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Physicochemical and sensory properties of yoghurt from cow milk, soy bean milk and tiger nut milk blends spiced with ginger powder

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Abstract
Purpose: The production and quality of yoghurt from cow milk, soybean milk, and tiger nut milk blends spiced with ginger powder was evaluated.
Methodology: Yoghurt samples were formulated with different concentration of milk blends. Samples includes; A (100% cow milk), B (100% cow milk with ginger), C (20% cow milk:80% soybean milk with ginger), D (20% cow milk: 80% tiger nut milk with ginger), E (50% cow milk: 50% tiger nut milk with ginger), F (20% Tiger nut: 80% soybean milk with ginger) and G(20% soybean milk: 80% tiger nut milk with ginger). The samples were analyzed for physico-chemical and sensory properties using standard methods.
Results: The pH values ranged from 3.75(A) to 4.55(G), TTA from 0.82% (G) to 0.94% (A) and viscosity from 1.21 to 1.29 Pa.s for G and A. The total solid ranged from 11.15 to 12.84g/100g for A and F whiles the solid non- fat had 8.60g/100g (A) to 10.35g/100g (G). The proximate composition revealed that; Moisture had 87.55 to 88.85% for G and A, Ash 0.60 to 0.71% for A and G, Protein 3.73to 4.61% for B and F, Fat, 2.62%, (C) to 2.82% (D) while Crude fibre trace in A to 0.28% in G. Carbohydrate had 4.56 to 5.33% for A and D. The mineral elements Ca had 110.68 to 177.34mg/100g for A and G, Potassium had 200.62 to 290.38mg/100g for F and D. Mg, ranged from 71.05 to 95.98mg/100g for A and C. For P we had 101.66 to 173.03mg/100g for A and G and Na had 110.45 to 120.25mg/100g for A and G. The trace mineral, Fe had 0.09 to 1.75mg/100g for A and G while Zn had (0.40 to 0.852) mg/100g for A and F. Vitamins B1 had 0.11 to 0.71mg/100g for A and G, B2 had 0.29 to 1.43mg/100g for A and G, B3 had 0.12 to 2.53 for A and G and Vit C had trace to 9.03mg/100g for A and G respectively. In conclusion, yoghurt from cow milk, soybean milk, tiger nut milk blends spiced with ginger powder increased the nutritional and sensory properties of yoghurt thus improved functional properties of yoghurt.

Keywords: cow milk, soybean, tigernut, ginger, yoghurt

Introduction

Yoghurt is a food produced by the fermentation of milk in the presence of microorganisms such as *Streptococcus thermophillus* and *Lactobacillus bulgariscus*. (Weerathilake *et al*., 2014) [36]. It is nutritionally rich in protein, carbohydrate, vitamins and minerals such as calcium which contributes to a healthy living. During fermentation, lactose in milk is converted to lactic acid rendering yoghurt more digestible than milk thus people who cannot tolerate milk either because of a protein allergy or lactose intolerance can digest yoghurt (Priyanka Aswal, 2012) [32]. There are various reasons for product development. These include the changing needs of consumers, new technology, ingredients, market opportunities and the need to feed an ever increasing world population with quality and sustainable foods (Bristone *et al*., 2015) [8, 9]. Many consumers are interested in reducing their consumption of animal products such as cow milk, bovine milk etc due to health, environmental and ethical issues. The food industry is now developing ranges of plant based milk beverages which serve as an alternative for people with lactose intolerance, cow milk allergy, vegetarians and people who want to avoid cholesterol (Badau *et al*., 2015) [8, 9]. These include soy yoghurt, tiger nut yoghurt, corn yoghurt, coconut yoghurt etc. Soybean (*Glycine max*), protein is one of the least expensive sources of dietary protein and is considered to be a good substituent for animal protein (Bristone *et al*., 2015) [8, 9] and their nutritional profile except sulfur amino acids (methionine and cysteine) is almost similar to that of animal protein because soybean proteins contain most of the essential amino acids required for animal and human nutrition (Jiang *et al*., 2013) [22] Soymilk contains high amounts of protein, iron, unsaturated fatty acids, and niacin, but low amounts of fat, carbohydrates, and calcium as compared with cow milk and human milk. More importantly, polyunsaturated and monounsaturated fats of soymilk do not lead to deposition of fats in blood vessels including those in heart, and therefore do not lead to heart diseases,(Mazumder & Hongsprabhas, 2016) [28]. Tiger nuts are actually tubers of the plant *Cyperus*

Esculentus with great deal of super food qualities. They have the perfect nutritional balance and they are rich in nutrients required to keep the whole body healthy (Bristone *et al*., 2015) [8, 9]. Dietary fiber in tiger nuts can help control diabetes in line with the first benefit, the great contribution of healthy and balanced fiber provided by tiger nuts does not raise blood glucose levels and, therefore, these foods are excellent for preventing and combating diabetes. (Gambo & Da'u, 2014) [16]. Most flavourants used in the industrial production of yoghurt are synthetic. The use of natural flavourants such as ginger (*Zingiber officinale*) could be more beneficial to the consumer's health because they are source of mineral, fibre, vitamins, and biological compounds with positive effects on human health. Ginger is a good source of fiber, vitamins (A, C, riboflavin, thiamin and niacin), minerals (Fe, Ca, F, K, Zn, Cu) and as a vegetable (Kaushik & Goyal, 2011) [24]. Ginger is used worldwide as herbal and warming remedy, cholesterol lowering herb. Yoghurt is rich nutritionally but has a short shelf life. Addition of ginger to yoghurt could improve the antimicrobial and antioxidant (bioactive) properties of yoghurt and thus rendering it more functional with improved shelf life (Kaushik & Goyal, 2011) [24].

Materials and Method

The material used for the processing of yoghurt samples includes, powder milk, yoghurt starter culture, sugar, tiger nut, soy bean and ginger. These were purchased from modern market Makurdi Benue state Nigeria for processing.

Preparation of ginger powder

Fresh ginger (*Zingiber officinale*) was washed, peeled and washed again using potable water. It was chopped into pieces (2-3mm) using manual method, dried in a vacuum oven at 63 ˚C for 48hrs. The dried ginger was then blended into powder using a blender (BL-500). Powder ginger was sieved using a sieve with pore size < 300µm. The sieved ginger powder was packaged in plastic bags and stored at room temperature (Amadou *et al*., 2017) [5].

Preparation of tiger nut (*Cyperus esculentus)* extract

Tiger nut extract was prepared by sorting out all unwanted objects and other rotten nuts, washed and rinsed in potable water and soaked for 12 hrs to soften the fiber. The water was changed 3 times to avoid fermentation. 1kg of tiger nut was added to two liters of warm water and blended several times. The mash was sieved twice with a neat cloth to separate the extract. It was further strained to obtain a fine consistency. The filtered extract was heated at 90°C for 15min, cooled to 4°C and refrigerated for further processes (El-Shenawy *et al*., 2012) [12].

Preparation of soy bean milk

Whole soybeans was sorted and washed to remove contaminant. It was then soaked in potable water for 12 hours after which it was blanched using 1.25%NaHCO3 for 10 mins and dehulled in-between two palms (rubbed abrasively between two palms). This was further washed and drained repeatedly until the seed coats were removed. The wet soybean was then wet milled and mixed in a ratio of 1:3 volume of potable water and strained through 4 layer muslin cloth to obtain the soymilk. The milk was then pasteurized at 75˚C for 5 minutes, cooled and stored at 6˚C (El-Shenawy *et al*., 2012) [12].

Yoghurt Formulation and sampling

Yoghourt samples were produced by varying the proportions of cow milk, soymilk and tiger nut milk and spicing with ginger powder. Sample A (100% cow milk) as control, B (100% cow milk with ginger powder), C (20% cow milk:80% soybean milk with ginger powder), D (20% cow milk: 80% tiger nut milk with ginger powder), E (50% cow milk: 50% tiger nut milk with ginger powder), F (20% Tiger nut: 80% soybean milk with ginger powder) and G(20% soybean milk: 80% tiger nut milk with ginger powder). All the yoghurt samples but A were spiced with 0.5% w/v ginger powder.

Production of yoghurt samples

The process of making plant based yoghurt is almost identical to that of cow milk yoghurt. Modified method of (Adekunbi Adetola Malomo *et al*., 2020) was used for the production of tiger nut and soy bean yoghurt. The milk blends was filtered through a muslin cloth and pasteurized at 85-90˚C for 3- 5 minutes during which 6.5%w/v sugar was added at 60-65˚C.The pasteurized milk was cool rapidly using cold-water bath to 42-45˚C and 2.5%v/v yoghurt culture (lactic acid bacteria, mainly *Lactobacillus bulgaricus* and *Streptococcus thermophiles*) was added and mixed thoroughly. It was incubated at 42-45˚C/3-4hr after which it was cooled at 4-6˚C/6-12hr. The yoghurt was well stirred to break the coagulum into a fluid. It was then spiced with 0.5% ginger powder (Heated at 80-85˚C/3-5min) and mixed thoroughly to have uniform distribution of the spice. The yoghurts was packaged into sterile bottles and stored at 4-6˚C (Lee & Lucey, 2010) [10]

Physico-chemical analysis of ginger spiced plant based yoghurt

The samples were analyzed for the following physico-chemical properties. The pH of the samples was determined using a digital pH meter, where 15ml of samples was poured into a beaker. The pH meter was deepened into the sample and the pH value read and recorded. Apparent viscosity of yoghurt samples, Yoghurt samples were gently stirred 5 times in clockwise direction with a plastic spoon prior to viscosity measurements. Apparent viscosity was measured at 27 ± 1˚C using a Brookfield digital viscometer (Model DV-II, Spindle-0,

Canada). The sample was subjected to a speed of 100 rpm with spindle No.1 (Hymavathi *et al*., 2020) [21]. Viscosity was expressed as Pascal (Pa.s). For the total Titratable acidity content was done using (AOAC, 2010) [7] method.

Chemical analysis
Proximate analysis that is moisture, ash, protein fat, crude fiber were determined in triplicate using the method of (AOAC, 2010) [7]. Total carbohydrate was determined by differences between 100 and total sum of the percentage of fat, moisture, ash, crude fiber and protein content. Solid non-fat content of the sample was obtained by subtracting fat content from dry matter. The mineral content (Ca, K, Na, Fe, P, Mg, and Zn) of the yoghurt samples was determined as described by Njoya and Richard (Amadou *et al*., 2020) [4]. Vitamin content of the yoghurt samples was determined using the spectrophotometric method, the determination of Vitamins B1, B2, B3 and C of yoghurt samples was done using the method described by (Amadou *et al*., 2020) [4].

Sensory evaluation
Sensory evaluation of yoghurt samples was carried out using a nine-point Hedonic scale where 1= dislike extremely and 9= like extremely. The qualities assessed were colour, texture, taste, flavour and overall acceptability by 30 panelists (Steve & Olufemi, 2019) [34].

Statistical analysis
Data were subjected to analysis of variance (one-way ANOVA) where it was appropriate and means separated by Duncan's Multiple Range test (DMRT) at 0.05 level of significance. Using the statistical package for social sciences SPSS version 28.

Result and discussion
Physical and some chemical properties of ginger spiced plant based yoghurt
The physicochemical properties of yoghurt produced from the plant-based milk components are presented in Table 1.

The pH of yoghurt samples
The pH values of the products ranged from 4.40 (A) to 4.55(G) with sample A(100% cow milk) having the lowest pH while samples G(20% soybean milk: 80% tiger nut milk with ginger) had the highest value. There was no significant different between the samples. Comparing the obtained values with the standard 4.0 to 4.6 FDA (food code Service, 2013) [15], Plant based yoghurt was within the range of the standard. During the production of yoghurt, fermentation occurs which is the breakdown of lactose to lactic acid in the presence of lactic acid bacteria (*Streptococcus thermophillus* and *Lactobacillus bulgariscus*). This process is responsible for the initial pH drop and increase in total titritable acidity in yoghurt and the characteristics texture and flavor of yoghurt. The pH in yoghurt is the measure of the acidity of the product and this serves as a major contributor to the overall taste of the yoghurt (Kliks *et al*., 2019) [26].

The total titratable acidity of yoghurt samples
The total titratable acidity (TTA) of the various yoghurt types ranged between 0.82 to 0.94 % lactic acid with significant difference $P<0.05$ between the samples. Yoghurt from 100% cow milk (A) had the highest TTA value while G (20%soymilk: 80% tiger nut with ginger) had the lowest. This may be due to the antimicrobial properties of ginger which turns to reduce the activity of lactic acid bacteria in the fermentation of yoghurt and thus decrease in % lactic acid. Comparing the value obtained and that of the Nigerian standard of 1.5 % max for yoghurt the TTA of the yoghurt samples was within the range. The TTA is essentially the total acid concentration contained within a food system. The TTA as a variable is usually used as a good predictor of acid's impact on food flavour (Usman & Bolade, 2020) [35].

Viscosity of yoghurt samples
Viscosity of yoghurt samples range from 1.49 to 1.21 Pa.s with significant difference $p<0.05$ between the samples. The highest value was recoded for B (100% cow milk with ginger) and lowest in sample D (20% cow milk and 80%tiger nut with ginger). This means sample B was thicker than all the other yoghurt samples. This could be due to the presence of lactose in cow milk samples that when acted upon by lactic acid bacterial coagulate and form a tick gel structure. This lactose is not presence in plant based milk samples (Amal *et al*., 2016) [6] and also due to the presence of ginger powder which contains starch and turns to make the sample ticker. Viscosity is the state of being thick, sticky, and semi-fluid in consistency, due to internal friction. The more thick a liquid is the more slowly it will flow. If a fluid is having more viscosity or a more viscous fluid, it will experience more resistance during flow. (Oduro & Science, 2018) [30]. Comparing these values with 0.23 to 0.55 Pa.S obtained by (Grasso *et al*., 2020) [20] on the Properties of Commercial Plant-Based Yogurts, the a viscosity is slightly higher. Meaning the yoghurts samples in this studies were thicker in consistency. This could be because ginger powder was added as a spiced that turns to add more dry matter to the yogurt samples and thus increase in thickness of samples.

The total solid of yoghurt samples

The total solids ranged from 11.51g/100g to 12.95g/100g. Sample A (100% cow milk) had the lowest value while sample G (20% soy bean milk: 80% tiger nut milk with ginger) had the highest value. There was significant difference between the samples at $p<0.05$. The dry matter of the yoghurt samples increased with increase in the concentration of tiger nut milk. This was similar to the findings of (Amadou *et al*., 2017) [5] who reported values for ginger spiced yoghurt ranging from 18.72g/100g to 19.96g/100g. This might be because powder ginger has 88-91% total solid so addition of ginger powder is indirectly adding dry matter to yoghurt thus high content of total solid. The total solids of food are basically the dry matter that remains after moisture removal (Bristone *et al*., 2018) [8, 9].

Solid non-fat of yoghurt samples

Solid nonfat is basically dry matter or total solid minus fat content. The solid non-fat ranged from 8.60g/100g to 10.70g/100g with significant deference $p<0.05$ between the samples. The highest value was observed in sample G (20% Soybean milk: 80% tiger nut milk with ginger) and the lowest in sample A (100% cow milk). The solid nonfat of the samples increased with increase in tiger nut milk concentrations. This could be because soybean milk content more fat than tiger nut milk, deducting the fat content turns to lower the content in samples with high soy bean milk concentrations. These values closely agree with FDA (food code Service, 2013) [15] who state that yoghurt should contain not less than 8.25g/100g

Proximate compositions of yoghurt from plant based milk blends

Table 2 shows the proximate composition of different yoghurt types produced from the blends of milk from cow, soy bean and tiger nut spiced with ginger powder.

Moisture content of yoghurt samples

The moisture content of all the yoghurt types ranged between 87.16g/100g to 88.85g/100g with significant differences $P<0.05$. Sample A (100% cow milk) had the highest and sample F (20% tiger nut milk: 80% soybean milk with ginger powder) had the lowest. There was decrease in moisture content as soy bean milk concentrations increases. This results agrees with 86.34g/100g to 94.11g/100g for soy yoghurt (Akusu & Wordu, 2017) [2]. The relative low moisture content of the spiced samples could be because ginger powder has very low moisture content of <10% weight basis so adding it to yoghurt will turn to reduce the moisture content of the yoghurt samples. The implication of this high moisture content in the yoghurt types is that the food product has a tendency of very low shelf stability as high moisture content in food (Khan *et al*., 2016) [25].

Total ash content of yoghurt samples

The total ash in the yoghurt samples ranged from 0.60 to 0.71 g/100g for sample A (100% cow milk) being the lowest and sample G (20% soy bean milk: 80% tiger nut milk with ginger) being the highest. There was a significant difference between the samples at $p<0.05$. The result shows increase in ash content as the concentration of tiger nut increases. This could be because tiger nut content very high content of mineral elements (Oladele & Aina, 2007) [31]. This was similar to the findings of (Amadou *et al*., 2017) [5] who got ash content of 0.68g/100g to 0.76g/100g in ginger spiced yoghurt. This was also within range (0.67 to 0.7 g/100g) of the ash content of yoghurt according to FDA (food code Service, 2013) [15]. Ginger powder contains 8g/100g ash so adding powder ginger to yoghurt was a sort of enriching the yoghurt with minerals such as P, Na, K, Fe (Gonzlez-Tenorio *et al*., 2012).

Protein content of yoghurt samples

The protein content of the yoghurt samples ranged from 3.73g/100g to 4.61 g/100g. There was significant difference $p<0.05$ between the samples. The highest value was observed in sample F (20% soymilk: 80% tiger nut milk with ginger powder) while the lowest is in sample A (100% cow milk). There was increase in protein content with increased soy bean milk concentrations. Studies done by Akusu *et al*, showed a range of 2.95g/100g to 4.29g/100g for soy bean yoghurt (Akusu & Wordu, 2017) [2]. The result in this case is slightly higher than that range. This could be because ginger powder was added and ginger powder contains 8.6g/100g of protein which will greatly contributes to the protein content of yoghurt (Kaushal *et al*., 2017) [23]. Soy bean also contain most of the essential amino acids required for human nutrition and thus a good source of dietary protein and can be considered as good substitutes for animal protein (Hymavathi *et al*., 2020) [21].

Fat content of yoghurt samples

Fat content of the yoghurt ranges from 2.52g/100g to 2.62 g/100g with significant difference $p< 0.05$. The highest value was observed in sample C (20% cow milk: 80%soy bean milk with ginger) while the lowest was in sample G (20% soy bean milk, 80% tiger nut with ginger). It was observed that fat content increased with increase in soy bean milk concentrations and decreases with increase in tiger nut milk concentrations. This could be because soy bean is regarded as oil seed with high fat content, but this is an advantage because the fat in soy bean is polyunsaturated and monounsaturated fats and and does not lead to the deposition of fat in the blood vessels and the heart and thus does not lead to heart diseases (Giri & Mangaraj, 2012) [17]. According to FDA (Saleh *et al*., 2018) [33], yoghurt that contains less than 3g/100g of fat per 100g of yoghurt is low fat yoghurt.

This yoghurt falls in this category and thus can be term Low fat yoghurt. High fat and high sugar in any food can lead to health problems. So a low fat and low sugar yoghurt product would be ideal for healthy living.

Crude fibre of yoghurt samples

The crude fibre ranged between 0.00 and 0.28 g/100g with significant difference $p<0.05$ between the samples. The lowest value was observed in sample A (100% cow milk) while the highest was observed in sample G (20% soybean milk: 80% tiger nut milk with ginger). The fibre content increased with increase in the concentrations of tiger nut milk. This result agrees with (Gambo & Da'u, 2014) [16], in the composition and health benefits of tiger nut milk which ranged from 0.24g/100g to 0.33g/100g fibre content of tiger nut milk. Studies also shows that tiger nut contains large amount of fiber which is clearly beneficial to keep the digestive system in a perfect shape and combating constipation problems (Oladele & Aina, 2007) [31].

Carbohydrate content of yoghurt of yoghurt samples

Carbohydrate content in the product ranged from 4.56g/100g to 5.33g/100g of yoghurt samples. The lowest value was observed in sample A (100% cow milk) and highest in sample G(20% soy bean milk and 80% tiger nut milk). It was observed that carbohydrate content were high in samples that contains tiger nut milk. This results agrees with that in the quality evaluation of yoghurt from plant based sources with values 3.77g/100g to 9.27g/100g of carbohydrate in the yoghurt (Bristone *et al*., 2018) [8, 9]. These values are relatively low and therefore yoghurt as a food product cannot be regarded as a good source of these nutrients. Nevertheless, most people consume yoghurt not as a main food but as a dessert drink, snack, or as a probiotic food drink for the re-establishment of a balance within intestinal micro flora (Priyanka Aswal, 2012) [32]. From the data obtained for the proximate composition of plant based yoghurt, it can be concluded that plant based milk sources improved the nutrient content of yoghurt and spicing it with ginger powder makes it better in nutritional point of view.

Mineral composition of yoghurt samples

The selected mineral profile of yoghurt produced from the milk blends is presented in table 3.

Calcium content of yoghurt samples

The calcium (Ca) concentration in the yoghurt samples ranged between 110.68mg/100g to 177.34 mg/100g with significant differences at $P<0.05$. Sample G (20% soy bean milk: 80% tiger nut milk with ginger) had the highest Ca content while A (100% cow milk) exhibited the lowest value. There was an increase in the Ca content as the concentrations of tiger nut milk increases. The values were within the range with 119mg/100g to 225mg/100g obtained by David *et al*. (McClements *et al*., 2019) [29] in a study on plant based milk. An inadequate intake of Ca in human diet can lead to such disease conditions as osteoporosis, hypercholesterolemia and high blood pressure (Oladele & Aina, 2007) [31].

Potassium content of yoghurt samples

Potassium (K) content in the yoghurt samples ranged from 200.62mg/100g to 290.38mg/100g, there were significant differences in the samples at $P<0.05$. The highest value was recorded in sample D (20% cow milk and 80% tiger nut milk with ginger) and lowest in sample F (20% tiger nut milk: 80% soy bean milk with ginger). There was increase in potassium content as concentrations of cow milk increases. But due to the high content of K in ginger it turns to burst up the content of K in spiced yogurt samples. Comparing this result with 146mg/100g to 264mg/100g (McClements *et al*., 2019) [29] in plant based yoghurt, the values were within range. Also the standard for Dairy counsel (Embark & Abdalla, 2019) [13] ranged from 130mg/10g to 280mg/100g. The results obtained was slightly above this ranged this could be because the yoghurt was spiced with ginger powder a good source of K and this turn to step up the content. The values were far below the RDA of K is 3500mg to 4700mg daily.

K is one of the most important mineral in the body; it helps regulate fluid balance, muscle contractions and nerve signals. A high K diet may help reduce blood pressure and water retention, protect against stroke and prevent osteoporosis and kidney stones (Usman & Bolade, 2020) [35].

Magnesium content of yogurt samples

The magnesium (Mg) content of the yoghurt types exhibited a range of 71.05mg/100g – 95.98 mg/100g with significant differences at $P<0.05$. The highest values was recorded for G (20% soy bean milk: 80% tiger nut milk with ginger) and the lowest sample A(100% cow milk). studies on plant based yoghurt showed 20mg/100g to 49mg /100g (Oladele & Aina, 2007) [31].

The ranged in these studies had higher range. This could be because ginger powder was added and it contains mg and also tiger nut contains high content of Mg up to 51mg/100g to 56.3mg/100g. These values are far below the recommended daily allowance (RDA) of 200-400 mg per day (Oladele & Aina, 2007) [31] but since yoghurt is usually consumed as a snack drink, it may be regarded as a good complementary source for Mg. In human nutrition, Mg has been implicated in energy metabolism, release of neurotransmitter and endothelial cell functions. It is also a co-factor of up to about 300 enzymes in the body system (Farinde, E. *et al*., 2012).

Iron content of yoghurt samples

The iron (Fe) content exhibited a range of 0.09mg/100g to 1.75 mg/100g with significant difference at $p<0.05$. Sample G (20% soy bean milk: 80% tiger nut milk with ginger) had highest while A(100% cow milk) had lowest. The Fe content of the samples increased with increased in tiger nut milk concentrations. In a similar study conducted by David *et al* (Oladele & Aina, 2007) [31], it was indicated that plant based yoghurt Fe content ranged from 0.05mg/100g to 0.84mg/100g. The result in this study is higher; this is because tiger nut milk is an excellent source of Fe. And it has as much iron as red meat.(Oladele & Aina, 2007) [31] This can be regarded as being low and cannot meet the recommended daily allowance (RDA) of 8 – 18 mg per day(Usman & Bolade, 2020) [35]. The major function of Fe in human nutrition is related to the synthesis of hemoglobin and myoglobin in the blood (Oladele & Aina, 2007) [31].

Zinc content of yoghurt samples

Zinc (Zn) content of the samples ranged between 0.40mg/100g to 0.85 mg/100g for sample A and F(20% tiger nut milk: 80 soy bean milk with ginger) respectively. There was significant difference amongst the samples at $P< 0.05$. A similar studies on ginger spiced yoghurt done by Njoya *et al*., 2020 ranged from 0.39mg/100g to 0.44mg/100g.

The values in this study are higher than what he obtained. Studies on plant based yoghurt showed 0.38mg/100g to 0.75mg/100g al (Oladele & Aina, 2007) [31] which is in line with the result obtained in this studies. This is because Zn is higher in plant sources than animal sources. These values are below the Recommended Dietary Allowance (RDA) which is 8-11mg/day. Zn is needed in human nutrition for the body s defensive (immune) system to properly work. It plays a role in cell division, cell growth, wound healing and the breakdown of carbohydrate (Oladele & Aina, 2007) [31].

Sodium content of yoghurt samples

The sodium (Na) concentration in the various yoghurt types produced from the milk blends ranged between 110.45mg/100g to 120.25 mg/100g for sample A(100% cow milk) and G(20% soy bean milk: 80% tiger nut milk with ginger) respectively with significant differences at $P<0.05$. Similar studies on yoghurt had 111.08mg/100g to 111.42mg/100g (Amadou *et al*., 2020) [4] which is within the ranged obtained from this studies. There was increase in Na content as tiger nut milk content increases. This could be because tiger nut contains high content of Na up to 245 to 235mg/100g dry basis. These yoghurt types can serve as a good complementary source for Na due to the relative high content of this mineral. The RDA of Na 2300 to 3400mg per day. The principal role of Na in human physiology is related to the maintenance of physiological fluids such as blood pressure (Usman & Bolade, 2020) [35].

Phosphorus content of yoghurt samples

The phosphorus (P) content of the yoghurt types exhibited a range of 101.66 to 173.034 mg/100g with significant differences at $P<0.05$. Sample G (20% cow milk and 80% tiger nut with ginger) had the highest while sample A (100% cow milk) had the lowest. Higher concentrations tiger nut had higher content of phosphorus. Studies on ginger spiced yoghurt had 91mg/100g to 94.35mg/100g (Oladele & Aina, 2007) [31]. Comparing these results, the result of this study had higher content but was still lower than the recommended daily allowance (RDA) of 800-1300 mg per day. However, the consumption of yoghurt might serve as a complementary source for the mineral element. Phosphorus has been implicated in majority of the metabolic actions in the body system including kidney functioning, cell growth and contraction of the heart muscle (González-tenorio & Fernández-diez, 2012) [18]. The body uses minerals to build bones, make hormones, and regulate body. Minerals are also important for making for making enzymes and hormones. (Usman & Bolade, 2020) [35].

Selected Vitamins profile of yoghurt samples

The vitamins content of yoghurt samples are presented in table 4.

Thiamine (B1) content of yoghurt samples

Vitamin B1 content ranged from 0.11mg/100g to 0.71mg/100g in sample A (100% cow milk) and G (20% soybean milk and 80% tiger nut with ginger) respectively. There was significant difference at $P<0.05$. The value of B1 increases with increase in tiger nut milk concentrations. A study reported 0.04 mg/100g to 0.08mg/100g content of B1 in soy yoghurt (McClements *et al*., 2019) [29]. Comparing this range with the higher range gotten from this study, tiger nut contains high content of B1 than soy bean milk and also ginger powder that was incorporated also added to this effect. This value was less than the standard value of 1.1-1.2 mg per day for RDA (Recommended Daily Allowance) for adult male and female. Vitamin B1 is essential for glucose metabolism and it plays a key role and helps prevent complication in nerve muscle, and heart function (Yadav *et al*., 2015) [37].

Riboflavin (B2) content of yoghurt samples

The riboflavin content of the yoghurt samples ranged from 0.29mg/100g to 1.43mg/100g for sample A (100% cow milk) and G (20% soy milk: 80% tiger nut milk with ginger) respectively with significant difference at $P<0.05$. Comparing this result with 0.19mg/100g to 0.30mg/100g in plant based yoghurt (McClements *et al*.,

2019) [29]. The content was higher in this case due to the present of tiger nut and ginger which help to enrich the yoghurt. Vitamin B2 RDA is 1.1 to 1.3 mg per day. Vitamin B2 (Riboflavin) is used as a dietary supplement. It is required by the body for cellular respiration. Riboflavin is a heat stable vitamin and is not affected by severe heat treatment (Donovan & Shamir, 2014) [11].

Niacin (B3) content of yoghurt samples

The content of vitamin B3 in yoghurt samples ranged from 0.12mg/100g to 2.53 mg/100g. Sample A (100% cow milk) had the lowest while sample G (80% soymilk: 20% tiger nut milk with ginger) had the highest. There was significant difference at $p<0.05$ for the samples. Increase in concentrations of tiger nut milk increased vitamin B3 content. Studies on soy yoghurt showed 0.28 mg/100g to 0.80mg/100g, which was far lower than the ranged in this study. The increased in this case could be due to the presence of tiger nut which content more vitamins B3 than soy bean milk and also spicing the yoghurt samples with ginger which is an excellent source of the B complex vitamin lead to this high content. This range is below the RDA of niacin which is 14-16mg per day for adult women and men respectively (McClements *et al*., 2019) [29]. Niacin is an essential human nutrient. It helps keep the nervous system, digestive system and skin healthy. It also help to convert food to energy (Donovan & Shamir, 2014) [11].

Ascorbic acid (Vit. C) Content of yoghurt samples

Vitamin C content ranged from trace to 9.03mg/100g. The lowest value was recorded with sample A (100% cow milk) and the highest in sample G (80% soymilk: 20% tiger nut milk with ginger) there was significant difference at $p <0.05$. There was a general increase in vitamin C content as the concentrations of tiger nut increases. Studies on soy bean yoghurt showed 0 to 1.5mg/100g vitamin C content (McClements *et al*., 2019) [29]. The range in this study was higher, this could be because ginger contains vitamin C and tiger nut too forming a blend with these ingredients indirectly fortified the yoghurt(Kaushal *et al*., 2017) [23]. This range is far below the RDA of vitamin C which is 45-120mg per day. Ascorbic acid (vitamin C) is necessary for the growth, development and repair of all body tissues. It is involved in many body functions, including formation of collagen, absorption of iron, the proper functioning of the immune system, wound healing, and the maintenance of cartilage, bone and teeth (Donovan & Shamir, 2014) [11]. Vitamins helps in the body to breakdown food (Carbohydrates) into fuel (glucose) which the body uses to produced energy. They also help the body to metabolized fat and protein. Vitamins are classified according to the materials they dissolve in. Some dissolve in water thus water soluble vitamins and others dissolve in fat (fat soluble vitamins). Water soluble vitamins are carried through the bloodstream. Whatever the body does not use is eliminated in urine. All selected vitamins of this study are water soluble (Yadav *et al*., 2015) [37].

Sensory evaluation of yoghurt samples

The sensory quality rating of different yoghurt types produced from the milk blends is presented in Table 5.

Appearance of yoghurt samples

For appearance, scores by the panelist ranged from 6.40 to 8.33 on a scale of 9 for sample G (20% soybean milk: 80% tiger nut milk with ginger) and A (100% cow milk) respectively. This means the score ranged from like slightly to like very much, this gave a positive impression about the appearance of the yoghurt samples.

Aroma of yoghurt samples

In term of aroma, samples A (100% cow milk) and B (100% cow milk with ginger) were preferred most and sample E (50% soybean milk: 50% tiger nut milk with ginger) was the least preferred. There was significant difference between the samples at $P<0.05$. The scores ranged from 5.73 to 8.07 (like slightly to like very much) for E and A respectively. This means the ginger flavour in the yoghurt samples was appreciated by the panelists.

Taste of yoghurt samples

For the taste of the yoghurt samples, the scores ranged from 5.73 to 8.06 (like slightly to like very much) for E and A respectively samples A (100% cow milk) and B (100% cow milk with ginger) were preferred most and sample E (50% soybean milk: 50% tiger nut milk with ginger) was the least preferred. There was significant difference between the samples at $P<0.05$.

Mouth feels of yoghurt samples

For mouth feel, the highest score was 7.96 in A and B while the lowest score was 5.93 in E. Sample A (100% cow milk) and B (100% cow milk with ginger) were the most preferred while sample E (50% soybean milk: 50% tiger nut milk with ginger) was the least preferred. This means panelists like sample A and B very much and sample E was slightly liked.

Overall acceptability of yoghurt samples

For overall acceptability, sample A (100% cow milk) was the most preferred with the score of 8.23/9 (like very much) and the score was not significantly different from that of sample B (100% cow milk with ginger), making sample B the second preferred sample with the score of 7.93 (like very much). Sample D (20% cow milk: 80%

tiger nut milk with ginger) came third with the score of 6.93 (like moderately) and it was not significantly different from samples C (20% cow milk: 80% soy milk with ginger), F (20% tiger nut milk; 80% soybean milk with ginger) and G (20% soy milk: 80% tiger nut milk with ginger). The least preferred samples was sample E (50% soy bean: 50% tiger nut milk) which got the score of 6.06 /9 (like slightly). This implies that yoghurt from plant base milk bends spiced with ginger was generally accepted by the panelists

Conclusion

The production of imitation yoghurt from the blends of cow milk, soy bean milk and tiger nut milk is highly possible. Plant based yoghurt spiced with ginger powder increased the nutritional and antioxidant activity of yoghurt thus improved functional properties of yoghurt. Spicing yoghurt with ginger powder improved the sensory property of yoghurt. The microbial loads of plant based yoghurt sample were within permissible limits and thus were generally regarded as safe. Ginger also positively affected the pH and the titratable acidity of yoghurt during storage and thus improved shelf life of yoghurt.

Table 1: Some physico- chemical analysis of yoghurt samples pH, titratable acidity and viscosity of yoghurt samples

Samples	pH	TTA %lactic acid	Viscosity (Pa.s)	Total solid (g/100g)	Solid non fat (g/100g)
A	$4.40^{b} \pm 0.00$	$0.94^{a} \pm 0.01$	$1.49^{a} \pm 0.00$	$11.15^{b} \pm 0.08$	$8.60^{c} \pm 0.09$
B	$4.44^{b} \pm 0.14$	$0.93^{a} \pm 0.02$	$1.25^{b} \pm 0.00$	$11.44^{b} \pm 0.03$	$8.87^{bc} \pm 0.06$
C	$4.55^{a} \pm 0.07$	$0.84^{b} \pm 0.03$	$1.23^{c} \pm 0.00$	$12.52^{aB} \pm 0.06$	$9.90^{b} \pm 1.00$
D	$4.55^{a} \pm 0.07$	$0.84^{b} \pm 0.01$	$1.21^{d} \pm 0.01$	$12.61^{a} \pm 0.11$	$10.34^{a} \pm 0.86$
E	$4.55^{a} \pm 0.07$	$0.83^{b} \pm 0.01$	$1.21^{d} \pm 0.00$	$12.48^{ab} \pm 0.34$	$10.18^{ab} \pm 0.06$
F	$4.55^{a} \pm 0.07$	$0.83^{b} \pm 0.01$	$1.21^{d} \pm 0.00$	$12.84^{a} \pm 0.04$	$10.21^{ab} \pm 0.04$
G	$4.55^{a} \pm 0.07$	$0.82^{b} \pm 0.00$	$1.21^{d} \pm 0.00$	$12.95^{a} \pm 0.16$	$10.70^{a} \pm 0.11$

Mean values within the same column having the same letter are not significantly different at P>0.05.

Table 2: Proximate composition of yoghurt samples

Samples	Moisture g/100g	Ash g/100g	Protein g/100g	Fat g/100g	Crude fibre g/100g	CHO g/100g
A	$88.85^{a} \pm 0.09$	$0.60^{b} \pm 0.04$	$3.73^{c} \pm 0.01$	$2.55^{a} \pm 0.01$	N.D	$4.56^{c} \pm 0.07$
B	$88.56^{b} \pm 0.03$	$0.61^{b} \pm 0.07$	$3.79^{c} \pm 0.18$	$2.57^{a} \pm 0.03$	$0.05^{cd} \pm 0.00$	$5.01^{ab} \pm 0.06$
C	$87.48^{c} \pm 0.06$	$0.64^{ab} \pm 0.00$	$4.15^{b} \pm 0.07$	$2.62^{a} \pm 0.14$	$0.14^{c} \pm 0.01$	$5.09^{b} \pm 0.12$
D	$87.39^{c} \pm 0.01$	$0.66^{ab} \pm 0.02$	$3.74^{c} \pm 0.15$	$2.28^{b} \pm 0.11$	$0.26^{a} \pm 0.01$	$5.33^{a} \pm 0.14$
E	$87.52^{c} \pm 0.04$	$0.65^{ab} \pm 0.02$	$3.84^{c} \pm 0.00$	$2.30^{b} \pm 0.00$	$0.21^{b} \pm 0.00$	$5.19^{b} \pm 0.02$
F	$87.16^{d} \pm 0.04$	$0.65^{ab} \pm 0.02$	$4.61^{a} \pm 0.07$	$2.59^{a} \pm 0.00$	$0.16^{c} \pm 0.00$	$4.94^{b} \pm 0.05$
G	$87.55^{c} \pm 0.16$	$0.71^{a} \pm 0.01$	$4.47^{a} \pm 0.03$	$2.25^{b} \pm 0.05$	$0.28^{a} \pm 0.00$	$5.27^{ab} \pm 0.08$

Mean values within the same column having the same letter are not significantly different at P> 0.05.

Table 3: Selected mineral profile of yoghurt samples

Samples	Ca mg/100g	K mg/100g	Mg mg/100g	Fe mg/100g	Zn mg/100g	Na mg/100g	P mg/100g
A	$110.68^{d} \pm 0.05$	$230.14^{b} \pm 0.02$	$71.05^{e} \pm 0.07$	$0.09^{d} \pm 0.01$	$0.40^{c} \pm 0.01$	$110.45^{e} \pm 0.00$	$101.66^{e} \pm 0.01$
B	$112.13^{d} \pm 0.07$	$241.15^{b} \pm 0.00$	$75.36^{d} \pm 0.01$	$0.15^{d} \pm 0.01$	$0.45^{c} \pm 0.01$	$111.62^{d} \pm 0.00$	$121.01^{d} \pm 0.01$
C	$177.34^{a} \pm 0.07$	$202.11^{c} \pm 0.01$	$95.98^{a} \pm 0.01$	$0.82^{c} \pm 0.01$	$0.81^{a} \pm 0.00$	$112.25^{d} \pm 0.00$	$142.45^{c} \pm 0.00$
D	$157.39^{b} \pm 0.08$	$290.38^{a} \pm 0.37$	$81.02^{c} \pm 0.01$	$1.59^{a} \pm 0.01$	$0.72^{b} \pm 0.01$	$119.20^{b} \pm 0.07$	$171.03^{a} \pm 0.02$
E	$136.96^{c} \pm 0.01$	$211.55^{c} \pm 0.00$	$90.56^{b} \pm 0.01$	$1.05^{b} \pm 0.00$	$0.75^{b} \pm 0.01$	$115.86^{c} \pm 0.01$	$166.13^{b} \pm 0.01$
F	$157.00^{b} \pm 0.00$	$200.62^{b} \pm 0.01$	$95.95^{a} \pm 0.00$	$0.90^{c} \pm 0.00$	$0.85^{a} \pm 0.02$	$113.15^{d} \pm 0.01$	$145.81.05^{c} \pm 0.01$
G	$177.11^{a} \pm 0.02$	$280.46^{a} \pm 0.01$	$82.07^{c} \pm 0.05$	$1.75^{a} \pm 0.07$	$0.76^{b} \pm 0.11$	$120.25^{a} \pm 0.14$	$173.05^{a} \pm 0.29$

Mean values within the same column having the same letter are not significantly different at P< 0.05

Table 4: Selected vitamin content of yoghurt samples

Samples	B1 (Thiamine) Mg/100g	B2(Riboflavin) Mg/100g	B3 (Niacin) Mg/100g	C(Ascorbic acid) mg/100g
A	$0.11^{e} \pm 0.01$	$0.29^{d} \pm 0.03$	$0.12^{g} \pm 0.00$	$0.00^{g} \pm 0.00$
B	$0.27^{c} \pm 0.01$	$0.49^{d} \pm 0.03$	$0.15^{f} \pm 0.00$	$0.35^{f} \pm 0.00$
C	$0.55^{c} \pm 0.00$	$1.11^{c} \pm 0.13$	$2.17^{e} \pm 0.01$	$6.16^{e} \pm 0.01$
D	$0.54^{c} \pm 0.02$	$1.27^{bc} \pm 0.07$	$2.45^{d} \pm 0.00$	$8.18^{b} \pm 0.01$
E	$0.67^{b} \pm 0.01$	$1.04^{c} \pm 0.00$	$2.46^{c} \pm 0.00$	$6.18^{d} \pm 0.01$
F	$0.71^{a} \pm 0.99$	$1.13^{a} \pm 0.02$	$2.51^{b} \pm 0.00$	$6.22^{c} \pm 0.02$
G	$0.71^{a} \pm 0.03$	$1.43^{b} \pm 0.23$	$2.53^{a} \pm 0.01$	$9.03^{a} \pm 0.00$

Mean values within the same column having the same letter are not significantly different at P< 0.05.

Table 5: Sensory evaluation of yoghurt samples

Samples	Appearance	Aroma	Taste	Mouth feel	Overall acceptability
A	$8.33^{a} \pm 0.75$	$8.07^{a} \pm 0.78$	$8.06^{a} \pm 0.78$	$7.96^{a} \pm 0.99$	$8.23^{a} \pm 0.82$
B	$7.93^{a} \pm 0.87$	$8.00^{a} \pm 0.98$	$8.00^{a} \pm 0.98$	$7.76^{a} \pm 1.10$	$7.93^{a} \pm 0.87$
C	$6.83^{b} \pm 0.87$	$6.23^{a} \pm 1.36$	$6.23^{bc} \pm 1.36$	$6.56^{b} \pm 1.45$	$6.43^{bc} \pm 1.16$
D	$6.86^{b} \pm 1.48$	$6.73^{b} \pm 2.03$	$6.73^{b} \pm 2.03$	$6.70^{b} \pm 1.84$	$6.93^{b} \pm 1.62$
E	$6.66^{b} \pm 1.54$	$5.73^{c} \pm 1.78$	$5.73^{c} \pm 1.78$	$5.93^{b} \pm 1.89$	$6.06^{c} \pm 1.41$
F	$6.66^{b} \pm 1.39$	$6.16^{bc} \pm 2.09$	$6.16^{bc} \pm 2.09$	$6.60^{b} \pm 1.96$	$6.66^{bc} \pm 1.63$
G	$6.40^{b} \pm 1.32$	$6.00^{bc} \pm 1.74$	$6.00^{bc} \pm 1.74$	$6.40^{b} \pm 1.98$	$6.46^{bc} \pm 1.19$

Mean values within the same column having the same letter are not significantly different at P>0.05

Key

The letters represent yoghurt samples produced from;

A: 100% cow milk
B: 100% cow milk and spiced with ginger powder
C: 20% cow milk, 80% soybean milk spiced with ginger
D: 20% cow milk, 80% tiger nut milk spiced with ginger
E: 50 % soy bean milk, 50% tiger nut milk spiced with ginger
F: 20% tiger nut milk, 80% soy bean milk spiced with ginger
G: 20% soy bean milk, 80 % tiger nut milk spiced with ginger

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