at p>0.05. Cyanide contents for plant based yoghurt include SMY (7.70 ± 0.40), TNY (74.90 ± 0.89), CNY (90.29±1.21) while dairy yoghurt like CMY (21.08±0.87) and GMY (14.18 ± 0.78) with significant difference p>0.05. Oxalate content of plat based yoghurts (0.03±0.01), TNY (59.80±0.41) and CNY (90.29±1.22) while dairy yoghurt like CMY (38.79±0.75) and GMY (38.79 ± 0.75). Saponin content for plant based yoghurt include SMY (37.36± 0.49), TNY (0.05 ± 0.01), CNY (67.51±0.47) while CMY (0.14 ± 0.01) and GMY (0.14±0.00) which indicate significant difference of plant-based yoghurt compare with dairy yoghurt at p>0.05.

Table 2: Anti-nutritional composition of fermented dairy and plant based yoghurt (mg/100 g)

Sample Code	Phytate (X ± SD)	Cyanide (X ± SD)	Oxalate (X ± SD)	Saponin (X ± SD)
SMY	18.99±0.09^{i}	7.70±0.40^{cd}	0.03±0.01^{e}	37.36±0.49^{i}
TNY	2.87±0.11^{f}	74.90±0.89^{a}	59.80±0.41^{h}	0.05±0.01^{b}
CNY	1.96±0.07^{l}	90.29±1.21^{e}	90.28±1.22^{a}	67.51±0.47^{abc}
GMY	5.41± 0.29^{k}	14.18±0.78^{jkl}	30.33±0.68^{kl}	0.14±0.01^{b}
CMY	10.01±0.12^{m}	21.08±0.87^{fg}	38.79±0.75^{d}	0.14±0.01^{a}

Keys: SMY- Soy milk yoghurt; TNY- Tiger nut milk yoghurt; CNY- Coconut milk yoghurt; GMY-Goat milk yoghurt; CMY- Cow milk yoghurt; Values bearing the same alphabets down group are not significantly different ($p<0.05$), Values are presented as Mean± SD at ($p<0.05$).

DISCUSSION

Yoghurt samples Na content is between 2.20 to 5.85 mg/100 g showing significant difference at p>0.05 in levels of Na content. Soy milk yoghurt (SMY) sample have highest content of Na 5.85 ± 0.55 mg/100 g which may be as a result of milk used while CNY sample have lowest content of Na 2.20 ± 0.10 mg/100 g that can be as a result of low sodium milk used. The plant-based yoghurt samples with high Na content may serve as complementary source for Na due to high content of the mineral. The main role of Na as a mineral in the human physiology is related to maintenance of physiological fluids like blood pressure Usman and Bolade, (2020).

Yoghurt samples calcium (Ca) content ranges from 3.21 to 16.05 mg/100g showing significant difference at p< 0.05 in the content. CMY fermented dairy sample have the highest Ca content of 16.05 ± 0.02 mg/100g as a result of high content of calcium in the milk used while CNY as plant based sample have the lowest calcium content of 3.21± 0.01mg/100g as a result of type of milk used or processing methods. In human diet insufficient Ca intake can cause conditions of disease as hypercholesterolemia, high blood pressure and osteoporosis Oladele and Aina, (2007).

Yoghurt sample potassium content ranges between 17.20 to 192.85 mg/100 g showing significant difference p<0.05 in the content of K. SMY plant based sample have the highest K content of 192.85 ± 4.55 mg/100 g which can be as a result of high K content presence in milk used while CNY plant based sample have low content of K 17.20 ± 0.10 mg/100 g that may be as a result of type of milk used. One of the most vital mineral in the body is K that helps the body to regulate the fluid balance, nerve signals and muscle contractions. A diet with high content of K help to decrease water retention and blood pressure, protection against kidney stone, osteoporosis and stroke as reported by Usman and Bolade, (2020).

Yoghurt samples Mg content ranges between 3.46 to 12.62 mg/100 g showing significant difference at p>0.05 in Mg content. GMY fermented dairy sample have highest Mg content of 12.62 ± 0.06 mg/100 g while CNY plant based sample have the lowest Mg content 3.46 ± 0.05 mg/100 g which is as a result of type of milk used. The values obtained in this study for both fermented dairy and plant based yoghurts are far below recommended daily allowance of 200-400 mg per day Kelly *et al*., (2022) however, since yoghurt is consumed as a snack drink, which can be regarded as a complimentary source for Mg. In the nutrition of human Mg have been linked to metabolism of energy, endothelial cells function and release of neurotransmitter which is also a co-factor of up to about 300 enzymes in the system of body Farinde *et al*., (2012).

Yoghurt samples Fe content ranges from 0.80 to 3.60 mg/100 g showing significant difference at p>0.05 in Fe content. CNY plant based sample have the highest content of Fe 3.60 ± 0.05 mg/100 g while SMY plant based sample have the lowest content of Fe 0.80 ± 0.05 mg/100 g which may be as a result of the type of milk used for yoghurt production. In this study its reveal that the plant base milk have high content of Fe than the animal based milk. Although, main function of Iron in human nutrition is linked to synthesis of myoglobin and hemoglobin in the blood Kelly *et al*., (2022). Yoghurt sample phosphorus content ranges from 2.18 to

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4.06 mg/100 g show significant difference at p>0.05. CNY plant based sample have the highest P content of 4.06 ± 0.83 mg/100 g while SMY and CMY sample have lowest P content 2.18 ± 0.05 mg/100 g which may be as a result of the type of milk used for yoghurt product with low P content. The phosphorus have been involved in metabolic actions in the body system such as in cell growth, contraction of the heart muscle and kidney function Gonzalez-tenorio and Fernandez diez, (2012). The phosphorus minerals are used by the body to make hormones, regulate body and build bones which are also important for making enzymes Usman and Bolade, (2020).
Yoghurt sample zinc (Zn) content ranges between 0.38 to 3.54 mg/100 g showing significant difference at p>0.05. Highest content of Zn was found in GMY and CMY fermented dairy samples with 3.54 ± 0.05 mg/100 g while lowest Zn content is found in SMY plant based sample 0.38±0.05 mg/100 g which can be as a result of zinc content in type of milk used for the sample production. The content of Zn is higher in animal based milk than in plant based milk, Zn in human nutrition is needed to defend body immune system and also to work effectively. Zn plays a vital role in cell growth, cell division, carbohydrate breakdown and healing of wound Oladele and Aina, (2007). Yoghurt sample copper content (Cu) ranges between 0.01 to 0.35 mg/100 g showing significant difference at p>0.05 with low Cu content. SMY sample have highest content of Cu with 0.35 ± 0.05 mg/100 g while TNY, CNY, CMY and GMY are found with lowest content of Cu which may be as a result of their low content in milk used or processing conditions for the samples production. All the yoghurt samples cadmium (Cd) and lead (Pb) content was below the detection limit showing that Cd and Lead are not the main contaminant in these samples.
Table 2 reveal the result of Anti-nutrient factors analyzed for the yoghurt samples of fermented dairy and plant-based yoghurt that shows significant difference in the content of phytate, cyanide, oxalate and saponin. The phyatate content ranges between 1.96 to 18.99 mg/100 g. The sample of SMY of plant based yoghurt have highest content of phytate (18.99 ± 0.09 mg/100 g) and CNY plant based yoghurt with lowest content of phytate (1.96 ± 0.07 mg/100 g). The content of cyanide ranges between 7.70 to 90.29 mg/100 g. The plant based yoghurt have high and lowest content of cyanide with CNY 90.29 ± 1.21 mg/100 g) and SMY with (7.70 ± 0.40 mg/100 g). The content of oxalate is between 0.03 to 90.28 mg/100 g. The highest oxalate content is recorded in CNY (90.28 ± 1.22 mg/100 g) and SMY with lowest content of (0.03 ± 0.01 mg/100 g) while the content of saponin ranges between 0.05 to 67.51 mg/100 g. Samples of plant-based with highest content of saponin is CNY (67.51± 0.47 mg/100 g) and TNY with the lowest content of (0.05 ± 0.01 mg/100 g).

The fermented dairy samples of GMY and CMY have low contents compare to plant-based yoghurt Anti-nutrient factors such as phytate, cyanide, oxalate and saponin that can be as a result of the fact that anti-nutrients factors are commonly present in sources of plant food, but the high content of anti-nutrient values in this research for fermented dairy could be as a result of locally source animal milk from Fulani herders, since their animals feed on all plants available to them as a food source, no selection to feed on plant with low levels of anti-nutritional factor. So, in this study plant-based yoghurt samples have highest anti-nutrient factors which is similar to the report of Ani *et al*.,(2019); Oluwole *et al*.,2013. Phytate value of SMY 18.99 % obtained in this study is higher than the one obtained by Mba *et al*., 2012 in his study.

Conclusion
The mineral composition of the fermented dairy and plant-based yoghurt in this study shows significance in the products. Although, the fermented dairy have high values of anti-nutrients compare to standard value which may be as a result of locally milk source from Fulani herders. It was studied that plant-based yoghurt anti-nutritional factors was within acceptable standards with suggestive on minerals bioavailability when consumed. So, the results of this study aid the consumers to make choice on yoghurt varieties and, also for producers to optimize their products for healthier nutritional content.

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