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Effect of ginger flour addition on the chemical composition, anti-nutrients and sensory properties of soymilk

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Abstract
This study investigated the effect of ginger flour addition on the quality of soymilk. Fresh ginger rhizome was processed to flour by oven drying (OD), sun drying (SD) and ambient drying (AD). The ginger flour were incorporated into processed soymilk at 1 g and 2 g levels, respectively to obtain ginger spiced soymilk, which was stored for 21 days. The chemical composition, anti-nutrient and sensory properties of the soymilk were determined. The findings showed that the ginger flour decreased the moisture content and increased the ash, protein, fibre, crude fat and carbohydrate content from, 88.07 - 91.16 %, 0.36 - 0.63 %, 4.40 - 4.60 %, 0.3 -0.5 %, 2.02 - 2.88 % and 2.02 - 3.88 %, respectively. The ginger flour increased the vitamins content: thiamine, riboflavin, niacin, and ascorbic acid from, 0.07 to 0.18 mg/100 mL, 0.03 to 0.11 mg/100 mL, 0.73 to 0.79 mg/100 mL, and 3.52 to 5.39 mg/100 mL, respectfully. Mineral content (calcium, magnesium, Iron, zinc and phosphorus) increased from 225.21 to 448.57 mg/100 mL, 71.45 to 132.13 mg/100 mL, 1.79 to 11.23 mg/100 mL, 0.97 to 6.11 mg/100 mL and 132.17 to 210.06 mg/100 mL, respectfully. The anti-nutrients composition was low with the highest value of 0.9 % for tannins. Sensory evaluation results showed that the soymilk containing 1 g of the oven dried ginger flour was the most preferred with respect to taste and overall acceptability. It is concluded that the incorporation of ginger flour affected the nutritional composition, anti-nutrient and sensory properties of soymilk.

Keywords: soymilk, ginger flour, chemical composition, anti-nutrients, sensory attributes

Introduction

Soymilk (also known as, soy juice and soybean milk or soy drink/beverage) is a traditional oriental food beverage that is growing in popularity in Nigeria and the World [1]. It is an aqueous, white, creamy extract produced from soybeans and is similar to cow milk in appearance and consistency [2]. It is a highly nutritious beverage, containing proteins, fat, carbohydrates vitamins and minerals [3]. Soymilk plays an important role in the dietary pattern of people in most developing countries [4]. Since it contains no lactose, it can be consumed by lactose-intolerant people, because it is free of gluten and casein [1]. This beverage which can be produced with simple technology is a good source of nutrition for vegetarians [5]. Due to its high nutritional content, it can be used as an alternative for cow milk [4]. Soymilk is a very interesting food due to its extraordinary nutritive value and health characteristics [2]. It is a very rich source of highly valuable proteins, unsaturated fatty acids, soluble and insoluble dietary fibers, and isoflavones whose presence in everyday diet is very important [1]. It has about the same amount of protein as cow milk, though the amino acid profile differs [2]. The importance of protein in the diet of growing children and its continuous supply is very vital in Africa where the occurrence of protein energy malnutrition (PEM) is very rampant [6]. However soymilk is highly perishable and needs to be preserved.

Amongst the spices, ginger (*Zingiber officinale*) a root vegetable is one of the most used as culinary spice and is appreciated for its taste, aroma and flavour [7]. Traditionally, it aids against gastrointestinal disorders as antispasmodic in stomach aches and diarrhoea and has been used since ancient times as traditional medicines in Asia [8]. It is characterized by its pungent taste and represents a potential source of fibres, proteins, vitamins (A, C, Riboflavin, thiamine and niacin), minerals (Fe, Ca, F, K, Zn, and Cu), and essential amino acids. As a vegetable it has low fat content [9]. It has a considerable amount of starch (up to 40 % dry basis) with potential applications [10]. The importance of ginger has long been recognized as they are an important source of energy and represent one of the most frequently used thickening and gelling agents in food production [11, 12]. Studies by Japanese researchers showed that ginger has a tonic effect on the heart and may lower blood pressure [13]. It can lower cholesterol level by reducing cholesterol absorption in the blood and liver [11]. Ginger root contains polyphenol compounds (6-gingerol) most active component and its derivatives which have a high antioxidant activity [14]. It helps in the treatment and prevention of many types of cancer [7]. Many studies indicated that ginger is endowed with antibacterial and antifungal properties, hypoglycaemia, hypolipidemia and hypocholesterolaemia properties and antioxidant and anti-inflammatory effects [15], and also improves gastro-intestinal function [16]. In addition to the nutritional value, its incorporation as spice can also improve on medicinal, therapeutic and functional properties of soy milk [11].

The use of ginger to spice soymilk could therefore confer some beneficial effects on the soymilk. The aim of the present study therefore was to evaluate the chemical composition, anti-nutritional and sensory characteristics of ginger spiced soymilk.

Materials and Methods

Sample Collection

The fresh roots (rhizomes) of ginger (*Zingiber officinale*) and soybeans (*Glycine max*) were purchased from Wurukum market, Makurdi, Benue State and taken to the Food Technology Laboratory of the Centre for Food Technology and Research (CEFTER), Benue State University for processing and analysis.

Preparation of ginger flour

The ginger was washed several times with tap water (potable water). It was peeled, rewashed with tap water, sliced into fillets of 2- 3 diameters thick.

1. Oven dried at 50°C for 12 h.
2. Sun dried at 40°C to 42°C for 3 days, with relative humidity at 75 % to 75.3 % using a thermo-hygrometer.
3. Ambient (room) dried at 30.35°C to 32.2°C for 5 days, with relative humidity at 59.5 to 63.5 %.

The dried ginger were milled into flour in three proportions using a kitchen blender (model: Binatone BLG-452), and sieved through a sieve of pore size 0.5 mm [11]. The sieved ginger flour was stored in well-sealed plastic containers at room temperature in a closed cupboard to avoid UV light.

Preparation of ginger spiced soymilk

Soybean was sorted and cleaned to remove stones, damaged and deformed seeds. Then soybean was further weighed using an electronic weighing balance (capacity 2,500 g), washed and soaked in water (500 g in 1 L) overnight for 8-12 h. It was then rinsed and blanched in 1.25% $NaHCO_3$ (baking soda) for 30 min. The rehydrated soybean was then washed, manually dehulled and rinsed. The soybean seeds were wet milled (in the ratio of 3:1 water to beans on a weight basis) using a kitchen blender (model: SB736). The milk obtained was sieved (0.5 mm) and pasteurized at the temperature 70ºC for 15 seconds, cooled (18ºC) [11]. The soymilk and ginger flour were homogenised to ensure uniformity throughout the product. The mix was subsequently packaged and stored at refrigeration temperature (4 to 6ºC).

Formulation of ginger spiced soymilk

The obtained milk was then formulated by adding ginger flour. The ginger spiced soymilk was used to produce 7 samples in all (A - G). Sample A was plain soymilk which served as the control and samples B - G were prepared by addition of 1 g and 2 g ginger flour to every 500 mL of soymilk as shown in Table 1.

Table 1: Sample formulation for ginger spiced soymilk

Samples	Soymilk (mL)	Ginger flour (g)
A (control)	500	0
OB	500	1
OC	500	2
SD	500	1
SE	500	2
AF	500	1
AG	500	2

A= plain soymilk, OB=500 mL soymilk and 1 g oven dried ginger flour, OC = 500 mL soymilk and 2 g oven dried ginger flour, SD = 500 mL soymilk and 1 g sundried ginger flour, SE = 500 mL soymilk and 2 g sundried ginger flour, AF= 500 mL soymilk and 1 g ambient dried ginger flour, AG = 500 mL soymilk and 2 g ambient dried ginger flour

Evaluation of proximate analysis of ginger spiced soymilk

The proximate analysis was carried out according to the standard method described by AOAC [17]. The percentage moisture content was determined at 105ºC.The approximation of nitrogen was done using micro-Kjeldahl method for crude protein. Crude fat was extracted using soxhlet apparatus and n-hexane as solvent. The sequential acid and alkaline hydrolysis were adopted for the crude fibre determination followed by ignition of the hydrolysate as described by AOAC [17]. The ash content was estimated with the aid of a muffle furnace at 500ºC.The difference; that is, the sum of all the percentages of moisture, fat, crude protein, ash, and crude fibre was subtracted from 100 % to account for the carbohydrate content.

Determination of vitamin content of ginger spiced soymilk

Determination of ascorbic acid (Vitamin C)

Ascorbic acid was determined by titration using Standard indophenol solution [18]. Indophenol solution was prepared by dissolving 0.05 g of 2, 6-dichloro indophenol in deionized water and diluted to 100 mL. Titration was done with the indophenols solution till a faint pink colour persists for 15seconds.

Determination of naicin (Vitamin B_3)

Five millilitres of each sample was treated with 50 mL of 1N sulphuric acid (H_2SO_4 solution) for 30 minutes. The mixture was treated further with 3 drops of aqueous ammonia and filtered. The filtrate (extract) was used for the analysis. Standard niacin (nicotinic acid) solution was prepared and diluted as desired. 10 mL portion of the standard solution, sample extract, and 10 mL of the acid solution (treated with a drop of ammonia) was dispensed into separate flasks to serve as standard, the sample, and reagent blank respectively. Each of them was treated with 5 mL of normal potassium cyanide solution and acidified using 5 mL of 0.02 $(NH_4)_2SO_4$ solutions; in each case, the absorbance value was read at a wavelength of 470 nm. The reagent blank was used to calibrate the instrument at zero. Niacin content was estimated from the calibration curve [19].

Determination of riboflavin (Vitamin B_2)

Riboflavin content was determined spectrophotometrically by adding 5 mL of the sample in 100 mL of 50 % ethanol solution and shaken for 1 h. This was filtered with the aid of a filter paper into 100 mL flask; 10 mL of the extract was pipetted into 50 mL volumetric flask. 10 mL of 5 % potassium permanganate and 10 mL of 30 % H_2O_2 were added and allowed to stand for 30 min in a water bath. 2 mL of 40 % of sodium sulphate was added. This was made up to 50 mL mark with distilled water and the absorbance measured at 510 nm in a spectrophotometer [19]. The standard riboflavin was prepared in a similar manner for the establishment of the calibration curve.

Determination of thiamine (Vitamin B_1)

The UV-Visible spectrophotometric method was used for the determination of thiamine described by [19]. Five millilitres of the sample was homogenized in 50 mL ethanolic sodium hydroxide (1N solution). The extraction was done for 1h. The extract was filtered and the filtrate was used for analysis. An equal volume of 10 mL extract was added to an equal volume of 0.1N $K_2Cr_2O_7$ solution. Standard thiamine solution was prepared similarly. The absorbance of the sample and the standard solutions were measured using a spectrophotometer at a wavelength of 360 nm.

Determination of mineral content of ginger spiced soymilk

Two macro (Ca, Mg) and three trace minerals (Fe, P and Zn) was determined using atomic absorption spectrophotometer. The optimum range for each element was prepared and all the operational instruction for setting up the instrument for the analysis of specific element was strictly followed [17]. The ash residues were digested with 5 mL of concentrated nitric acid, filtered and the filtrate transferred into a 100 mL volumetric flask and diluted with distilled water to 100 mL volume. This was done for all the samples, and stored at room temperature while awaiting atomic absorption spectrophotometer analysis.

Anti-nutrient Properties

Determination of Phytate

The method used was that of Young and Greaves described with slight modification as documented [20]. A 2 mL of samples were measured and added to 100 mL of 20 % concentrated HCL in a 250 conical flask. Thereafter the samples were filtered with a filter paper and 50 mL of the filtrate was placed in a 250 beaker and 100 mL of distilled water added. Then 10 mL of 0.3 % ammonium thiocyanate solution was added as an indicator and titration was carried out with standard Iron (III) Chloride (0.00915 g/1 mL). After titrations, the phytates content was calculated by the formula below

Determination of Tannins

Tannin acid was determined by titration, based on the method of Follins Dennis [21]. To 10 mL of each sample in a 250 conical flasks, 100 mL of petroleum ether was added, covered and allowed to extract for 24 h. The samples were later filtered and allowed to stand for 15 min. Re-extraction was again carried out with 100 mL of 10 % acetic acid in ethanol for 4 h. Thereafter, filtration was done and 25 mL of NH_4OH was added to the filtrate to precipitate the alkaloids. Heating was done on electric hot plate to remove the left over NH_4OH. A 5 mL of the remaining solution was collected; 20 mL of ethanol added and titration was carried out with 0.1M NaOH using Phenolphthalein as indicator. Tannins content was then calculated in percentage.

Determination of Oxalates

Oxalates was determined by titration method using $KMnO_4$ [22]. In the determination of oxalate, 2 mL samples were weighed and mixed with 20 mL 0.1M HCl in a 50 mL beaker to extract total oxalate and another 2 mL of each selected samples was weighed and mixed with 20 mL of distilled water to extract soluble oxalate (both samples were placed in a water bath for 30 min) later filtrated using Whattman number one filter paper. A 0.5 mL of 5 % Calcium chloride added to the filtrates to precipitate out Calcium oxalate, the precipitate was separated by centrifugation at 3500 rpm for 15 min, and the supernatant discarded. The Calcium oxalate precipitate was washed with 2 mL of 0.35 M Ammonium hydroxide and then dissolved in 0.5 M of Sulphuric acid. The dissolved solution was titrated with 0.1M of Potassium Permanganate at 60 ºC till the faint pink colour was persisted for at least 15 seconds. The oxalate content was calculated by using stoichiometric formula.

Determination of Saponins

The method of estimation of saponins was documented [23]. A 2 mL of ginger spiced soymilk samples were put into a conical flasks and 20 mL of 20 % ethanol was added. The solutions were allowed to extract for 24 h in a water bath at 50ºC. Thereafter, the extracts were filtered and reduced to about 40 mL over a water bath. The concentrates were then transferred into a 250 mL conical flasks and 20 mL of diethyl ether added to the extract and shaken. The aqueous layer was recovered while the ether layer was discarded and the purification process was repeated. A 60 mL of n-butanol was added, the combined extract was washed twice with 10 mL of 5% NaCl. The remaining solution was heated in a water bath and after evaporation. The precipitates were dried in the oven at 105 ºC to a constant weight and calculated in percentage of sample mass analysed.

Determination of hydrogen cyanide

Hydrocyanic acid was determined according to the method of AOAC [24]. Using this method, 10 mL of the sample was measured and weighed. Eight millilitres of 6 N NH4OH and 2 mL of 5 % (w/v) potassium iodide was added to the distillate before titrating with 0.02 N AgNO3 to a faint but permanent turbidity (mL of 0.02N AgNO3 = 1.08 mg HCN).

Sensory evaluation of ginger spiced soymilk

The sensory evaluation of the samples was assessed for colour, flavour, taste and overall acceptability by a panel of 30 panellists made up of CEFTER MSc/Phd students. The taste panellists were asked to rate the sample on a 9 point hedonic scale [2] for colour, flavour, taste and overall acceptability with the ratings of: 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely.

Statistical analysis

Data obtained were subjected to the Analysis of variance (ANOVA) using Statistical Package for Social Science (SPSS) version 21. The means obtained were separated using Tukey HSD test. Differences were considered at 95 % ($P \leq 0.05$) confidence interval.

Results and Discussion

Proximate composition of ginger spiced soymilk

The proximate composition of ginger spiced soymilk is presented in Table 2. There was general increase in ash content with addition of ginger flour, and also with increase in levels. This can be attributed to addition of ginger flour. The untreated soymilk had the lowest ash content, which coincided with some results reported in literature [25], while the sample AG (500 mL soymilk and 2 g ginger dried at ambient conditions) had the highest ash content. Ash is a source of minerals, and substantial amount of mineral element depends on the chemical composition of the soil, cultural practices, time of planting and the amount of water available to the plant [26]. The moisture content of the ginger spiced soymilk decreased with increase of dosage of ginger flour across the samples. The untreated soymilk had the highest moisture content. The significant decrease in the moisture content of the treated samples could be due to the addition of the spice which gave the sample a slight solid content. Moreover, because starch is the main carbohydrate component in ginger and it is used as thickener and gelling agent, its action could be high at certain levels of concentration and thus justify the slight loss of moisture in the product. The results were in agreement with the findings of Dauda and Adegoke. [25] on the comparative study of the effect of dry and wet ginger spice on the proximate and microbial safety of soybean beverage. The protein content increased with addition of ginger flour. In fat content, sample OC (500 mL soybean beverage and 2 g oven dried ginger) had the highest value, while sample A (plain soymilk) had the least value. The fat content increase in the sample OC could be due to the concentrated nature of the components of ginger flour incorporated. The results were similar to findings of Dauda and Adegoke. [25]. Ginger is also a good source of fibre. Crude fibre, consisting principally of cellulose, and lignin together with the small amounts of hemicelluloses had values ranging from 0.03 % to 0.05 %. The untreated sample had minimal fibre content, which conforms to the report of [25]. The protein content of the untreated sample was the lowest. The values reported in this study were similar to findings of Ugochi *et al*. [26] on the nutrient and sensory quality of soymilk produced from different improved varieties of soybean. The variation in the protein content could be attributed to the addition of ginger spice which is a potential source of protein. Carbohydrate content increased with addition of ginger flour. The untreated sample had the least carbohydrate value, while the sample OC (500 mL soymilk + 2 g oven dried ginger) had the highest value. The results were similar to findings of Ani *et al*. [26]. The increase in carbohydrate content noticed in the sample OC could be due to the concentrated nature of the components of the ginger that was dried.

Table 2: Proximate composition (%) of ginger spiced soymilk

Parameters	Ash	Moisture	Fat	Fibre	Protein	Carbohydrate
A	$0.36^{f}\pm0.01$	$91.16^{a}\pm0.05$	$2.02^{e}\pm0.01$	$0.03^{e}\pm0.001$	$4.40^{c}\pm0.00$	$2.02^{d}\pm0.05$
OB	$0.46^{c}\pm0.01$	$90.03^{b}\pm0.04$	$2.59^{c}\pm0.01$	$0.04^{c}\pm0.001$	$4.45^{bc}\pm0.05$	$3.42^{ab}\pm0.07$
OC	$0.51^{b}\pm0.01$	$88.07^{d}\pm0.03$	$2.69^{b}\pm0.01$	$0.05^{b}\pm0.001$	$4.50^{abc}\pm0.10$	$3.88^{a}\pm0.04$
SD	$0.40^{e}\pm0.01$	$89.54^{bc}\pm0.50$	$2.54^{d}\pm0.01$	$0.04^{bc}\pm0.003$	$4.45^{bc}\pm0.05$	$3.01^{bc}\pm0.53$
SE	$0.48^{c}\pm0.01$	$88.94^{c}\pm0.06$	$2.69^{b}\pm0.02$	$0.05^{a}\pm0.001$	$4.55^{ab}\pm0.05$	$3.24^{ab}\pm0.10$
AF	$0.43^{d}\pm0.01$	$89.99^{b}\pm0.01$	$2.61^{c}\pm0.01$	$0.04^{d}\pm0.001$	$4.50^{abc}\pm0.00$	$2.41^{cd}\pm0.00$
AG	$0.63^{a}\pm0.01$	$89.41^{bc}\pm0.49$	$2.88^{a}\pm0.01$	$0.05^{b}\pm0.001$	$4.60^{a}\pm0.00$	$2.71^{bcd}\pm0.39$
LSD	0.02	1.42	0.02	0.002	0.09	0.04

Values are means ± SD of 3 replicates. Means within a column with the same superscript were not significantly (P>0.05) different.

Vitamin content of ginger spiced soymilk

Vitamins play vital functions in the body. They are needed for formation of hormones, cell growth, needed for proper functioning of the immune system, enhances clear vision etc. There was a constant increase in the vitamin content of the ginger spiced soymilk as presented in Table 3. The values of vitamin B_1 (Thiamin) increased with addition of ginger flour. The significant $p<0.05$ differences in the treated sample noticed in vitamin B_1 could be due to the addition of the ginger spice. Ginger is a good source of this vitamin (0.85 mg/100 g and therefore responsible for the increase. The values were much higher than the 0.058 to 0.074 mg/100 g reported by Ugochi *et al.* [26] on nutrient and sensory quality of soymilk produced from different improved varieties of soybean. The vitamin B_2 (Riboflavin) content also increased with addition of ginger flour. The untreated soymilk had least vitamin B_2 content, while sample AG had the highest vitamin B_2. Ginger is a good source of this vitamin (0.13 mg/100 g). This values were higher than the 0.04 to 0.05 mg/100 g reported by [26]. Vitamin B_3 content increased with addition of ginger flour. Sample AG had the highest value, while sample A (untreated) had the least value. Ginger is a potential source of vitamin B_3 (0.75 mg/100 g). This values were higher than the 0.062 to 0.085 mg/100 g reported by [26]. The vitamin C (Ascorbic acid) content increase in treated samples was due to addition of ginger flour. Ginger is a good source of vitamin C (12.0 mg/100 g). The values were much higher than the 0.34 to 0.43 mg/100 g reported by [26]. However, ginger is a good source of vitamins, thus responsible for the constant increase in vitamin content of ginger spiced soymilk.

Mineral content of ginger spiced soymilk

Minerals are micronutrients needed in the body for its proper functioning, though not always needed in high quantity; they help in several body functions such as bone and tooth formation, blood formation, transmission of signals etc. The mineral contents of ginger spiced soymilk are presented in Table 4. Ginger is a good source of minerals, thus was responsible for the consistent increase in all the minerals. The increase in calcium and other minerals can be attributed to the high mineral content of ginger. The high calcium content of 488.57 mg/100 mL suggests that, ginger spiced soymilk sample could be used in complementary foods to help build the bones and teeth's. Calcium also plays a role in blood clotting [28]. Moreover, essential minerals like calcium and phosphorus are important in extra- cellular and intra-cellular body functions and as components responsible for the building block of structural component in human body [9].

Table 3: Vitamin composition (mg/100 mL) of ginger spiced soymilk

Parameters	Thiamin (B_1)	Riboflavin (B_2)	Niacin (B_3)	Ascorbic acid (Vitamin C)
A	$0.07^{d}\pm0.001$	$0.05^{f}\pm0.00$	$0.73^{f}\pm0.003$	$3.52^{e}\pm0.004$
OB	$0.10^{b}\pm0.016$	$0.06^{e}\pm0.00$	$0.74^{ef}\pm0.007$	$3.77^{d}\pm0.001$
OC	$0.18^{ab}\pm0.003$	$0.08^{d}\pm0.00$	$0.75^{de}\pm0.001$	$4.66^{c}\pm0.001$

SD	0.08^{bc}±0.003	0.10^{c}±0.00	0.76^{cd}±0.001	4.85^{b}±0.016
SE	0.09^{abc}±0.007	0.11^{b}±0.00	0.77^{bc}±0.001	4.97^{b}±0.001
AF	0.08^{c}±0.002	0.11^{b}±0.00	0.77^{b}±0.001	5.00^{b}±0.000
AG	0.19^{a}±0.002	0.21^{a}±0.00	0.79^{a}±0.004	5.39^{a}±0.047
LSD	0.012	0.001	0.006	0.111

Values are means ± SD of 3 replicates. Means within a column with the same superscript were not significantly (P>0.05) different.

Ginger is a potential source of calcium (280.0 mg/100 g). The values were higher than the 41.82 to 45.78 mg/100 g reported by Ugochi *et al*. [26] on nutrient and sensory quality of soymilk produced from different improved varieties of soybean. Ginger is also a good source of magnesium. The high magnesium content of 132.13 mg/100 ml obtained, could be used in making proteins and releasing energy and helps hold calcium in the enamel of the teeth [29]. Magnesium has been reported to serve as a co-factor in more than 300 enzymes systems that regulate diverse bronchial reactions in the body, including protein synthesis, muscle and heme function, blood glucose control, blood pressure regulation, structural development of bone, nerve impulse condition, muscle contraction and normal heart rhythm [25]. The addition of ginger flour resulted in increase in magnesium content of ginger spiced soymilk. Iron is an essential component of hundreds of proteins and enzymes [26]. Addition of ginger also resulted in an increase in iron content of ginger spiced soymilk. The high iron content of 11.23 mg/100 mL obtained, could be used in the management of iron deficiency anaemia since iron is a vital part of red blood cells that carry and release oxygen [29]. It will also be of nutritional importance especially to infants and growing children and pregnant mothers. Enough consumption of iron will help prevent impaired intellectual development in children, lead poisoning in children and help in the metabolism of all living organisms and humans. Ginger is a potential source of zinc (64.0 mg/100 g). Zinc is an important co-factor for more than 70 enzymes and plays a central role in cell division, protein synthesis and growth. Zinc deficiency will result in growth failure, anemia, enlarged liver and spleen, impaired skeletal development. Zinc content of the samples increased with increase in ginger flour addition. The high zinc content of 6.11 mg/100 mL obtained, will help in growth and development, immune response and neurobiological function and regulatory roles [26]. Ginger is also a good source of phosphorus. Phosphorus is reported to serve as a major structural component of bone in the form of a calcium phosphate salt called hydroxyapatite phospholipids and this phosphorus are major structural components of cell membrane. Also phosphorus is reported to help maintain normal acid-base balance (pH) by acting as one of the body’s most important buffers as well as prevention of loss of appetite, anaemic condition, muscle weakness, bone pain, rickets (in children), osteomalacia (in adults) [23]. Addition of ginger flour also resulted in an increase in phosphorus content of ginger spiced soymilk.

Table 4: Mineral content (mg/100 mL) of ginger spiced soymilk

Parameters	Calcium	Magnesium	Iron	Zinc	Phosphorus
A	225.21^{g}±0.01	71.45^{g}±0.01	1.79^{g}±0.58	0.97^{g}±0.01	132.17^{g}±0.01
OB	331.32^{f}±0.01	83.30^{f}±0.01	4.23^{f}±0.01	2.12^{f}±0.01	166.46^{f}±0.01
OC	349.16^{e}±0.01	91.34^{e}±0.01	4.95^{e}±0.01	2.55^{e}±0.01	175.34^{e}±0.01
SD	383.17^{d}±0.01	95.46^{d}±0.01	6.12^{d}±0.01	4.12^{d}±0.00	181.22^{d}±0.01
SE	441.35^{c}±0.01	98.81^{c}±0.01	7.56^{c}±0.01	5.66^{c}±0.01	195.01^{c}±0.01
AF	482.32^{b}±0.01	120.0^{b}±0.00	8.95^{b}±0.01	5.88^{b}±0.00	198.82^{b}±0.01
AG	488.57^{a}±0.02	132.13^{a}±0.01	11.23^{a}±0.01	6.11^{a}±0.01	210.06^{a}±0.01
LSD	0.015	0.015	0.384	0.012	0.016

Values are means ± SD of 3 replicates. Means within a column with the same superscript were not significantly (P>0.05) different.

Anti-nutrient content of ginger spiced soymilk

Anti-nutrients are substances that interfere with the absorption or the metabolism of nutrients. The slight increase in phytate content observed in spiced soymilk samples may be due to the addition of ginger flour. Phytate is one of the anti-nutrient present in ginger zhizome in small quantities. The values were far less than a value of 2.37 to 8.78 mg/100 g reported by Ani *et al.* [30] on the nutritional values, anti-nutritional factors and molar ratio of minerals to anti-nutrients of plant- based yoghurt from bambaranut, soybean and *Moringa oleifera* seed milks**.** High values were also obtained by Amao *et al.* [31] 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*). Phytate forms complexes with divergent minerals thereby decreasing the bioavailability of these elements for absorption [31]. Phytate is also implicated in decreasing protein digestibility by forming complexes and also interacting with enzymes such as trypsin and pepsin [32]. The knowledge of the phytate level in feeds is necessary because high concentration can cause adverse effects on the digestibility. The tannin contents increased from 0.5 % to 0.9 %. The values were far less than a value of 1.11 to 3.53 mg/100g reported by Ani *et al.* [30]. The slight increase observed in tannin content could be due to the addition of ginger spice. Tannin is present in ginger zhizome, though in trace amount. Arekemase *et al.* [32] reported phytochemical screening of ginger extracts which showed the presence of tannins. Tannin-protein complexes may cause digestive enzymes inactivation and protein digestibility reduction caused by protein substrate and ionisable iron interaction [15]. There was a significant increase in the hydrogen cyanide contents of the unspiced and the spiced samples. The highest value was recorded by sample OC and AG while the least value was recorded by sample A. The slight increase observed in spiced samples is due to the addition of ginger flour which has a minimal content of hydrogen cyanide. Cyanide can bind to several metals in the body like Na, K, obstructing metabolic pathways [33]. The oxalate content was 0.01 % in all samples. The addition of ginger flour did not have an effect on the oxalate content on the product. This could be due to the small quantity of ginger flour used. These values were far less than a value of 0.16 to 0.62 mg/100 g reported by [30]. High oxalate content in food causes kidney stones [34]. The anti-nutrients content in ginger spiced soymilk is very negligible and hence suitable for consumption. The lower values reported in this study might be attributed to the processing techniques employed in this study. Even though the anti-nutrients are present in ginger zhizome, it may be for the defense of the stored reserves of food for the use of the plant [26]. The level at which they occur are safe for consumption.

Table 5: Anti-Nutrient Composition (%) of Ginger Spiced Soymilk

Parameters	Phytate	Hydrogen cyanide	Oxalate	Tannin
A	$0.04^{c}±0.00$	$0.04^{e}±0.00$	$0.01^{a}±0.00$	$0.05^{c}±0.01$
OB	$0.05^{b}±0.00$	$0.05^{d}±0.00$	$0.01^{a}±0.00$	$0.8^{ab}±0.10$
OC	$0.06^{a}±0.00$	$0.07^{a}±0.00$	$0.01^{a}±0.00$	$0.9^{a}±0.10$
SD	$0.04^{b}±0.00$	$0.06^{b}±0.00$	$0.01^{a}±0.00$	$0.5^{b}±0.17$
SE	$0.06^{a}±0.00$	$0.06^{b}±0.00$	$0.01^{a}±0.01$	$0.6^{ab}±0.20$
AF	$0.05^{b}±0.00$	$0.05^{c}±0.00$	$0.01^{a}±0.00$	$0.5^{b}±0.00$
AG	$0.06^{a}±0.00$	$0.07^{a}±0.00$	$0.01^{a}±0.00$	$0.9^{a}±0.10$
LSD	0.002	0.003	0.006	0.207

Values are means ± SD of 3 replicates. Means within a column with the same superscript were not significantly (P>0.05) different

Sensory attributes of ginger spiced soymilk

Sensory attributes of every food product is an important quality parameter that pulls consumers toward a food product. Food product might contain most of the macronutrients needed by the body for proper functioning but with poor sensory attributes, this product will not be patronized by the consumers. The results for the sensory attributes of ginger spiced soymilk are presented on Table 6. The results revealed significant (P<0.05) difference in the sensory attributes (mouth feel, taste, colour, flavour and general acceptability) at different levels of ginger flour addition. All ginger spiced soymilk samples were generally accepted by the panelists with the highest recorded value on a scale of 9 in sample OB (7.96) and lowest in sample AG (6.16). A similar trend of rating was reported by Amadou *et al.* [11] on physicochemical and sensory properties of ginger spiced yoghurt. The results showed that sample OB (500 mL soymilk and 1 g oven dried ginger flour) was generally acceptable by consumers for all its attributes and can be used as a good fortification medium. The results also showed that increasing the quantity of ginger flour in soymilk significantly decreased the sensory properties of soymilk and reduced its overall acceptability. The ginger flour is characterised by its flavour, pungent taste and brownish colour which modify the original colour, odour and taste of soymilk, thus reducing its appreciation by panellists [26]. Moreover, because starch is the main carbohydrate component in ginger and it is used as thickener and gelling agent, its action could be high at certain levels of concentration and thus justify the slight loss of original sensory attributes in samples spiced with higher levels of flour (2 g). Similar overall acceptability of soymilk spiced with low level of ginger flour (1 g) and unspiced soymilk could be explained by the low impact of ginger on the sensory properties of the soymilk. The good colour could also be as a result of intrinsic factors like carotenoid and polyphenol contents in high amounts [25].

Table 6: Sensory properties of ginger spiced soymilk

Samples	Appearance	Aroma	Taste	Mouth feel	Overall acceptability
A	$7.90^{a}±1.29$	$6.70^{b}±1.55$	$6.73^{b}±1.72$	$6.93^{a}±1.48$	$7.06^{ab}±1.38$
OB	$7.66^{a}±1.53$	$6.76^{b}±1.54$	$7.93^{a}±0.73$	$6.90^{a}±1.86$	$7.96^{a}±1.06$
OC	$7.60^{a}±1.30$	$7.76^{a}±0.72$	$6.36^{b}±1.51$	$7.30^{a}±1.53$	$6.80^{b}±1.29$
SD	$7.63^{a}±1.21$	$6.66^{b}±1.21$	$6.56^{b}±1.56$	$6.70^{a}±1.68$	$6.86^{b}±1.30$
SE	$7.73^{a}±1.08$	$7.00^{ab}±1.14$	$6.36^{b}±1.06$	$7.06^{a}±1.48$	$6.70^{b}±1.29$
AF	$7.83^{a}±1.01$	$6.56^{b}±1.40$	$6.90^{b}±1.53$	$6.63^{a}±1.79$	$7.10^{ab}±1.34$
AG	$7.86^{a}±1.04$	$7.00^{ab}±1.53$	$6.13^{b}±1.19$	$6.83^{a}±1.57$	$6.16^{b}±1.59$
LSD	0.624	0.679	0.699	0.833	0.680

Values are means ± SD of 3 replicates. Means within a column with the same superscript were not significantly (P>0.05) different.

Conclusion

The study established that the addition of ginger flour to soymilk significantly increased its quality nutritional. The study also established that oven dried ginger spiced soymilk was the most acceptable in terms of sensory attributes while the ambient dried ginger spiced soymilk was better in terms of nutritional composition.

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