ASSESSMENT OF GINGER AND GARLIC IN THE IMPROVEMENT OF THE SHELF-LIFE AND SENSORY QUALITY OF NUNU (FERMENTED MILK)

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Abstract
Nunu is consumed mostly in the northern part of Nigeria. Nunu has low keeping quality at room temperature. Therefore, assessing the potency of garlic (Allium sativum) and ginger (Zingiber officinale) for the improvement of the shelf-life and sensory qualities of Nunu is of importance. Nunu samples were separately treated with 0.005%, 0.01% and 0.015% w/v ginger and garlic and combination (0.02% w/v) comprising of equal weight of each. The sensory properties, pH, Titratable acidity and microbiological analysis were evaluated during storage period. The sample which contained 0.01% w/v of ginger had the best overall acceptance when compared with other samples. There was a decrease in pH and an increase in Titratable acidity in all the samples over the period of storage. A total of six bacteria were identified from the samples which include: Lactobacillus paracasei 10-3, Bacillus subtilis, Bacillus pumillus, Staphylococcus aureus, Leuconostoc sp., Lactococcus sp., Streptococcus sp. while four fungi were isolated which include Pichia kudriavzevii, Saccharomyces cerevisiae, Candida sp., Aspergillus niger, Mucor sp. and Rhizopus sp. The preservative reduced the total bacterial and fungal counts from 1.5 x 10^6cfu/ml to 3.0 x10^4cfu/ml, 1.6 x 10^6cfu/ml to 1.0 x 10^4cfu/ml respectively; there was no reduction in lactic acid bacteria counts.

Keywords: Preservative, Garlic, Ginger, 'Nunu', Shelf life, Potency

Introduction

Nunu is an opaque white to milky colored liquid food drink common among Nigerians. It is usually sold by Fulani women and it is taken with ground millet called "fura" and usually sweetened with sugar and ice crystals (it can also be taken without "fura" and sweetener). Nunu (noo-noo) is a locally fermented Nigerian milk product used as a staple food amongst the Saharan tribes of West Africa sub-region. Milk, if left untreated, spoils within a short time due to microbial activity; thus processing milk improves its storage and diversifies its use (1). Traditionally, nunu is prepared by inoculating freshly drawn cow milk with a little of the leftover as a starter culture and then is allowed to ferment for about 24 hours at room temperature (2). During fermentation, some of the lactose is converted to lactic acid. At the end of fermentation period, churning is used for removing milk butter and nunu which is the remaining sour milk, is a delicious and refreshing beverage. The organisms involved in the fermentation process are usually the bacteria, yeast and mould. Of these, *Lactobacilli* (*L. acidophilus* and *L. bulgaricus*), *Lactococci* sp. (*L. cremoni* and *L. lactis*), *Streptococcus thermophilus*, *Leuconostoc* sp. and *Saccharomyces* species seem to be the most common, giving products with characteristic flavours. Sour milk is thus not a uniform product (2).

The safety of milk products with respect to food-borne diseases is of great concern around the world. This is especially true in developing countries where processing of milk and milk products takes place under unsanitary and poor production conditions (3). Though, these might contribute to the short shelf life of the products and also result in food poisoning (4); smallholder milk producers in Ethiopia use natural preservatives to improve the quality of milk and milk products (3,5), however, this is yet to be practiced in Nigeria.

Ginger (*Zingiber officinale)* which belongs to the family Zingiberaceae is a perennial herb with thick tuberous rhizomes and is a widely consumed spice worldwide. From its origin in South-east Asia and Europe, they are used as herbal medicine to treat a variety of ailments including pain, indigestion, vomiting, and cold-induced syndromes (6,7,8). The cultivation of ginger plant has a long history. It originated in China and then spread to India, South East Asia, West Africa and the Caribbean (6,7,9). Ginger has been used by traditional Chinese and Indian medicine for over 25 centuries (10). Ginger is recommended to relieve and prevent nausea, caused by motion sickness and morning sickness (11). Apparently, this effect is not mediated through the central nervous system (CNS), but rather, ginger active principles act directly on the gastrointestinal tract (8). Ginger has been used as flavoring for cookies, crackers and cakes as well as flavour in ginger ale (a sweet, carbonated, non-alcoholic beverage), gingerbread, ginger snaps, ginger cake and ginger biscuits (9). It is extensively used in preparation of dietaries for its aroma and flavour. Dry ginger is used in the manufacture of oil, oleoresin, essence and processed meat (12).

Garlic has at least 33 sulfur compounds, several enzymes, minerals (germanium, potassium, magnesium, selenium, calcium, copper, iron, and zinc), vitamins A, B1 & C, fiber and water. It also contains 17 amino acids which include lysine, histidine, arginine, aspartic acid threonine, glutamine, proline, glycine, alanine, cysteine, valine, methionine, isoleucine, leucine, tryptophan and phenylalanine (13).

In Nigeria, however, there are very limited studies conducted so far thus little information is available on the effect of natural spices on microbial, chemical as well as sensory properties of Nunu. This study was, therefore, initiated to evaluate the effect of locally available spices namely garlic (*Allium sativum*) and ginger (*Zingiber officinale*) on microbial, chemical and sensory properties of Nunu.

The aims and objectives of this study were:

(i). To access the potency of ginger and garlic as preservatives.
(ii). To isolate and characterize microorganisms responsible for the spoilage of Nunu.
(iii). To determine the effect of ginger and garlic on the lactic acid bacteria present in Nunu.
(iv). To determine the effect of ginger and garlic, at various concentrations, on the shelf-life of Nunu.
(v). To determine the proximate analysis of the Nunu samples preserved with garlic and ginger.
(vi). To determine the sensory improvement or otherwise of Nunu preserved with garlic and ginger powder at various concentrations.

Materials and Methods

Collection of sample

Nunu (locally fermented milk) was freshly obtained from Fulani women hawkers at Oja-Oba market in Ilorin metropolis, Nigeria. Garlic (*Allium sativum*) and ginger *(Zingiber officinale)* used in this study were purchased at Challenge, Ilorin. They were sorted and cleaned manually.

Sample Identification

Garlic (*Allium sativum*) and Ginger (*Zingiber officinale*) were identified at the Herbarium unit of the Department of Plant Biology, University of Ilorin, and authenticated with the voucher number UILH/002/1209 and UILH/001/976 respectively. The freshly obtained plant materials were properly washed in tap water (H_2O), and then rinsed in sterile distilled water.

Sterilization of Materials
All materials used were sterilized. The work bench was sterilized using 70% alcohol, all media and contaminated materials were autoclaved at 121°C for 15 minutes, Glassware were sterilized in hot air oven at 170°C for 1 hour. Petri dishes were bought sterile. Aseptic techniques were used to prevent contamination.

Preparation of Ginger and Garlic and Incorporated into Nunu
The garlic and ginger were washed manually, peeled with a sharp knife and then dried in a hot air oven at 55°C for 24 hours (33). The dried garlic and ginger were ground to a fine powder in a mill. Then, different quantities (0.5g, 1.0g and 1.5g) of the powdery garlic and ginger were added to the bottles containing Nunu.

Extraction of Plant Material
Using the weighing balance, 25g each of powdered garlic and ginger were mixed with 250 ml of the solvent (distilled cold water) for different periods (14, 24 and 48 h) with agitation at room temperature. After, the extracts were taken and filtered by using a 0.45 milli pore filter paper. Then, the extracts were concentrated using a rotary evaporator at 40°C under reduced pressure. Finally, the extracts were weighed and stored in the refrigerator for further use.

Treatment of Preservatives
Different quantities of garlic and ginger samples were used to preserve Nunu and the various samples were assigned codes for proper identification.

	Sample Mixture	**Sample Code**
1.	Nunu sample + 0.5g of Garlic	GA-1
2.	Nunu sample + 1.0g of Garlic	GA-2
3.	Nunu sample + 1.5g of Garlic	GA-3
4.	Nunu sample + 0.5g of Ginger	GI-1
5.	Nunu sample + 1.0g of Ginger	GI-2
6.	Nunu sample + 1.5g of Ginger	GI-3
7.	Nunu sample + 1.0g of Garlic + 1.0g of Ginger	GAGI
8.	Refrigerated Nunu sample Control	Rf
9.	Nunu sample stored at Room temperature Control	Rt

Characterization of Isolates
Identification of the bacterial isolates were done using biochemical, microscopic and molecular techniques (14) while fungal identification were also carried out by molecular techniques and with the help of appropriate mycology textbooks (15,16).

Physicochemical Analysis of Nunu Samples

pH Determination: The pH of the Nunu samples were determined using a pH meter (Denver model 20); The determination was carried out by standardizing the electrode of the pH using buffer solution of pH 4, 7 and 9 respectively. The standardized pH meter was dipped into the samples and readings were taken and recorded accordingly.

Determination of Titratable Acidity: This was determined according to the methods described by Association of Official Analytical Chemists (AOAC) (2003) (17).

Proximate Analysis: The proximate analysis (quantitative) of the Nunu was carried out according to AOAC (2003) (17).

Determination of moisture

Moisture was determined by oven drying method. 2 g of sample was accurately weighed in clean, dried crucible (W_1). The crucible (containing the sample) was kept in an oven at 103.5°C for 4-5 h until a constant weight was obtained. Then the crucible was placed in the dessicator for 30 minutes to cool. After cooling it was weighed again (W_2). The percent moisture was calculated using the following formula:

$$\%\text{Moisture} = \frac{W_1 - W_2 \times 100}{\text{Wt. of sample}}$$

Where: W_1 = Initial weight of crucible + Sample W_2 = Final weight of crucible + Sample

Determination of total ash content

The ash content was determined using the AOAC (2000) method (18). The percentage ash was calculated as:

$$\%\text{Ash} = \frac{\text{Difference in Wt. of Ash} \times 100}{\text{Wt. of sample}}$$

Difference in wt. of Ash= W_2-W_1

Determination of carbohydrate content

The carbohydrate content of each Nunu sample was calculated by difference. The total of all the previously determined proximate parameters subtracted from 100 represent the carbohydrate content.

100 – (%Moisture content + % Ash Content + % Crude fibre + % Crude protein + % crude fat). Other determination of parameters carried out include fat, crude protein and crude fibre content

Phytochemical Screening of Plant Extract

Phytochemical tests were carried out on the crude extracts of ginger and garlic using standard procedures to identify the constituent present.

The following constituents tested for: steroid, glycosides, terpenoids, alkaloids, Saponins, flavonoids, phenols and phenolics.

Test for Steroids: Steroids were tested for using the method of Kumar *et al.* (19).

Test for Glycosides: 1g of extracts were treated with 5 ml of ferric chloride solution and immersed in boiling water for five minutes. The mixture was cooled and extracted with equal volumes of benzene. Ammonia solution was used to separate and treat benzene layer. Formation of rose-pink colour in the ammonia layer indicated the presence of anthranol glycosides.

Test for Terpenoids: 1g of crude extract was dissolved in 2ml of chloroform and evaporated to dryness. Two milliliter of concentrated hydrogen sulfide (H_2S) was added and heated for about two minutes. A greyish colour indicates the presence of terpenoids.

Test for Alkaloids: Alkaloid was tested for using the method of Kumar *et al.,* (19).

Determination of shelf life of Nunu samples

The Nunu samples (100 ml) were stored at ambient temperature (28 ± 2°C). The physico-chemical and microbiological changes in the stored Nunu samples were also determined.

Sensory qualities of different treated nunu samples: Sensory qualities such as taste, aroma, colour, appearance and texture were tested for the treated nunu samples.

Statistical Analysis: Means and standard deviations of the assays were calculated using conventional statistical methods. Each treatment was performed in three replicates. Statistical analysis (ANOVA) was applied to the data to determine differences ($p < 0.05$). Means differences were determined by using Tukey's HSD test. The statistical analysis was carried out using Minitab 17 for windows.

Results

The results of the microbiological, physicochemical, and sensory studies carried out on the Nunu samples are presented as follows:

Microorganisms Isolated from Nunu

Microorganisms found in Nunu were identified using molecular techniques and biochemical tests as presented in Tables 1 and 2 respectively. A total of six bacteria were isolated from the Nunu samples which include: *Lactobacillus paracasei* strain 10-3, *Bacillus subtilis*, *Bacillus pumillus*, *Staphylococcus aureus*, *Leuconostoc* sp., *Lactococcus* sp., and *Streptococcus* sp. while six fungi were isolated; they are *Pichia kudriavzevii* strain substrate 6, *Saccharomyces cerevisiae*, *Candida* sp., *Aspergillus niger*, *Mucor* spp. and *Rhizopus* sp.

Table 1: Molecular characterization of Isolates from Nunu samples

Isolate	Organism	Number Of Bases	Identity (%)	Accession Number
B1	*Lactobacillus paracasei* 10-3	855	97	GQ273916.1
B2	*Pichia kudriavzevii* substrate 6,	538	93	MF442412.1

Table 2: The cultural, morphological and biochemical characteristics of bacterial isolates from nunu samples

Isolate	B1	B2	B4	B5	B6
Colonial morphology	Large opaque & fuzzy white rods with rough edges	Flat opaque, off white & filamentous rods with irregular margin	Small golden yellow & smooth cocci,	Small, gray, entire and slightly raised	Spherical, creamy white and ovoid cells in chain
Gram reaction	+	+	+	+	+
Spore staining	+	+	-	-	-
Motility	+	+	-	-	-
Catalase	+	+	+	+	+
Urease	_	+		-	+
Citrate	+	+	-	-	
Oxidase	+	+	-	-	-
Hydrogen sulphide from TSI.	_	-	-	-	-
Probable Identity	*Bacillus subtilis*	*Bacillus pumilus*	*Staphylococcus aureus*	*Leuconostoc mesenteroides*	*Streptococcus thermophilus*

Key: (+): Present (-): Negative

Effect of Treatment on Microbial Counts of Nunu samples

Total Bacterial Counts: The total bacterial counts recorded a highest count of 1.5 x 10^6cfu/ml in GI-1 sample on day-5 and lowest of 3.0 x 10^4cfu/ml in GI-3 on day-3 as growth was recorded in all samples. For the garlic treated samples, the highest counts of 1.4 x 10^6 was recorded in day 6 in GA-1 and the lowest count was observed on day 3 as GA-3 had a total bacterial count of 3.7 x 10^4cfu/ml.

Total Fungal Counts: The yeast and mould counts observed after 5 days of plating showed the highest count of 1.6 x 10^6cfu/ml in GI-1 on day-5 and the lowest of 1.0 x 10^4cfu/ml in GI-3 on day-3; while the garlic treated samples showed the highest count of 1.5 x 10^6 cfu/ml in GA-3 on day-5 and the lowest count of 1.3 x 10^5 in GA-2 on Day-6.
Counts on (De Man, Rogosa and Sharpe**)** MRS agar.

The counts on MRS agar showed the highest count of 1.4 x 10^6cfu/ml on day 5 in GI-3 and the lowest count was recorded on day-3 in GI-3 with a count of 1.3 x 10^4cfu/ml. For garlic preservative, the highest count was recorded in GA-3 with a count of 1.4 x 10^6cfu/ml on day-3 and the lowest count was observed in GA-1 on day-3 with a count of 1.5 x 10^5cfu/ml. The counts on MRS indicated that the preservative showed no effect on the lactic acid bacteria in Nunu, that is the count remained stable throughout the preservation period.

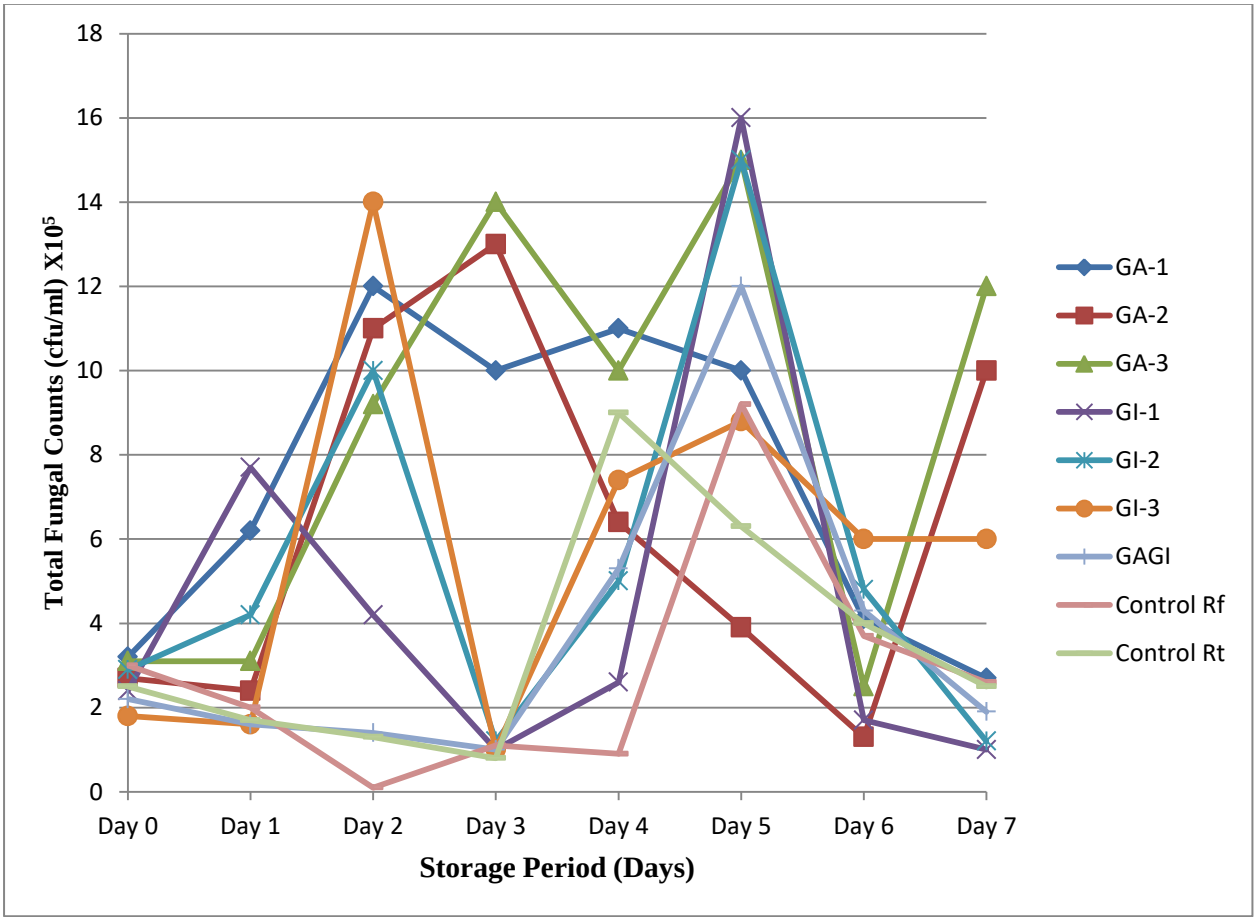

Figure 1: Effects of different treatments on bacterial counts of nunu samples preserved for 7 days

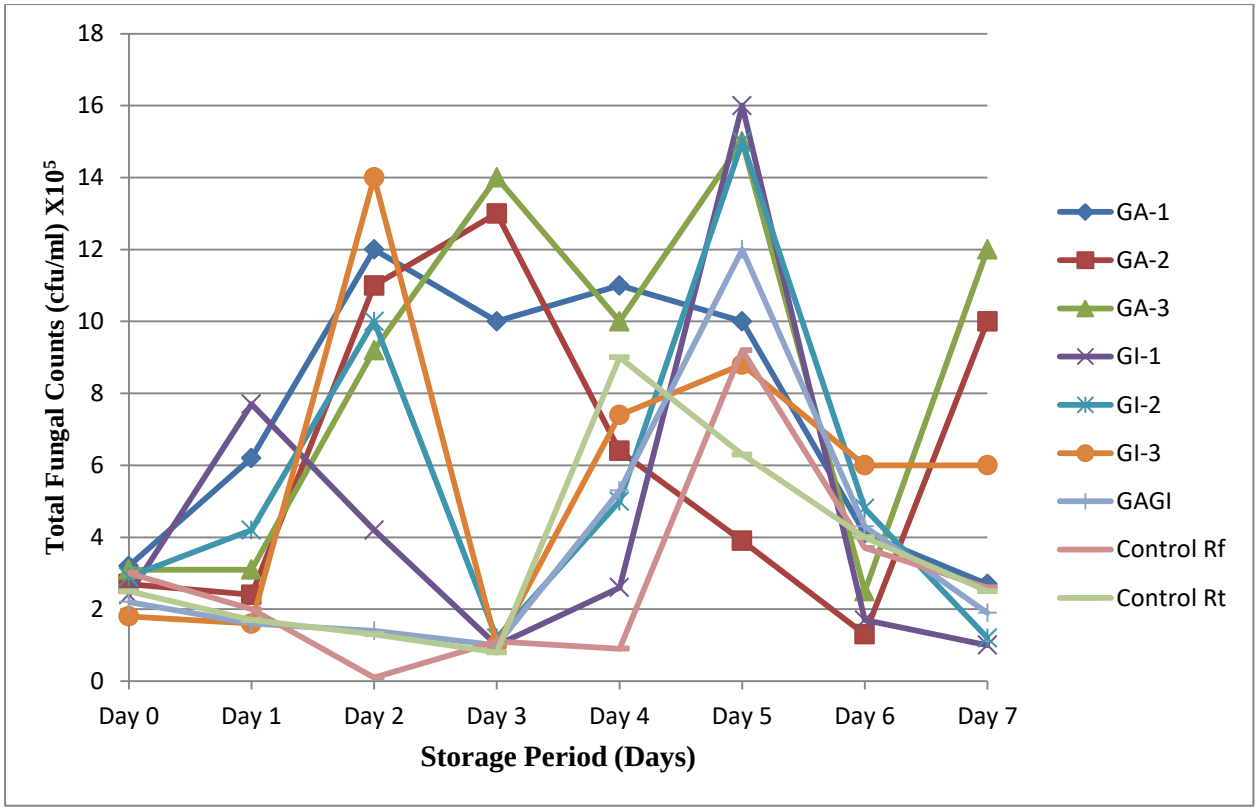

Figure 2: Effects of different treatments on fungal counts of nunu samples preserved for 7 days

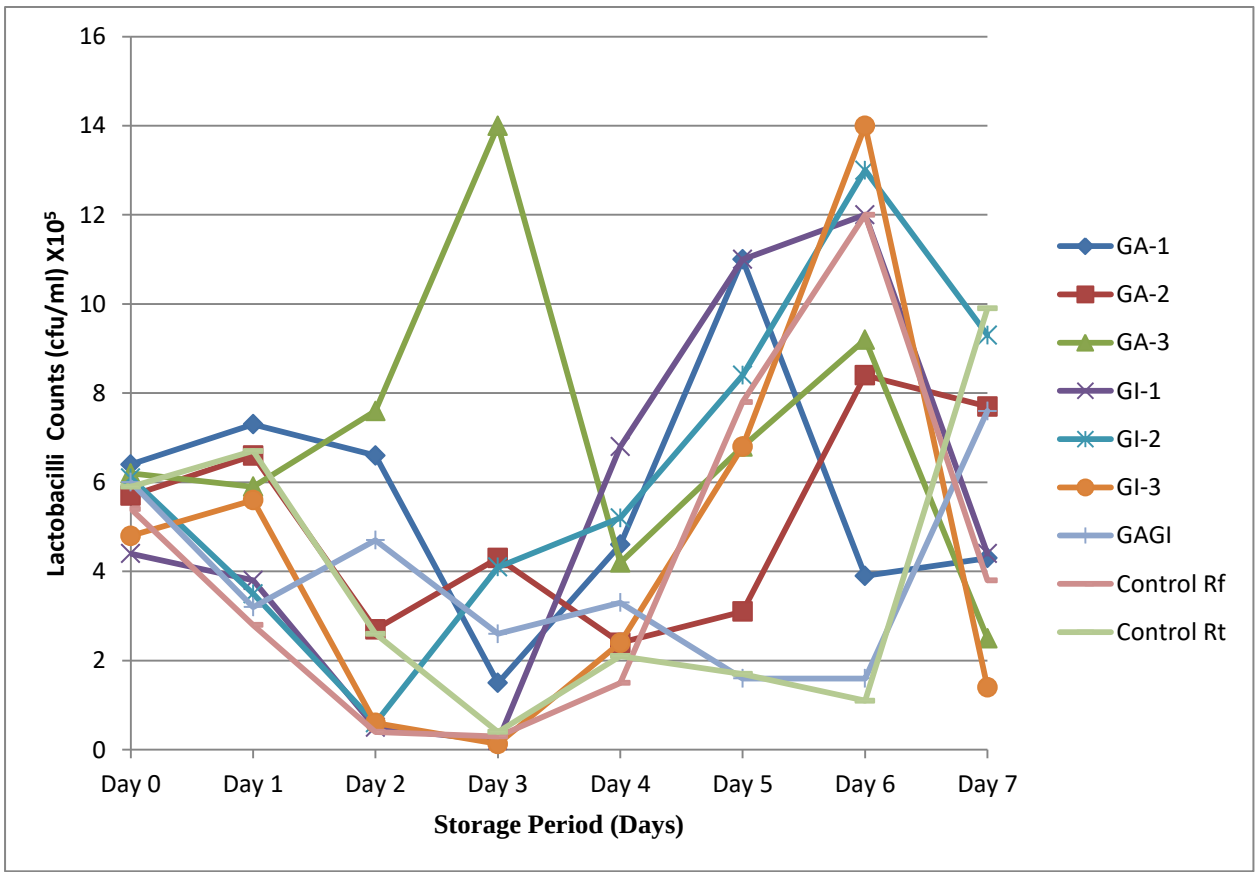

Figure 3: Effects of different treatments on MRS (de Man Rogosa Sharpe) counts of nunu samples preserved for 7 days

Effect of Various Treatments on pH of Nunu Samples

Changes in the pH of the preserved Nunu was observed as shown in Figure 4. GI-1 sample had the lowest pH of 3.8 on day 7 while GI-3 sample had the highest pH of 5.6 on day1. For the garlic powder, the lowest pH was observed in GA-2 on day-6 with a pH of 4.4 and the highest was observed in GA-2 on day 1 with pH of 5.2. A general decrease was observed over the period of storage.

Effect of Different Treatments on the Titratable Acidity of Nunu Samples

Changes in the Titratable acidity of the preserved Nunu milk was observed as shown in Figure 9. GI-1 sample had the highest Titratable acidity of 1.17% on day 7 while, GA-2 and GI-3 samples had the lowest Titratable acidity of 0.45% on day 0 of preservation. A general increase was observed over the period of the storage.

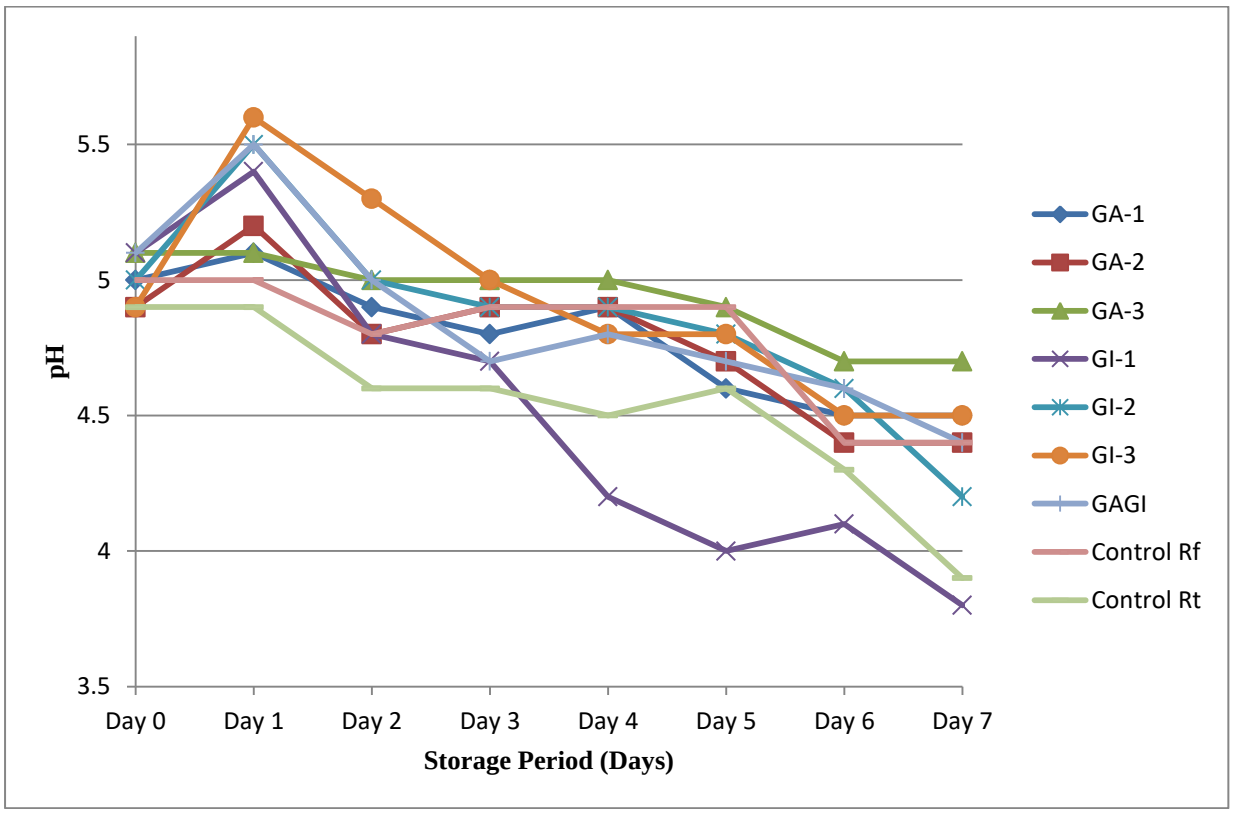

Figure 4: Effects of different treatments on pH of nunu samples preserved for 7 days

Physicochemical parameters

The physicochemical parameters investigated before and after preservatives were added are presented in Tables 4 and 5.

Effect of Different Treatments on the Moisture content

Changes in the moisture content of the preserved Nunu samples are presented in Tables 4 and 5. Moisture content analysis before preservation showed that GA-2 sample had the highest moisture content of 84.735% while, GI-2 sample had the lowest moisture content of 83.778%. However, after preservation, the spoilt samples showed an increase in moisture content with GA-2 sample having a value of 86.672% and GI-2 with the lowest value of 85.679%

Effect of Different Treatments on the Ash content

Changes in the ash content of the preserved Nunu samples are presented in Tables 4 and 5. The ash content of the Nunu samples before preservation of Nunu showed a considerably low percentage with the highest of 1.086% in GI-3 sample and the lowest of 0.617% in GI-1 sample. The analysis after preservation showed the highest ash content of 0.984% in GI-3 sample and the lowest value of 0.706% were observed in GA-1 sample.

Effect of Different Treatments on the Protein content

Changes in the protein content of the preserved Nunu are presented in Tables 4 and 5. GAGI sample had the highest protein content of 10.704 while the GA-3 had the lowest protein content of 9.120 during the pre-storage time. After preservation, the highest protein content of 11.477 was observed in GI-2 and the lowest of 10.604 was observed in GI-3.

Effect of Different Treatments on the Crude fat of Nunu Samples

Changes in the fat content were observed in the preserved Nunu samples as presented in Tables 4. Before preservation, the highest value of 1.907% of crude fat was recorded in GI-3 sample, while the lowest value of 1.812% was recorded in GI-2 sample. After preservation, the highest crude fat content of 0.784% was observed in GAGI while the lowest of 0.602% was observed in GA-1. Generally, it was observed that all Nunu samples at various treatments had a low-fat content during the analysis.

Effect of Different Treatments on the Fiber content of Nunu samples

No fiber content was detected before and after preservation. Effect of Different Treatments on the Carbohydrate content of Nunu samples. Changes in the carbohydrate (CHO) content were observed before and after preservation as presented Tables 4 and 5. Before preservation, the highest carbohydrate content of 3.690% was observed in GA-3 sample while the lowest value of 2.556% was observed in GAGI sample. After preservation, the highest carbohydrate content of 1.708% was observed in GA-1 while the lowest of 0.741% was observed in GA-3.

Table 4: Proximate composition of nunu samples before and after storage

Sample	Moisture%		Ash%		Protein%		Fat%		CHO%	
	Before	After	Before	After	Before	After	Before	After	Before	After
GA-1	83.858	85.950	0.697	0.706	10.674`	11.034	1.889	0.602	2.882	1.708
GA-2	84.735	86.672	0.804	0.785	9.961	10.825	1.904	0.637	2.596	1.081
GA-3	84.477	86.587	0.862	0.812	9.120	11.218	1.851	0.642	3.690	0.741
GI-1	84.453	86.582	0.617	0.711	9.733	10.952	1.779	0.582	3.218	1.173
GI-2	83.778	85.679	0.925	0.883	10.010	11.477	1.812	0.675	3.475	1.286
GI-3	84.552	85.914	1.086	0.984	9.652	10.604	1.907	0.781	2.803	1.717
GAGI	83.896	85.748	0.982	0.903	10.704	11.056	1.862	0.784	2.556	1.509
Control Rf	84.872	84.775	0.654	0.671	8.736	10.226	1.848	0.63	3.890	3.690
Control Rt	84.968	88.335	0.782	0.729	8.984	10.073	1.872	0.665	3.394	0.198

Shelf-life of Nunu samples

The shelf-life of the treated Nunu samples showed that Nunu with treatment GA-2 had the longest shelf life of 5 days, while GI-1 had the shortest shelf-life of 3days. However, it was found that the control stored in the refrigerator had a longer shelf-life of 6 days which exceeded all treated samples, while the control sample stored at room temperature had the least shelf-life of 2 days.

Table 7: Sensory qualities of different treated nunu samples

Sample	Taste	Appearance	Colour	Aroma	Texture	Overall Acceptance
GA-1	$2.2\pm0.1^{a,b}$	3 ± 0.5^{b}	3 ± 1.0^{a}	1.8 ± 0.2^{a}	3.4 ± 0.2^{a}	$2.6\pm0.2^{a,b}$
GA-2	2 ± 0.5^{a}	$2.8\pm0.2^{a,b}$	2.8 ± 0.2^{b}	1.4 ± 0.2^{c}	$3.2\pm0.3^{b,c}$	1.8 ± 0.2^{c}
GA-3	1.8 ± 0.2^{a}	2.8 ± 0.2^{a}	3.2 ± 0.1^{a}	1.6 ± 0.2^{b}	3.2 ± 0.2^{b}	1.6 ± 0.1^{b}
GI-1	3.8 ± 0.1^{a}	3 ± 1.0^{a}	3.4 ± 0.2^{a}	3.8 ± 0.1^{a}	3.4 ± 0.2^{a}	3.8 ± 0.1^{a}
GI-2	4.4 ± 0.2^{a}	3.4 ± 0.1^{a}	3.6 ± 0.2^{a}	4.4 ± 0.3^{a}	3.8 ± 0.2^{b}	4.6 ± 0.2^{a}
GI-3	4.2 ± 0.1^{a}	3.4 ± 0.3	3.2 ± 0.3^{a}	4 ± 1.0^{a}	3.6 ± 0.2^{a}	3.8 ± 0.1^{a}
GAGI	2.8 ± 0.2^{a}	3 ± 1.0^{a}	3.4 ± 0.2^{a}	3.2 ± 0.2^{a}	3.6 ± 0.2^{a}	3.2 ± 0.2^{a}
Control Rf	4.8 ± 0.2^{a}	4.4 ± 0.2^{a}	3.8 ± 0.2^{b}	3.4 ± 0.2^{b}	3 ± 0.0^{c}	4.4 ± 0.2^{a}
Control Rt	4 ± 1.0^{a}	3.8 ± 0.1^{a}	3.6 ± 0.1^{a}	3.2 ± 0.2^{a}	3 ± 1.0^{a}	3.4 ± 0.2^{a}

^{abc} Means with different superscripts in a row are significantly different ($p<0.05$). Values are means of three replicate determinations (±SD)

Discussion

The result showed that a total of ten microorganisms were altogether isolated from nunu samples before and during the storage period. These organisms include bacteria such as *Lactobacillus paracasei* strain 10-3, *Bacillus subtilis*, *Bacillus cereus*, *Micrococcus* sp., *Staphylococcus aureus*, *Leuconostoc* sp., *Streptococcus* sp. and fungal isolates which include *Pichia kudriavzevii* strain substrate 6, *Saccharomyces cerevisiae*, *Aspergillus niger*, *Mucor* sp., *Rhizopus* sp. and *Fusarium* sp. The organisms isolated are in agreement with the work of Braide *et al*., who isolated species of *Escherichia coli, Enterococcus, Streptococcus, Staphylococcus, Micrococcus, Bacillus, Corynebacterium* and *Lactobacillus* for bacteria and, *Mucor, Saccharomyces, Rhizopus, Fusarium, Geotrichum, Aspergillus* and *Penicillium* species of fungi (20). Other works in support of the isolated organisms include Egwaikhide *et al*., Akabanda *et al*., and Okonkwo who isolated *Lactobacillus sp, Leuconostoc sp.*, *Lactococcus sp*, *Staphylococcus aureus*. *Saccharomyces cerevisiae*, *Streptococcus sp.*, *Saccharomyces pastorianus*, *Zygosaccharomyces bisporus*, *Yarrowia lipolytica*, *Candida stellata, Kluyveromyces Candida kefyr*, *maxianus*, *Zygosaccharomyces rouxii* (1, 21, 22). Some of these organisms are known to aid the fermentation of Nunu ,while others are environmental contaminants that got into the milk through the udder of the cow, milking bowls, water used to dilute milk and hands of the Nunu hawkers. These organisms (environmental contaminant) are responsible for the short shelf-life of Nunu (fermented milk). Raw milk drawn from a healthy udder might contain only a few hundred to a few thousands of bacteria per milliliter, mostly from the genus *Micrococcus* and *Streptococcus* (23).

The shelf life study of the preserved Nunu samples revealed different levels of changes. The observed changes are as a result of some microorganisms present in the drink. Changes were observed in the total bacterial count, fungal count, lactobacilli count, pH, Titratable acidity, moisture content, ash content, protein content, fat content and organoleptics. All these were as a result of the growth and metabolic activities of microorganisms present in the nunu sample. The gradual decrease in the total bacterial and fungal counts after 3 days of preservative treatments with garlic and ginger powder suggest the efficacy of the plants as potent preservatives.

The counts on various media used showed the range of 1.5 x $^{1}0^{6}$cfu/ml– 3.0 x 10^{6}cfu/ml for aerophilic bacteria count, 1.0 x 10^{4} cfu/ml-1.6 x 10^{6}cfu/ml for yeast and fungal counts, and 1.3 x 10^{4}cfu/ml - 1.4 x 10^{6}cfu/ml for lactobacilli count. The inhibitory action of the preservatives was further enhanced by the low pH of the samples. Thus the decrease in microbial population tallied with the milder decrease in available nutrients (24).

The rapid deterioration in shelf life of nunu is widely acknowledged and is of great concern. However, the presence of the preservatives (garlic and ginger) helped to lower the microbial population to prevent rapid spoilage of the nunu. In general, ginger and garlic have comparable antimicrobial activities due to the presence of essential oils in them (25,26). But the more appreciable inhibitory effect exhibited by garlic (Figures 1, 2, and 3) might be attributed to the differences in their essential oil components. As indicated by Paramasivam *et al*. this might be due the high antimicrobial effect of garlic compared with the other treatments considered (35). Garlic tends to interfere more on the cell membrane and disruption than ginger due to the action of Allistatin I and Allistatin II (diallydisulphide oxide) contained in it which are otherwise not present in ginger and affect the growth and respiration of microorganisms (27). Whereas the treatment with ginger and garlic separately resulted in reduction in the microbial load, the combination of the two (ginger and garlic) showed comparable efficacy when compared to that of treatment with ginger alone. However, the magnitude of effectiveness of ginger and garlic as organic preservative on the microbial load of the sample differed with the concentration. A decrease in the number of microorganisms was observed with the increase in the concentration of the preservatives. But the effects of ginger and garlic tended to decrease with storage time and this might be due to microbial degradation particularly in the presence of high lactobacilli load (27).

The pH and Titratable acidity as shown in Figures 4 and 5 revealed a gradual decrease and increase, respectively of the nunu samples during the storage period. This is in agreement with the findings of Okonkwo, whose nunu samples had a pH range of 3.8 and 5.4 (1). This claim is further supported by the findings of El-Bakri and El-Zubeir (28). However, these claims contradict pHs 5.51 to 6.29 recorded by Adesokan *et al*. (29). Achi &Akobor as well as Nout also reported the decrease in pH and increase in total Titratable Acidity (TTA) during fermentation process of producing traditionally fermented food (30,31). The values of Titratable acidity of 0.10% - 0.41% by Adepoju *et al*. disagrees with the findings of this research work where Titratable acidity of nunu samples ranged from 0.45- 1.17 (32).

The moisture content of the treated Nunu samples ranged from 84.735% to 83.778% before preservation and ranged from 86.672% - 85.679% after the storage period. This concurs with the findings of Adesokan *et al*. whose values ranged from 80.78% - 87.11% in nunu produced using starter cultures (29).

Conclusion

Nunu samples treated with 100mg/ml of ginger powder (G1-2) ranked best in sensory quality ratings compared with other treatments. It was also effective in extending the shelf life of the nunu samples. Given the phytochemical constituents of ginger and the health benefits it confers, it is therefore proposed as a more viable preservative than garlic. If incorporated into nunu milk drink, it might notably improve the shelf life and sensory quality of locally fermented milk products.

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