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Preservation of the Nutritional Quality of Soymilk by Heat Treatment

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Abstract Household soymilk preparation is labor intensive and time consuming, hence, in order to encourage soymilk consumption there is need for safe, easy, available, accessible and affordable measure of preserving the nutritional and safety quality for at least a few days after preparation even in areas of poor power supply that makes refrigeration unreliable. This experimental study was therefore designed to determine the effect of boiling for three consecutive days on the nutritional, physical, sensory and microbial properties of soymilk with a view of preserving the milk for consumption within the first three days after preparation. Soymilk was prepared using standard procedure. A sample was taken on the day of production (SM0) and set as control. This was subjected to boiling for 5 minutes twice a day (morning, 7a.m. and evening, 5p.m.) without covering the pot for three consecutive days and samples were designated as SM1, SM2 and SM3 respectively. Proximate composition, thiamine, riboflavin, niacin, vitamin C, mineral composition as well as pH, viscosity, specific gravity, microbial status and sensory properties were assayed using standard analytical methods. Mean data were compared using analysis of variance at $p \leq 0.05$. Nutritional components of the soymilk sample increased with increase in days of preservation by boiling but the moisture content reduced significantly relative to control. Similarly specific gravity and viscosity increased while the pH reduced, though not significantly, throughout the experimentation period. The soymilk samples were free of coliforms throughout the preservation period while the microbial load fell within acceptable range for safe consumption. The sensory scores for taste, mouth feel, aroma and overall acceptability throughout the experimentation period was 8 which denotes 'like very much' except for color which reduced significantly to 7.79 in SM3 which is still acceptable. Boiling of soymilk for three consecutive days after production did not adversely alter its nutritional, physical, microbial and sensory properties except color which was impaired at the third day. Household preservation of soymilk by boiling should encourage its consumption especially in areas where refrigeration is not easily available.

Keywords: *soymilk, nutritional quality, boiling, food and nutrition security*

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1. Introduction

Soybean is a functional food because aside from providing valuable nutrients it is also useful in the prevention and treatment or management of some non communicable diseases. Soybean contains 39.4-44.4% crude protein, 14-18.7% oil, 4.3-6.7% starch, 5.6-7.9% total soluble sugars, 0.21-0.33% reducing sugars and 5.6-11.8% sucrose [1]. The phytochemical components are 2.3-5.6mg/g phytate, 1.0-1.5 total phenols, 0.26-0.34mg/g flavonols and 0.10-0.21mg/g ortho-dihydroxyphenols [1]. Isoflavones which are the notable bioactive components of soybean that exert some of its medicinal effects were reported to be 1176-3309µg/g in 11 varieties (8 American and 3 Japanese varieties) [2]. Soy foods are being recognized as having potentials in prevention and treatment of some chronic diseases such as cancer, heart disease, osteoporosis and kidney disease [3] and this has been corroborated by recent scientific studies [4]. Despite the unrivalled nutritional and health benefits derivable from soybean the level or rate of household consumption of soy foods is still relatively low compared to other food sources especially in Nigeria [5].

Soymilk is one of the most common forms in which soybean can be consumed. It is an aqueous extract of soybean. Soymilk contains 3.174% protein, 0.807%ash, 91.89%moisture, 2.35% fat at pH 7.395 [6]. Another study reported soymilk to contain 90.5% moisture, 0.55% ash, 3.6% protein, 2.0% oil, 0.45% crude fiber and 2.9% carbohydrate [7] while a more recent study reported the proximate composition of soymilk as; 3.5% protein, 2.9% carbohydrate, 2.0% fat and 0.5% ash [8].

Soymilk preparation is time, skill and labor intensive, hence, to encourage its consumption, especially among the

vulnerable low income households who rely of cheap sources of nutrients like soybean and mostly do not have easy access to refrigeration as a means of preservation, there is need to proffer easy, affordable, feasible and available means of preserving the milk without spoilage for at least e few days. Refrigeration which is the major and notable means of household soymilk preservation may not be feasible especially in low income country like Nigeria where access to substantial quantity and quality of electricity is low [9]. Heat treatment of soymilk by boiling to prevent spoilage few days after production (as it is commonly done with left over stews, soups and other foods) seems to be the only feasible, available and easy alternative but it is hypothesized in this study that the effect of this procedure on the nutritional quality of soymilk may not be favorable, hence, this study determined the effect of boiling of soymilk for three consecutive days after preparation and storing at ambient temperature on the proximate, physical parameters, minerals, vitamins, microbial status and sensory properties of soymilk.

2. Methodology

2.1. Collection of Soybean

Already cleaned and sorted soybean (TGX-1740) was purchased from the seed store of the Institute of Agricultural Research and Training, Obafemi Awolowo University, Apata, Ibadan, Nigeria.

2.2. Soymilk Preparation

Soymilk was prepared using the method of Madukwe and Eme [10] with slight modification. Soybean (500g) was washed and soaked in clean water overnight from 5pm to 7am the following day (14 hours) after which the soaking water was decanted and the beans rinsed in fresh water for 4 different times. The soybeans in clean water were then brought to simmering point (96°C) and allowed to simmer for 5 minutes after which the hot water was drained off and the soybean wet milled using plate attrition mill. The total quantity of water added during milling and after milling for dilution was 3 liters. This was then sieved using cheese cloth after which the extract was allowed to boil for 10 minutes. This was then re-sieved and allowed to cool in the pot (Tower aluminium pot) and a sample SM0 was taken as control. The remaining soymilk was subjected to boiling for 5 minutes (as it is commonly done to left over soups, sauces, stews and other meals) twice a day (morning ,7a.m. and evening, 5p.m) for 3 consecutive days while keeping it at ambient temperature. Samples SM1, SM2 and SM3 were taken on the 1st, 2nd and 3rd day respectively in the morning immediately after boiling. All samples were subjected to proximate, thiamine, riboflavin, niacin, vitamin C, pH, specific gravity, viscosity, calcium, magnesium, potassium, sodium, phosphate, zinc, manganese, microbial and sensory evaluation.

Laboratory analyses: The proximate, minerals and vitamins were analyzed using the methods as described by Kirk and Sawyer [11].

2.3. Moisture Content Determination

This was determined using the air oven method [11]. A known weight of the sample (3g) was put in a washed, dried and cooled crucible and this was dried at 103°C until a constant weight was obtained. This was allowed to cool in a desiccator and the difference in weight was used to calculate the moisture content.

2.4. Protein Content Determination

The crude protein content was determined using the micro Kjeldahl method as described by Kirk and Sawyer [11]. A tablet of Kjeldahl catalyst was added to a known weight of the sample (0.2077g) in a long necked Kjeldahl flask. This was heated in a fume cupboard with 25cm^3 of concentrated H_2SO_4 until a clear solution was obtained. This was cooled, poured into a 10cm^3 volumetric flask and made up to mark with distilled water after which 10ml of this was measured into a distillation set. Five centimeter cube of boric acid was pipette into a 100ml conical flask and placed at the receiving end of the distillation unit with the delivery tube completely dipped into the flask. Forty percent NaOH was used to liberate ammonia out of the digest into the boric acid under alkaline condition and this was titrated against 0.1N HCl. Blank sample was run through the procedure and the titre value was used to correct the titre value for the test samples. The protein content was calculated thus:

$$\%N = \frac{Molarity\ of\ HCl\ x\ (sample\ titre - blank\ titre)}{Weight\ of\ sample} x0.014\ x\ DF\ x100$$

%N was converted to the percentage crude protein by multiplying by 6.25
DF-Dilution Factor.

2.5. Crude Fat Content Determination

The fat content was determined using Soxhlets extraction method as described by Kirk and Sawyer [11]. A known weight of the sample (2g) was put into a weighed filter paper and folded neatly. This was put inside a pre-weighed thimble (W_1). The thimble with the sample (W_2) was inserted into the soxhlets apparatus and extraction was carried out under reflux with petroleum ether (40°C - 60°C boiling range) or 6 hours. At the end of the extraction, the thimble was dried in the oven for about for about 30 minutes at 100°C to evaporate the solvent and thimble was cooled in a desiccator and later weighed (W_3). Crude fat content of the sample was calculated thus:

$$\%\ Fat = \frac{Loss\ in\ weight\ of\ sample\ x\ 100}{Original\ weight\ of\ the\ sample} = \frac{W_2 - W_3}{W_2 - W_1} x100.$$

2.6. Ash Content Determination

The ash content denotes the total amount of minerals present in the products. This was determined using the method as described by Kirk and Sawyer [11]. A known

weight (1.5g) of finely ground sample was weighed into clean and dry previously weighed crucible with lid (W_1). The sample was ignited over a low flame to char the organic matter with lid removed. The crucible was then placed in muffle furnace at 600°C for 6 hours until it was turned to ash completely. This was then transferred directly to desiccators to cool and was later weighed (W_2).

$$\% \, Ash \equiv \frac{W2 - W1}{Weight \ of \ sample} \ x100.$$

2.7. Crude Fibre Determination

The crude fibre was determined using the method as described by Kirk and Sawyer [11]. Two hundred millilitres (200ml) of freshly prepared 1.25%H2SO4 was added to a known weight (3g) of the residue obtained from fat extraction and this was boiled for 30 minutes and then filtered after which the residue was washed until it was free from acid. The residue was transferred quantitatively into a digestion flask and 1.25%NaOH was added after which this was boiled for 30 minutes. This was followed by filtration and the residue was then washed with methylated spirit and then petroleum ether to be free of alkali. This was then allowed to drain and the residue was transferred to a silica dish (previously ignited at 600°C and cooled). The dish and its content were dried to constant weight at 105°C. The organic matter of the residue was burnt by igniting for 30 minutes in a muffle furnace at 600°C). The residue was cooled and weighed while the loss on ignition was reported as crude fibre.

2.8. Carbohydrate Content Determination

This was calculated by difference of all other proximate values from 100 [11].

2.9. pH Determination

pH of the samples was measured directly using a pH meter (Cole-Parmer), U.S.A.

2.10. Specific Gravity Determination

The specific gravity was determined using Avogadro's Specific Gravity determination bottle, New Jersey, U.S.A.

2.11. Viscosity Determination

The viscosity of the samples was determined using Ostwald viscometer, Germany.

2.12. Thiamine, Riboflavin and Niacin Determination

These B vitamins content were determined using the method as described Kirk and Sawyer [11].

2.13. Thiamine Determination

Method as described by Kirk and Sawyer [11] was used. Fifty millilitres (50ml) of 50% methanol and 50ml 0f 17% sodium carbonate was added to 1g of the sample in order to extract the vitamin. This was then filtered after which Folins-Denis reagent was added. This was allowed to cool until a bluish color was developed and absorbance was read in a spectrophotometer at 415nm. A standard curve was prepared using the data obtained with Tannic acid in place of the sample and the values for the sample were extrapolated from this curve.

2.14. Riboflavin Determination

The method as described by Kirk and Sawyer [11] was used. To 0.5g of the sample 30ml of Dichloroethane and 30ml of 30% HCl were added. This was followed by the addition of 50ml of ammonium hydroxide solution after which filtration was carried out and later the absorbance was read at 415nm. A standard curve was constructed using the data obtained from the use of standard Riboflavin in place of the sample and the curve was used to extrapolate the values for the samples.

2.15. Niacin Determination

Method as described by Kirk and Sawyer [11] was used. Niacin was extracted by autoclaving the sample (1g) with 0.75g calcium hydroxide and 20ml deionised water at 121°C for 30 minutes. The mixture was diluted with 30 ml of water, mixed thoroughly and allowed to cool after which it was centrifuged at 0°C and 2500 rpm for 15 minutes. A 15ml sample of the supernatant was adjusted to pH 7 with aqueous oxalic acid. The resulting suspension was centrifuged at 2500 rpm for 10 minutes to precipitate the calcium oxalate and the absorbance was measured at 650nm. A standard curve was constructed using the absorbance readings obtained from the reference niacin solutions in place of the sample and this was used to extrapolate the niacin content of the samples.

2.16. Vitamin C determination

The method as described by Kirk and Sawyer [11] was used. About 5g of the sample was weighed into a 50ml volumetric flask and this was made up to the mark with distilled water after which it was filtered. A measure of the filtrate (10ml) was measured into a conical flask containing one drop of dilute acetic acid. This was then titrated against redox dye, 2:6 dichlorophenol indophenol solution in a burette. The volume of dye required to decolorize 10ml of the sample was noted. The titration was repeated using a standard ascorbic acid solution (1mg pure vitamin C per 100ml) in place of the sample for checking for accuracy.

2.17. Minerals Determination

The method as described by Kirk and Sawyer [11] was used. A small quantity of the sample (0.2g) was weighed into a clean crucible and the organic content was burnt off in an open flame after which it was transferred into a muffle furnace and allowed to ash for 6 hours at 600°C until the ash turned to white completely. This was then washed with 10ml 0.1N HCl into a 100ml volumetric flask and warmed on a heater for a few seconds to avoid frothing. This was filtered into another 100ml volumetric

flask and distilled water was added to the filterate to make it up to 100ml. This was then aspirated through the nebulizer into the air-acetylene flame where atomization took place. Using specific source of lamp (of an Atomic Absorption Spectrophotometer) for each element or mineral (for example calcium lamp for calcium assay) the amount of energy absorbed in the flame was proportional to the concentration of the mineral in the sample over a limited concentration range.

2.18. Microbial Analyses

Pour plate method [12] was used to carry out the microbial analyses. One (l) ml of the sample was aseptically dispensed into a sterile petri dish using a sterile pipette. A measured quantity (15 - 20ml) of sterile nutrient agar was added and the two mixed thoroughly by swirling gently. The dish was then incubated at 37°C for 18-24hours. For total viable count, the number of colonies growing in the agar plate was then counted.

For Coliform, MacConkey Agar was used.

For Anaerobes, MRS Agar (MRS = de Manns Rogosa and Sharpe) was used.

For Fungi, Potato Dextrose Agar was used.

For Aerobes, Nutrient Agar was used.

2.19. Sensory Evaluation

Soymilk samples were subjected to sensory evaluation with a total of 20 trained taste panelists (students of tertiary institution) using a 9 point hedonic scale with 1 denoting 'dislike extremely' and 9 denoting 'like extremely'. The following sensory properties were evaluated: color, taste, mouth feel, aroma and overall acceptability [13].

2.20. Statistical Analysis

Data were analyzed with Statistical Package for the Social Science version 23.0 while mean data were compared using analysis of variance at $p \leq 0.05$

3. Result

The proximate composition (as-is-basis) of the soymilk sample throughout the experimentation period are expressed in Table 1.

Table 2 contains the values for the physical parameters of the soymilk sample throughout the experimentation period. Specific gravity and viscosity increased with increase in period of storage.

Table 1. Proximate composition (%) of the soymilk samples

Samples	MC	Protein	Fat	Ash	Crude fiber	Carbohydrate
SM0	83.77±0.15	4.37±0.15	3.23±0.15	0.90±0.10	0.13±0.06	7.80±0.30
SM1	81.13↓±0.15	4.47±0.15	3.40±0.10	0.97±0.12	0.17±0.06	9.87↑±0.40
SM2	78.37↓±0.21	4.87↑±0.15	3.80↑±0.10	1.17±0.21	0.27↑±0.06	11.53↑±0.15
SM3	73.63↓±0.15	5.37↑±0.17	4.17↑±0.15	1.33↑±0.15	0.29↑±0.07	15.21↑±0.35

↓-significantly lower than the control
↑- significantly higher than the control
SMO-soymilk sample on the day of production (control)
SM1- soymilk sample one day after production
SM2- soymilk sample 2 days after production
SM3- soymilk sample 3 days after production
MC- moisture content.

Table 2. Physical parameters of the soymilk samples

Samples	Specific gravity	Viscosity (Centistokes)	pH
SM0	1.1234±0.002	174.80±0.56	6.90±0.00
SM1	1.1237±0.001	180.20↑±0.20	6.90±0.00
SM2	1.1242±0.001	181.73↑±0.80	6.80±0.00
SM3	1.1280↑±0.001	197.93↑±0.60	6.70±0.00

↓-significantly lower than the control
↑- significantly higher than the control
SMO-soymilk sample on the day of production (control)
SM1- soymilk sample one day after production
SM2- soymilk sample 2 days after production
SM3- soymilk sample 3 days after production.

Table 3 shows the mineral composition of the soymilk samples during the experimentation period.

Table 3. Mineral composition (mg/100g) of the soymilk samples

Samples	Ca	Mg	K	Na	Phosphate	Zn	Mn
SM0	256.67±7.64	46.67±2.89	36.67±7.64	215.00±5.00	208.33±2.89	0.23±0.06	0.020±0.00
SM1	266.67±7.64	50.00±5.00	40.00±5.00	223.33±7.64	220.00↑±5.00	0.23±0.06	0.023±0.01
SM2	281.67↑±2.89	56.67↑±7.64	43.33±2.89	243.33↑±7.74	226.67↑±7.64	0.30±0.00	0.030±0.00
SM3	290.00↑±5.00	66.67↑±7.64	56.67↑±7.64	266.67↑±7.64	253.33↑±7.64	0.40↑±0.10	0.040↑±0.01

↓-significantly lower than the control
↑- significantly higher than the control
SMO-soymilk sample on the day of production (control)
SM1- soymilk sample one day after production
SM2- soymilk sample 2 days after production
SM3- soymilk sample 3 days after production.

Vitamin content of the soymilk samples throughout the 3-day experimentation period is expressed in Table 4. The thiamine, riboflavin, niacin and vitamin C content increased with increase in period of soymilk storage.

Table 4. Vitamin composition (mg/100g) of the soymilk samples

Samples	Thiamine	Riboflavin	Niacin	Vitamin C
SM0	0.087±0.02	0.157±0.02	0.407±0.02	1.233±0.06
SM1	0.113±0.02	0.187↑±0.02	0.423±0.03	1.267±0.06
SM2	0.147↑±0.02	0.210↑±0.01	0.510↑±0.03	1.367±0.15
SM3	0.177↑±0.02	0.260↑±0.01	0.700↑±0.05	1.667↑±0.42

↓-significantly lower than the control
↑- significantly higher than the control
SMO-soymilk sample on the day of production (control)
SM1- soymilk sample one day after production
SM2- soymilk sample 2 days after production
SM3- soymilk sample 3 days after production.

The microbial load of the soymilk sample throughout the experimentation perios is expressed in Table 5.

Table 5. Microbial status of the soymilk samples

Parameters	SM0	SM1	SM2	SM3
Total Viable count (CFU/ml)	4.9×10^2	7.3×10^2	6.9×10^2	9.2×10^2
Total coliform count (CFU/ml)	Nil	Nil	Nil	Nil
Total fungal count (CFU/ml)	1.3×10^2	2.3×10^2	4.1×10^2	5.9×10^2

SMO-soymilk sample on the day of production (control)
SM1- soymilk sample one day after production
SM2- soymilk sample 2 days after production
SM3- soymilk sample 3 days after production.

Table 6 expresses the scores for the sensory properties of the soymilk sample throughout the experimentation period. Only the color was impaired at the third day of experimentation.

Table 6. Sensory properties' scores of the soymilk samples

Samples	Color	Taste	Mouth feel	Aroma	Ov Accept
SM0	8.29b±0.21	8.16a±0.37	8.07a±0.34	8.19a±0.67	8.12a±0.13
SM1	8.45a±0.12	8.24a±0.18	8.03a±0.15	8.04a±0.35	8.34a±0.51
SM2	8.10bc±0.27	8.25a±0.29	8.04a±0.29	8.27a±0.56	8.22a±0.30
SM3	7.79c±0.28	8.14a±0.17	8.26a±0.23	8.26a±0.72	8.22a±0.20

Mean data in same column with different alphabets are significantly different ($p<0.05$)
Ov Accept- Overall Acceptability
SMO-soymilk sample on the day of production (control)
SM1- soymilk sample one day after production
SM2- soymilk sample 2 days after production
SM3- soymilk sample 3 days after production.

4. Discussion

The moisture content of the soymilk samples significantly reduced from 83.77% in SM0 to 73.63% in SM3. On the other hand the other proximate composition (in %) increased in SM0 to SM3 as follows: protein- 4.37 to 5.37; fat- 3.23 to 4.17; ash- 0.90 to 1.33; crude fiber- 0.13 to 0.29 and carbohydrate- 7.80 to 15.21 (Table 1). Evaporation of moisture from the soymilk samples which occurred in the course of boiling could be responsible for the significant reduction in moisture content. The moisture content of the soymilk on the day of production is in disparity with that reported by Madukwe and Eme [10] who observed moisture content of 89.64% in plain soymilk. This may be as a result of difference in production procedure especially in dilution of the soybean paste as well as difference in soybean varieties used. The protein, fat, ash, crude fiber, and carbohydrate content (in %) of soymilk (SM0) in this study were 4.37, 3.23, 0.90, 0.13 and 7.80 respectively which are in contrast with the observation of Madukwe and Eme [10]. This could be traceable to differences in methods of preparation and soybean variety used. Except for moisture content all other proximate composition increased with increased in period of preservation. This increase was significant in the last two days of preservation for protein, fat and crude fiber relative to control (SM0) while for ash the increase was significant only on the last day and for carbohydrate the increase was significant for the three days of preservation (Table 1). This increase could be attributed to the continuous reduction in the moisture content in the course of boiling thus concentrating the soymilk samples.

The values of the physical parameters of the soymilk samples are expressed in Table 2. The specific gravity ranged from 1.1234 in SM0 to 1.1280 in SM3, viscosity (in Centistokes) increased significantly from 174.80 in SM0 to 197.93 in SM3 while there existed no significant difference in the pH of the soymilk samples as can be seen in Table 2. The specific gravity and viscosity of milk are dependent on the protein and fat content; hence, it is not

unexpected that these also increased with increase in days of preservation of soymilk in this study. For the specific gravity this increase was significant in SM3 relative to control (SM0), hence, a reflection of the increase in protein and fat content which resulted from the concentration of the soymilk samples as they underwent heat preservation by boiling. As expected the viscosity of the soymilk samples significantly increased relative to control throughout the heat preservation period (Table 2). This could be as a result of gradual loss of moisture via evaporation during the boiling process. The pH of the soymilk sample on the day of production was 6.9 (Table 2) and this reduced, though not significantly, to 6.7 on the third day of experimentation showing that no appreciable or marked biochemical or microbiological reaction occurred during the period of preservation to significantly alter the pH, hence, the pH was preserved by the boiling procedure. The pH of soymilk observed in this study is in close proximity with that reported by Lakshmanan *et al.* [14] who reported a pH of 7.0 of soymilk treated with high pressure processing treatment. This could be as a result of similarity in the pH of water used to extract the milk as well as soybean varieties used. On the other hand, the pH of soymilk observed in this study is different from that reported by Nwoke and Umelo [15] who observed a pH range of 6.18 to 6.28 in five soymilk samples produced for five different varieties of soybean. This could be as a result of different soybean variety used since the variety used in this study was not part of the soybean varieties used by Nwoke and Umelo [15].

The calcium, magnesium, potassium, sodium, phosphate, zinc and manganese content of the soymilk samples increased in a trend similar (that is from SM0 to SM3) to that of the proximate composition, specific gravity and viscosity (Table 3). Calcium, magnesium, potassium, sodium, phosphate, zinc and manganese content (in mg/100g) of soymilk on the day of production were 256.67, 46.67, 36.67, 215.00, 208.33, 0.23 and 0.020 respectively (Table 3). These values increased with increase in period of preservation by boiling. This increase was significant throughout the experimentation period for phosphate, for calcium and sodium the increase was significant for the last two days relative to control (Table 3). The calcium, magnesium, zinc and phosphate content of soymilk sample in this study are in disparity with the observation of Nwoke and Umelo [15] who reported the range of mineral content (in mg/100g) of soymilk samples from 5 different soybean varieties thus: calcium content ranged between 41.82 to 45.75, magnesium- 53.76 to 54.82, zinc- 0.85 to 0.96 and phosphate- 84.55 to 89.53. The difference in the mineral content observed in this study compared to that of Nwoke and Umelo [15] could be as a result of different soybean varieties used since TGX-1740 which was used in this study was not part of the varieties used by Nwoke and Umelo [15]. Furthermore, the zinc content of plain unfortified soymilk as reported by Madukwe and Eme [10] was 35.77mg.100g which is notably higher than that observed in this study (0.23mg/100g). This may be due to different soybean varieties used.

Table 4 expresses the vitamin content of the soymilk samples in mg/100g. Thiamine content ranged from 0.087 in SM0 to 0.177 in SM3, Riboflavin ranged from 0.157 to 0.260, and Niacin content increased from 0.407 in SM0 to 0.700 in SM3 while Vitamin C content increased from 1.233 to 1.667 similarly. On the day of production the thiamine, riboflavin, niacin and vitamin C content (in mg/100g) of the soymilk (SM0) were 0.087, 0.157, 0.407 and 1.233 respectively (Table 4). These also witnessed an increasing trend during the course of preservation by boiling showing that the heat treatment or boiling did not adversely alter these vitamins in the soymilk sample within the period of preservation by boiling, even, vitamin C was not adversely affected. This increasing trend could be as a result of the concentration of the soymilk samples due to loss of moisture by evaporation during the boiling sessions. Nwoke and Umelo [15] reported that thiamine, riboflavin, niacin and vitamin C content (in mg/100g) of soymilk samples prepared from five different soybean varieties ranged from 0.058 to 0.074(thiamine), 0.046 to 0.059 (riboflavin), 0.062 to 0.084 (niacin) and vitamin C content ranged from 0.350 to 0.440. It is of interest to note that the values observed in this study are notably higher than that reported by Nwoke and Umelo [15] depicting or suggesting differences in soybean varieties used as well as differences in soymilk processing methods used. Soybean variety-TGX-1740 was used in this study while TGX-4482E, TGX 814496, SAMSOY 1, SAMSOY 2 and SAMSOY 3 were used by Nwoke and Umelo [15]. Furthermore, the vitamin content of plain unfortified soymilk as reported by Madukwe and Eme [10] was 8.70mg/100g which is notably higher than the value observed in this study which was 1.233mg/100g (Table 4). This may be as a result of different soybean varieties used.

Table 5 expresses the microbial status of the soymilk samples. All the samples were free of coliforms and pathogenic microorganisms throughout the experimentation period. The total viable bacterial count was 4.9×10^2 CFU/ml in SM0 and this increased to 9.2×10^2 CFU/ml in SM3. while that of fungal count ranged between 1.3×10^2 to 5.9×10^2 This microbial load is still satisfactory and denotes or still indicates good microbiological quality since there was no hygiene indicator organism (pathogen) present and the microbial load is still $<10^5$ CFU/ml which is the threshold for good microbiological quality [16], hence, the soymilk samples are safe for consumption throughout the three days of preservation by boiling. The total viable bacterial count observed in this study are comparable to that observed in commercial soymilk samples (both branded and unbranded) by Adeleke *et al.* [17] who reported a range of 1.02×10^2 CFU/ml to 9.3×10^2 CFU/ml. Also the total fungal count observed in this study was 1.3×10^2 which increased to 5.9×10^2 CFU/ml on the third day after production while that observed by Adeleke *et al.* [17] in commercial soymilk brands ranged from 1.43×10^2 to 6.9×10^2 CFU/ml. showing that the soymilk samples in this study contained even lesser microbial load than the commercial brands.

There was no significant difference in the scores for taste, mouth feel, aroma and overall acceptability of the soymilk samples but these differed significantly in the scores for color (Table 6). The color, taste, mouth feel, aroma and overall acceptability scores of the soymilk prepared in this study were all above 8 on the day of production and throughout the period of preservation by boiling except for color on the third day of preservation

which was scored 7.79. This shows that sensory properties of the soymilk were liked very much throughout the preservation period while on the last day the color was liked moderately judging from the score 7.79. The sensory properties of soymilk produced in this study were more acceptable than those of the soymilk samples produced from five different soybean varieties as reported by Nwoke and Umelo [15] who observed scores lesser than 8 for all the soymilk samples. This difference in sensory scores could be as a result of different soybean varieties used as well as variation in soymilk processing methods. The score for overall acceptability of plain soymilk as reported by Madukwe and Eme [10] was 8.36 which is comparable to that observed in this study but the score for color, aroma, mouth feel which were 7.88, 7.40 and 7.68 respectively [10] were in close proximity with the scores observed in this study depicting some slight similarity in soymilk processing method used as well as soybean varieties.

5. Conclusion and Recommendation

Boiling of soymilk twice a day (morning and evening) for three days preserved the proximate, vitamins, minerals composition as well as the microbial, physical and sensory properties of the milk and made it safe and still nutritious for consumption. However, the color was being impaired at the third day of preservation and this was reflected in the sensory assessment. Household preparation and consumption of soymilk is hereby recommended and encouraged even where facility for refrigeration is not easily available since the nutritional and safety quality can be preserved by boiling for the first three days. Further study to determine when the soymilk will no longer be safe for consumption is also recommended.

References

[1] Sharma S., Kaur M., Goyal R. and B.S. Gill. Physical characteristics and nutritional composition of some new soybean (Glycine max L. Merril) genotypes. *Journal of Food Science and Technology* 2014; 51(3): 551-557.

[2] Wang H. and P.A. Murphy. Isoflavone composition of American and Japanese soybeans in Iowa: Effects of variety, crop year and location. *Journal of Agricultural and Food Chemistry* 1994; 42(8): 1674-1677.

[3] Messina M. Modern application for an ancient bean: soybeans and the prevention and treatment of chronic disease. *The Journal of Nutrition* 1995; 125(3): 5675-5695.

[4] Singh B.P., Yadav D. and S. Vij. Soybean bioactive molecules: current trend and future prospective. In: Merillon J.M., Ramawat K. (eds) Bioactive molecules in food. *Reference Series in Phytochemistry* 2019, Springer, Cham, Switzerland.

[5] Maziya-Dixon B., Akinyele I.O., Oguntona E.B., Nokoe S., Sanusi R.A. and E. Harris. Nigeria food consumption and nutrition survey 2001-2003. International Institute of Tropical Agriculture (I.I.T.A.) 2004, Nigeria.

[6] Kundu P., Dhankhar J. and A. Sharma. Development of non-dairy milk alternative using soymilk and almond milk. *Current Research in Nutrition and Food Science* 2018; 6(1).

[7] Mohammed M.A., Haggar I.S. and M. Hasbalrasol. Effect of different processing methods on chemical composition and sensory quality of soymilk. *International Journal of Fermented Foods* 2017; 6(2): 100-108.

[8] El-Tawab A.M.A. Soymilk as an unconventional alternative of milk for sucking calves. *International Research Journal of Animal and Veterinary Sciences* 2019: 1(1): 1-10.

[9] Oseni M.O. Household's access to electricity and energy consumption pattern in Nigeria. *Renewable and Sustainable Energy Review* 2012; 16(1): 990-995.

[10] Madukwe E. and P.E Eme**.** Chemical evaluation and sensory attributes of soymilk fortified with carrot powder. *African Journal of Food Science* 2012; 6(20): 483-486.

[11] Kirk R.S and R. Sawyer**.** Pearson's Composition and Analyses of Foods, 9th edition, 2005, Longman, United Kingdom.

[12] Harrigan W.F and M.E. McCance**.** Laboratory methods in food and dairy microbiology, 1976, Academic Press, London.

[13] Walfe K.A. Use of reference standards for sensory evaluation of product quality. *Food and Agriculture Organization of the United Nations*. Available from: www.agris.fao.org [internet]. Accessed: 2019 January 28.

[14] Lakshmanan R., Lamballerie M. and S. Jung. Effect of soybean-to-water ration and pH on pressurized soymilk properties. *Journal of Food Science* 2006; 71(9): 384-391.

[15] Nwoke F.U. and M.C. Umelo**.** Nutritional and sensory quality of soymilk produced from different improved varieties of soybean. *Pakistan Journal of Nutrition* 2015; 14(12): 898- 906.

[16] Chua S., Ng M., Craig D., Liu X., Chen S. and P. Ho. Microbiological guidelines for food. Centre for Food Safety 2014, Hong Kong.

[17] Adeleke O.E., Adeniyi B.A. and A.A. Akinrinmisi. Microbiological quality of local soymilk: A public health appraisal. *African Journal of Biomedical Research* 2000; 3: 89-92.