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Assessment of the Effect of Ginger Flour Addition on the Chemical and Storage Stability of Soymilk

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study evaluated the effect of adding ginger flour on the storage stability 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 and microbiological load of the soymilk were determined. The pH ranged from 6.6 to 4.7. The values decreased as storage time progressed. Total titratable acidity (TTA) ranged from 0.0015 to 0.0698 % and increased with storage time. Total soluble solids (TSS) decreased from 26.60 to 3.99 ^{o}Brix as storage time increased. Total solids (TS) decreased from 7.76 to 0.31 % during storage. The total viable counts of the control sample increased from 4.0×10^{3} to 71×10^{3}cfu/mL while those of the treated samples increased from 0 to 33×10^{3} cfu/mL, Coliform was not detected. Yeast and mould

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growth did not occur from day 0 to day 7 but increased from 2.0×10^3 to 5.0×10^3 cfu/mL on day 14 and 21, respectively. The highest microbial load was obtained in the control soymilk sample. Two grams of ginger flour preserved the soymilk better than one gram. As conclusion, the incorporation of ginger flour affected the chemical composition and microbial load of soymilk during storage at refrigeration conditions.

Keywords: Soymilk; ginger flour; chemical composition; storage stability; microbial load.

1. INTRODUCTION

"Soymilk is an aqueous, white, creamy extract produced from soybeans (*Glycine max*)" [1] . "It is a highly nutritious food drink which contains proteins, fats, carbohydrates, vitamins and minerals" [2]. "The oldest evidence of soya milk production is from China where a kitchen scene proving use of soya milk is incised on a stone slab dated around AD 25–220" [3]. The quality of soymilk is dependent on changes observed in its physiochemical, microbiological and sensory attributes [4]. The shelf-life of soymilk is limited due to the deterioration of its properties with storage [5]. To improve on the quality of soymilk, different flavouring ingredients have been added to it during the manufacturing stage [6]. "Other than the whole seed, many processed soy products are available in the market. They include soya milk, soya flour, soya curd and *tofu* (soya paneer)" [7]. Soybean is the main raw material used in the preparation of soymilk.

"Soybean (*Glycine max*) being a non-native and non-staple crop in Sub-Saharan Africa (SSA), it is known to be of great commercial potentials, owing to its wide range of uses as food, feed, and industrial raw material" [8]. "Soybean is known to have been introduced in Nigeria in 1908 from when it was cultivated as an export crop in a small area in Benue state, where the introduced variety 'Malayan' was adopted" [9]. "Zaire has a long history of soybean production by indigenous farmers" [3]. "Soybeans were introduced and promoted first by the missionaries long before independence. Soybean is considered a medicinal food which is known to prevent and cure the wasting effects of malnutrition in Zaire and other parts of Africa" [10]. "As of 2016, South Africa was known to be the largest soybean producer, followed by Nigeria, Zambia, and Uganda" [8]. "Since the value of soybean as a high-protein food source has been recognized, the use and consumption pattern of soybean-based foods have become popular in Sub-Saharan Africa" [9]. "A number of various food products such as *nshima*, also called *bidia*, *dawadawa*, *mahewu*, *soy-ogi* (fortifying maize with soybean), *soy kebab* (spicy *tofu*), biscuits, soy flour, soy yogurt, and soymilk have been produced and accepted by local people in many SSA countries" [8]. "In SSA, soymilk have been used and incorporated in the daily meal of malnourished children and HIV/AIDS-infected patients in public schools and hospitals" [3]. "Nigeria stands out in SSA for the promotion and utilization of soy-based food products in rural and urban areas. Nigeria has resorted to the development of home-level and small scale processing technologies for soy-based foods; this has led to the high utilization and consumption of soy-based food products in Nigeria" [8].

Most flavourings used in the industrial production of soymilk are synthetic [5]. The use of natural flavourings such as fruits or vegetables will be more beneficial to the consumers' health because they are a good source of minerals, fibres, vitamins, and bioactive compounds [8]. Amongst many other spices, ginger; a root vegetable is one of the mostly used culinary spices [11]. The need for use of inexpensive local resources in the preservation of staple foods to limit post-harvest losses is of high importance in our society today. As a local beverage produced by traditional methods, soymilk offer only a short lifespan [6]. The milk is underutilized due to its short shelf-life, which hinders widespread consumption of the beverage due to the deteriorating effects of some microorganisms on the milk [5]. There have been many attempts to industrialize the locally prepared soymilk, but the inability to preserve the milk for a long time has been a major problem [8]. Some authors have evaluated the preservative effect of ginger on food products [12-16] but highlighted the need for intensification in order to obtain improved flavour, aroma, as well as to improve and/or extend the shelf life. Addition of ginger powder to soymilk could improve the antimicrobial and antioxidant (bioactive) properties of soymilk and thus rendering it more functional with improved shelf life [17]. The aim of the study therefore was to assess the effects of ginger flour on the chemical and storage stability of soymilk.

2. MATERIALS AND METHODS

2.1 Sample Collection

The study was carried out between June and August 2021. 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.

2.2 Preparation of Ginger Flour

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

i. Oven dried at 50°C for 12 h.
ii. Sun dried at 40°C to 42 °C for 3 days, with relative humidity at 75 % to 75.3 % using a thermo-hydrometer.
iii. Ambient dried at 30.35°C to 32.2°C for 5 days, with relative humidity at 59.5 %, 60 % and 63.5 %.

The dried ginger was blended into powder in three proportions using a kitchen blender (model: Binatone BLG-452), and sieved through a sieve of pore size 0.5 mm [18]. The sieved ginger powder was stored in well-sealed plastic containers at room temperature in a closed cupboard to avoid sun light.

2.3 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 70^oC for 15 seconds, cooled (18^oC) [18]. 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 6^oC).

2.4 Formulation of Ginger Spiced Soymilk

The obtained milk was then formulated by adding ginger powder. 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 powder to every 500 mL of soymilk as shown in Table 1.

2.5 Chemical Properties of Ginger Spiced Soymilk

2.5.1 Determination of pH

The pH measurement was carried out using a glass electrode pH meter (Model: OAKLON, SN: 1564140) at ambient temperature according to the method of AOAC [19]. Ten millilitres of sample was measured in to a beaker. The pH was then standardized using a buffer solution. The electrode of the pH meter was rinsed with distilled water and then inserted into the beaker containing the sample. The pH reading was recorded in triplicates and pH electrode rinsed with distilled water.

Table 1. Sample formulation for ginger-spiced soymilk

Samples	Soymilk (mL)	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

2.5.2 Determination of total titratable acidity

"Titratable acidity was carried out using the method as described in AOAC" [19]. The samples blends (2 mL each) were each weighed and transferred into 50 mL centrifuge tube. Ten (10) mL of distilled water was added. One (1) mL aliquot of each solution was taken into another 50 mL centrifuge tube and 10 mL of distilled water added to dilute the sample. The diluent (10 mL) was titrated against 0.1N NaOH solution using phenolphthalein (2 drops) indicator and percentage titratable acidity was calculated:

$$\text{TTA} = \frac{\text{mL of NaOH used} \times 0.1\text{M NaOH} \times \text{milliiequvalent} \times 100}{\text{Volume of sample}} \quad (1)$$

2.5.3 Determination of total solids content

The total solids content of ginger spiced soymilk samples was measured as described by Matin *et al*. [20] and the results were expressed as percentage. Two millitres of ginger spiced soymilk sample was measured into a beaker, warmed slowly to 35 - 40 °C on a water bath with careful mixing to incorporate any cream adhering to the sample. The sample was then cooled quickly to room temperature. A dish was heated with its lid alongside in the drying oven at least 1 h. The lid was then placed on the dish and immediately transferred to a desiccator. It was allowed to cool to room temperature (at least 30 min) and weighed to 0.1 mg. A 5 mL of prepared sample was added and lid placed on the dish and the weight was again taken. The dish was further placed without the lid on the vigorously boiling water bath in such a way that the bottom of the dish was directly heated by the steam. There was continuous heating till water was removed. The dish was removed from the water bath, with the underside wiped and placed it in the oven alongside the lid for 2 h. The lid was put on the dish and then transferred to the desiccator. The dish was allowed to cool and the weight taken to the nearest 0.1 mg. The dish was further heated in the oven for 1 h. It was allowed to cool and weighed again. The operation was repeated until the difference in the two consecutive weighing did not exceed 1 mg. The least of the masses was recorded.

2.5.4 Determination of total Soluble Solids content

The total soluble solids in the ginger spiced soymilk samples was determined by using a digital refractometer (Model: ATAGO RX-5000) and expressed in terms of °Brix (^{o}Bx) [21].

2.5.5 Determination of total viable count

"All media were prepared by weighing appropriate amounts of the flour according to manufacturer's specification" [22]. Following sterilization of media by autoclaving at 121 ^{o}C for 15 min, 1 mL of ginger spiced soymilk samples was measured with the aid of a sterile syringe. After vigorous shaking, a plastic rack was arranged with sterile test tubes containing 9 mL of sterile distilled water. A tenfold serial dilution [23], was carried out by dropping 1 mL of the sample into the first test tube labelled 10^{-1}. This was mixed properly. 1 mL was again taken from the 10^{-1} dilution tube and transferred into the next test tube labelled 10^{-2}. The dilutions continued to dilution 10^{-3}. Each test tube was vigorously shaken before each transfer. All plate samples were duplicated. After incubation, the colonies were counted and recorded accordingly [24].

2.5.6 Determination of coliform count

"Eosin methylene blue agar (EMB) was inoculated with serial dilutions of the sample by the pour plate method and incubated at 37 °C for 24-48 h. The different representative colonies from Eosin methylene blue agar (EMB) plates were then counted and recorded after incubation" [25].

2.5.7 Determination of fungi count

Fungi counts were determined on Potato dextrose agar (PDA). The PDA media was modified with Chloramphenicol capsule to inhibit bacterial contamination. One millilitre of the diluted samples was measured with the use of a sterile syringe and poured into an empty sterile petri dish, followed by pouring PDA into the prepared plates. The plates were rotated clockwise for easy mix up of the sample and the media and incubated for 3-5 days at 37 °C. Colonies were then counted and recorded after incubation period [26].

2.5.8 Counting of the colonies

Using a hand tally counter, the number of colonies were counter after incubation [22]. A mean of the count was obtained and multiplied with the appropriate diluting factor. The mean count was calculated as shown below:

Mean = total viable count/ number of plates

The estimation of viable number of microorganisms (total viable counts) in each sample was made in colony forming units (cfu)

TVC = 1 Weight of sample *N*D

Where

N = average number of colonies
D = dilution factor

2.5.9 Storage stability study

Storage stability was determined within 21 days (3 weeks) of storage at refrigeration conditions (4–6 ^{o}C). Data were collected at 0, 7, 14 and 21 days interval on pH, total titratable acidity, total dissolved solids and total soluble solids.

2.6 Statistical Analysis

The data was obtained and analysed using SPSS v21 by one-way ANOVA, in triplicates. The means obtained were separated using Tukey HSD test. Differences were considered at 95 % (p<0.05) confidence interval.

3. RESULTS AND DISCUSSION

3.1 pH of Ginger Spiced Soymilk during Storage

There was a significant decrease in the pH of ginger spiced soymilk during storage at refrigeration conditions between control and test soymilk samples. The initial pH of all the soymilk samples ranged from 6.6 to 6.9. Results similar to this were reported by Arekemase *et al*. [27] on the assessment of the effectiveness of ginger (*Zingiber officinale*), clove (*Syzygium aromaticum*) and Sodium Benzoate on the shelf life of soymilk. Odom et al. [28] got similar results on a study on the comparative studies of ginger (*Zingiber officinale*) and black pepper (*Piper guinenses*) on soymilk. The pH of the entire samples followed the same decreasing pattern as storage progressed. During storage, and in refrigerated conditions, activity of organic acids is not completely stopped and there is acidification by organic acid leading to a drop of pH. The reduction in pH might also be due to the fact that the initial pH of the soymilk samples favoured the growth of bacteria and then led to subsequent release of metabolic products into the medium. Similar results were reported by Afroz et al. [29] on the preparation of soymilk using different method. This results were also in line with values reported by Amadou et al. [18] on the physicochemical and sensory properties of ginger spiced yoghurt. In a study by Odu et al. [30], it was reported that "the reduction in pH during fermentation might be as a result of acidification by acetic acid fermentation of breadfruit which reduces the chance of microbial spoilage". At the end of storage, the control soymilk had the lowest (P<0.05) pH value while soymilk sample spiced with 2 g ginger flour had the highest. The low values (P<0.05) observed for the spiced soymilk samples compared to the control soymilk sample at the end of storage could be as a result of low level of fermentation due to the antimicrobial activity of the ginger, thus the ginger could contribute to the preservation of soymilk. The significant (P<0.05) difference between the initial and the final values of soymilk samples pH could also be related to the continuous fermentation at refrigerated conditions.

Table 2. pH of Ginger Spiced Soymilk during Storage

Samples	Day 0	Day 7	Day 14	Day 21
A	6.9^{a}±0.05	5.5^{cd}±0.10	4.2^{d}±0.00	3.7^{e}±0.05
OB	6.8^{ab}±0.05	5.5^{cd}±0.00	5.3^{ab}±0.05	4.7^{cd}±0.05
OC	6.7^{bc}±0.05	5.7^{ab}±0.00	5.4^{b}±0.05	4.9^{a}±0.00
SD	6.8^{b}±0.05	5.4^{d}±0.05	5.2^{c}±0.05	4.7^{d}±0.00
SE	6.7^{bc}±0.05	5.6^{c}±0.00	5.3^{ab}±0.05	4.8^{bc}±0.00
AF	6.8^{b}±0.00	5.5^{cd}±0.00	5.3^{ab}±0.05	4.8^{ab}±0.05
AG	6.6^{c}±0.05	5.8^{a}±0.00	5.5^{a}±0.05	4.9^{a}±0.00
LSD	0.08	0.08	0.07	0.17

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

3.2 Total Titratable Acidity of Ginger Spiced Soymilk during Storage

There was a gradual increase (P<0.05) in titratable acidity of all samples during storage. Moreover, the control sample presented the highest increase in titratable acidity (P<0.05) especially on day 14 and at the end of storage. For spiced samples, the initial and the final values of titratable acidity were significantly (P>0.05) different while those of control sample showed a similar difference (P>0.05). The high increase in titratable acidity obtained with the control sample was due to fermentation (activity of bacteria) which is not completely stopped during refrigeration thus leading to the production of organic acid. The antimicrobial activity of ginger could be responsible for the non-significant variation of titratable acidity in the spiced soymilk samples during storage. The gradual increase in titratable acidity during storage was also observed in Sudanese yoghurt [18]. The titratable acidity values obtained during storage at refrigeration temperature is comparable to the values obtained by [2], who reported mean values of titratable acidity in the range of 0.87 to 1.13%. This was different from the values of 2.5 to 2.07% reported by [31] on soymilk stored at refrigeration temperature. "It was also observed that titratable acidity increased with decrease in pH of the samples. Similar increasing trend of titratable acidity with a decrease in pH was observed in soymilk samples preserved with local spices during storage" by [25]. "These values were in line with the values reported for soy-corn milk (0.063 and 0.057% in white and yellow maize, respectively)" by [32]. The high titratable acidity of control sample compared to spiced samples could indicate a positive effect of ginger on the preservation of soymilk.

3.3 Total Soluble Solids of Ginger Spiced Soymilk during Storage

Statistically TSS of samples showed significant (P<0.05) difference with respect to increased number of storage days and change in treatment. According to Khodke et al. [33] "about half of the solids in soymilk consist of soybean protein. As a common problem with soymilk is lack of stability sediment precipitation of proteins and other added solid particles such as minerals or flavours it might be the reason for lowered value of TSS during storage". Similar results were reported by khodke et al. [33] on a study on the storage of sterilized soymilk.

3.4 Total Solid Content (TS) of Ginger Spiced Soymilk during Storage

There was a significant (p<0.05) difference in the initial TS of ginger spiced soymilk and the untreated sample. The ginger spiced samples had the highest TS and the least value was recorded by sample A. This could be due to the

Table 3. Total Titratable Acid (%) of Ginger Spiced Soymilk during Storage

Samples	Day 0	Day 7	Day 14	Day 21
A	0.002^{a}±0.00	0.006^{a}±0.00	0.062^{a}±0.00	0.069^{a}±0.00
OB	0.002^{a}±0.00	0.005^{b}±0.00	0.055^{c}±0.00	0.063^{f}±0.00
OC	0.002^{a}±0.00	0.005^{b}±0.00	0.053^{d}±0.00	0.066^{e}±0.00
SD	0.002^{a}±0.00	0.006^{a}±0.00	0.061^{a}±0.00	0.067^{c}±0.00
SE	0.002^{a}±0.00	0.005^{b}±0.00	0.057^{b}±0.00	0.068^{b}±0.00
AF	0.002^{a}±0.00	0.006^{a}±0.00	0.057^{b}±0.00	0.067^{d}±0.00
AG	0.002^{a}±0.00	0.005^{b}±0.00	0.051^{e}±0.00	0.061^{g}±0.00
LSD	0.002	0.003	0.007	0.003

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

Table 4. Total Soluble Solids (^{O}Bx) of Ginger Spiced Soymilk during Storage

Samples	Day 0	Day 7	Day 14	Day 21
A	21.19^{c}±0.00	13.32^{e}±0.02	6.66^{e}±0.00	3.99^{e}±0.01
OB	23.14^{b}±0.12	13.35^{de}±0.05	6.67^{e}±0.00	4.01^{e}±0.00
OC	23.02^{b}±0.00	14.86^{c}±0.04	7.43^{c}±0.00	4.27^{b}±0.01
SD	22.94^{b}±0.00	13.52^{d}±0.02	6.77^{d}±0.01	4.05^{d}±0.00
SE	23.26^{b}±0.00	16.47^{b}±0.09	8.24^{b}±0.01	4.11^{c}±0.01
AF	26.53^{a}±1.00	13.35^{de}±0.13	6.66^{e}±0.00	4.01^{e}±0.00
AG	26.60^{a}±0.00	18.52^{a}±0.02	9.26^{a}±0.00	4.64^{a}±0.01
LSD	0.67	0.12	0.01	0.02

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

higher levels of suspended particles in the treated samples. These results were in line with findings of Ajala et al. [32] on physicochemical and sensory qualities of spiced soy-corn milk.

3.5 Microbiological Analysis of Ginger-spiced Soymilk during Storage

3.5.1 Total Viable Count (TVC) of ginger spiced soymilk during storage

Microbial growth causes degradation of food quality which leads to visible changes in colour, odour and texture. Changes in colour, flavour, taste, whey separation and acid production were observed in the preserved ginger spiced soymilk samples at different time intervals. There was a gradual increase in counts as storage progressed from day 0 to day 21 in all samples. Lower viable counts were observed in samples treated with ginger powder as compared to the untreated sample. The lower counts observed in treated samples was attributed to the antimicrobial properties (gingerol, shigoal and gingerdoil) of ginger. Similar results were reported by Arekemase et al. [27] on the assessment of the effectiveness of ginger, clove and sodium Benzoate on the shelf life of soymilk. It is also in line with the work of Amadou et al. [10] on the effect of ginger extract on the physicochemical and sensory properties of yoghurt. This result were in accordance with the work of Akponah et al. [34] who reported on the potency of ginger in extending the shelf life of orange juice. The result dovetails with the findings of Adesokan et al. [35], who reported the effectiveness of ethanolic extract of ginger in prolonging the shelf life of West African soft cheese for up to 3 days. This is also in agreement with the work of Obi et al. [36], who reported that the prolonged shelf life of ginger treated zobo drink for 6 days at room temperature was due to it antimicrobial property.

Table 5. Total Solids (%) content of Ginger Spiced Soymilk during Storage

Samples	Day 0	Day 7	Day 14	Day 21
A	3.76^{f}±0.00	1.70^{c}±0.00	1.50^{e}±0.01	0.31^{e}±0.01
OB	4.76^{e}±0.00	2.70^{b}±0.00	1.51^{e}±0.01	0.31^{e}±0.01
OC	4.78^{e}±0.02	2.76^{b}±0.00	1.85^{a}±0.02	0.81^{b}±0.01
SD	4.81^{d}±0.00	1.77^{c}±0.01	1.67^{c}±0.00	0.83^{b}±0.00
SE	6.81^{b}±0.01	2.80^{a}±0.00	1.86^{a}±0.01	0.97^{a}±0.01
AF	5.50^{c}±0.00	1.76^{c}±0.00	1.57^{d}±0.01	0.36^{d}±0.01
AG	7.76^{a}±0.00	2.76^{b}±0.00	1.76^{b}±0.00	0.53^{c}±0.01
LSD	0.016	0.008	0.019	0.017

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

Table 6. Total Viable Bacterial Count (TVBC) (x10^3cfu/mL)

Samples	Day 0	Day 7	Day 14	Day 21
A	4.0^{a}±0.00	17^{a}±0.10	30^{a}±0.10	71^{a}±2.00
OB	3.0^{b}±0.05	4.0^{b}±0.00	23^{b}±0.50	33^{b}±0.30
OC	2.0^{b}±0.00	4.0^{b}±0.05	15^{c}±0.10	22^{bc}±0.20
SD	3.0^{b}±0.05	5.0^{b}±0.05	10^{d}±0.45	22^{bc}±1.15
SE	2.0^{b}±0.05	3.0^{b}±0.00	9.0^{d}±0.00	11^{c}±0.10
AF	-	-	6.0^{e}±0.10	14^{bc}±0.36
AG	-	-	4.0^{e}±0.00	10^{c}±0.25

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

Table 7. Total Coliform Count (TCC) (x10^3cfu/mL)

Samples	Day 0	Day 7	Day 14	Day 21
A	Nil	Nil	Nil	Nil
OB	Nil	Nil	Nil	Nil
OC	Nil	Nil	Nil	Nil
SD	Nil	Nil	Nil	Nil
SE	Nil	Nil	Nil	Nil
AF	Nil	Nil	Nil	Nil
AG	Nil	Nil	Nil	Nil

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

Table 8. Total Yeast and Mould Counts (x10^{3}cfu/mL)

Samples	Day 0	Day 7	Day 14	Day 21
A	-	-	2.0^a±0.50	5.0^a±0.57
OB	-	-	1.0^b±0.00	1.0^b±0.00
OC	-	-	1.0^b±0.00	1.0^b±0.00
SD	-	-	1.0^b±0.00	1.0^b±0.00
SE	-	-	1.0^b±0.00	1.0^b±0.00
AF	-	-	1.0^b±0.00	1.0^b±0.00
AG	-	-	1.0^b±0.00	1.0^b±0.00

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

3.6 Total Coliform Counts (TCC) of Ginger Spiced Soymilk during Storage

There was no coliform detected in all samples throughout the storage period of 21 days. These results were in accordance with the SON standard which stipulates no coliform count is allowed in soymilk. The inhibition of coliform in all samples could be due to proper method of production and preservation of samples. This could also be attributed to the antimicrobial properties of ginger in spiced samples. Arekemase et al. [27] reported that, "phytochemical screening of ginger and clove extracts showed the presence of tannins, phenol, alkaloid, flavonoid, terpenoids, steroids, glycosides, coumarin and saponins. The antimicrobial activities of ginger might be due to these phytochemicals". This finding agrees with those of other workers [36,28]. The findings of Odom et al. [28] suggest that "the preservative effect of ginger and black pepper on soymilk was as a result of their essential oil fraction which was inhibitory to microbial growth". Obi et al. [36] reported that "the antimicrobial activity of spice in zobo drink was as a result of their volatile oil. This study confirms that the use of ginger flour was effective in the inhibition of coliforms in the product".

3.7 Total Yeast and Mould Counts of Ginger Spiced Soymilk during Storage

According to the standards organisation of Nigeria (SON), a maximum of 5 cfu/mL yeast and mould count is allowed in soymilk. From the results, there was no yeast and mould count detected from 0 to 7 days. During day 14 and day 21 of storage there were fungi counts (1cfu/mL) grew in each of the treated samples, while the untreated sample had the highest count. All the treatments showed a higher suppressive action against fungal, than the bacterial isolates. The findings agreed with those of other workers including [37,38]. Similar findings were reported by Akponah et al. [34] that all extracts of ginger, garlic and rosemary exhibited more antimicrobial action against fungal isolates than the bacterial isolates. Arekemase et al. [27] point to the fact that the antifungal effects might be due to monoterpene, which destroyed the integrity of fungi membrane. Kabiru et al. [31] reported that "the inability of the ginger, clove and a combination of ginger-clove extract to completely inhibit fungal and bacterial growth might be due to the low concentration of the extracts used, as higher concentrations of plant extracts were required before antimicrobial properties were observed". "In addition, it was observed that many spices have the ability to inhibit microbial growth in food than in culture media" [27]. "However, large amounts of the spice extracts required for complete microbial inhibition would affect the organoleptic properties of the milk products" [31].

4. CONCLUSION

Results of this finding indicate conclusively that:

i. The oven, sun and ambient temperature drying of ginger flour affected the nutrient composition, physicochemical and sensory properties of soymilk.
ii. The soymilk containing 1 g of ginger oven dried at 50 ^{o}C was the most preferred.
iii. The microbial counts of ginger spiced soymilk were within the permissible levels and the soymilk was generally regarded as safe.

The study therefore established that the ginger spiced soymilk had a longer shelf stability compared to the untreated (control).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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