American Journal of Food and Nutrition, 2018, Vol. 6, No. 4, 115-125
Available online at http://pubs.sciepub.com/ajfn/6/4/4

DOI:10.12691/ajfn-6-4-4

Physicochemical, Microbiological, Sensory Properties and Storage Stability of Plant-based Yoghurt Produced from Bambaranut, Soybean and *Moringa oleifera* Seed Milks

Edith Ani, Julius Amove, Bibiana Igbabul*

Department of Food Science and Technology, University of Agriculture, Makurdi, Nigeria
*Corresponding author: bibideke@yahoo.com

Received June 12, 2018; Revised August 18, 2018; Accepted October 17, 2018

Abstract The physicochemical, microbiological properties and sensory characteristics of plant-based yoghurt (PBY) produced from bambaranut, soy and *Moringa oleifera* seed milks were studied. Milks were produced from bambaranut, soybean and *moringa oleifera* seed and then fermented using *Lactobacillus bulgaricus* and *Streptococcus thermophilus* to produce the yoghurts. These yoghurts were stored at 6 °C for 14 days (2 weeks) and their quality monitored. The study revealed that the physicochemical parameters; Peroxide value, Total solid non-fat (TSNF), Total titratable acidity (TTA), Total solids, Viscosity and pH of these yoghurt samples were within the acceptable standards from zero to 14 days of storage. Peroxide value ranged from 10.00-11.00 mEq/kg; 10.24-11.12 mEeq/kg and 10.40-11.30 for 0, 7 and 14th day of storage respectively. TSNF ranged from 12.06-14.29 %; 12.56-14.78 % and 12.96-15.19 % for 0, 7 and 14th day of storage respectively. TTA ranged from 0.65-0.78 %; 0.86-0.99 % and 1.08-1.18 % for 0, 7 and 14th day of storage respectively. Total solids ranged from 16.25-17.91 %; 17.00-18.51 % and 17.34-19.02 % for 0, 7 and 14th day of storage respectively. Viscosity ranged from 526.43-659.26 cP; 476.47-609.28 cP and 428.15-568.90 cP for 0, 7 and 14th day of storage respectively. The pH ranged from 4.00-4.50; 3.66-4.27 and 3.21-3.85 for 0, 7 and 14th day of storage respectively. Results showed that these yoghurt samples from zero to 14 days of storage were microbiologically stable and were found to be within the acceptable standard specified by NAFDAC and Codex Alimentarius. The sensory properties revealed that cow milk yoghurt was liked very much in terms of overall acceptability followed by sample 577 (50 % Soymilk +35 % Bamabara milk + 15 % *Moringa* seed milk) which was liked moderately and the other samples which all were generally accepted.

Keywords: *plant-based yoghurt, bambaranut, soyabeans, moringa oleifera seeds*

Cite This Article: Edith Ani, Julius Amove, and Bibiana Igbabul, "Physicochemical, Microbiological, Sensory Properties and Storage Stability of Plant-based Yoghurt Produced from Bambaranut, Soybean and *Moringa oleifera* Seed Milks." *American Journal of Food and Nutrition*, vol. 6, no. 4 (2018): 115-125. doi: 10.12691/ajfn-6-4-4.

1. Introduction

Yoghurt is a Turkish name for a fermented milk product. It is originated by early normadic herdsman, especially in Asia, Southern and Eastern Europe. Yoghurt is made by adding a culture of acid forming bacteria to milk that is usually homogenized, pasteurized and fermented. The micro-organisms which are used conventionally in this process are referred to as "Starter Culture". They include *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. The average size of *Lactobacillus bulgaricus* ranges from 0.8 to 1.0 μm in diameter [1]. During the fermentation, hydrolysis of the milk proteins occur, the pH drops, the viscosity increases and bacterial metabolites are produced that contribute to the taste and possibly to the health promoting properties of yoghurt. The sugars are fermented by the bacteria into lactic acid, which causes the formation of the characteristic curd [2]. The authors further observed that the acid lowers the pH of the yoghurt and restricts the growth of food poisoning bacteria (putrefactive or pathogenic). Not only is yoghurt a wonderful quick, easy and nutritious food, but also research evidence point to the fact that milk and yoghurt may actually add years to life as found in some countries where fermented dairy products are a dietary staple.

Several health benefits have been reported for traditional yoghurt and this healthy image is enhanced by supplementation with probiotic bacteria. Scientists have found that the intake of yoghurt with active cultures may aid digestion, ease diarrhoea, boost immunity, fight infection and protect against cancer [3,4]. These specific health benefits depend on the strain and viability of the culture in yoghurt [3]. In addition, yoghurt has more amount of calcium, which helps the body to improve the strength of muscles and bones. Calcium is needed throughout life, but most people don't get enough in their diets. And across the board, the consumption of calcium-rich dairy products tends to decrease as people age [5,6]. Yoghurt is easier to digest than milk and so many people including children who cannot tolerate milk, either because of a protein allergy or lactose intolerance can enjoy yoghurt which is more digestible than milk. Bacterial enzymes created by the culturing process partly digest the milk protein casein making it easier to absorb and less allergenic [4].

Vegetable milks generally are lactose-free and thus can be consumed by people that are lactose intolerant. Examples of crops that can be used to produce milk include bambaranut, soybean and *Moringa oleifera* seed etc. Bambaranut (*Vigna subterranean*) which belongs to family fabaceae is an annual herbaceous, intermediate plant with creeping stems at ground levels. Bambaranut (*Vigna Subterranean)* is an indigenous African crop that is now grown across the continent from Senegal to Kenya and from the Sahara to South Africa [7]. It originated in the Sahelian region of present day West Africa, which its name originating from the Bambara tribe who now live mainly in Mali [8].

Several workers have examined the biochemical composition of bambaranut [9,10]. On average, the nuts were found to contain 49.72 % carbohydrate, 21.18 % protein and 6.38 % fat. Lysine and Leucine were the predominant essential amino acids [10]. Bambara groundnuts are eaten in many ways. They can be eaten fresh or grilled while immature. In many countries in West Africa, fresh pods are boiled with salt and pepper and eaten as a snack. In East Africa, the beans are roasted, pulverized and used in preparing soup. Bambara groundnut flour has been used in bread production [11]. Bambaranut milk is preferred to that prepared from other pulses because of its flavour and colour [12]. Bambaranut is used to make a paste out of the dried seeds, which is then used in Nigeria for the preparation of various fried and steamed products such as "akpekpa" "akara", "moi-moi", and "okpa". Also in Nigeria, we have various recipes on puddings and cakes such as Bean Cake. *Okpa and akpekpa* are similar to *Moi-Moi* in the major ingredient and method of preparation, but completely different in taste. It is a common food in the eastern and central Nigeria.

The soybean belongs to the family *Leguminosae*, subfamily *Papilionoideae*, and genus *Glycine*, L. The soybean (*Glycine max* (L) undoubtedly originated in the Orient, probably in China [13]. The US and Brazil are the 1^{st} and 2^{nd} biggest producers of soybeans in the World with an output of 73 million metric tons (33 %) and 42 million metric tons (MT) (28 %), respectively, in 2008 [14]. Egypt the largest producer of soybeans in Africa produces about 180,000 tonnes annually [14]. Soybean is one of the most important oil and protein crops of the world [15]. Soybeans contain 30 to 45 % protein with a good source of all essential amino acids [16,17,18]. The protein content of soybean is about 2 times of other pulses, 4 times of wheat, 6 times of rice grain, 4 times of egg and 12 times of milk. Soybean has 3 % lecithin, which is helpful for brain development. It is also rich in calcium, phosphorous and Vitamins A, B, C and D, it has been referred to as "the protein hope of the future" [15].

The history of *Moringa* dates back to 150 B.C. *Moringa oleifera* is one of the vegetables of the Brassica order and belongs to the family *Moringaceae*. The *Moringaceae* is a single genus family with 13 known species [19]. *M. oleifera* is a small native tree of the sub-Himalayan regions of North West India, which is now indigenous to many regions in Islands and South America but is now found worldwide in the tropics and sub-tropics. The plant thrives best under the tropical insular climate. It can grow well in the humid tropics or hot dry lands and can survive in less fertile soils and it is also little affected by drought [20].

Moringa oleifera has an impressive range of medicinal uses with high nutritional value. Different parts of this plant contain a profile of important minerals, and are a good source of protein, vitamins, beta-carotene, amino acids and various phenolics [20]. Mature seeds yield 38–40% edible oil called ben oil from its high concentration of behenic acid. The refined oil is clear, odourless and resists rancidity. Moringa seeds contain more vitamin A than carrots, more calcium than milk, more vitamin C than oranges, and more potassium than bananas, 4 times the fibre in oats, 9 times the iron in spinach, and that the protein quality rivals that of milk and eggs [19]. Proximate composition of *Moringa* seeds as reported by [19] (in percentage) are as follows; Carbohydrate (18.0), Fat and Oil (40.0), Moisture (7.0), Protein (9.98) and Crude Fibre (20.0). The Mineral analysis revealed Calcium concentration of of 1.475 x 102 + 0.15 mg/l, Chlorine concentration of 2.482 x 102 + 0.01 mg/l and Phosphorus concentration of 3.85 + 0.20 mg/100g in seed sample whereas the concentration in the leaves recorded calcium (1.151 x 102 + 0.02 mg/l), Chlorine (0.319 + 0.07 mg/l) and Phosphorus (3.85 + 0.04 mg/100g). The *Moringa oleifera* seed is also rich in protein (25.5-38.3%) [21,22]. It would appear that combining bambaranut, soybean and *Moringa oleifera* seed milks in production of yoghurt-like poduct would be novel since these crops are known for their high nutrient profile. Therefore, the aim of the study was to investigate the physico-chemical, microbiological and sensory properties of Plant-based yoghurt from bambaranut, soybean and *Moringa oleifera* seed milks.

2. Materials and Methods

2.1. Procurement of Materials

Soybeans, Bambaranut, *Moringa oleifera* seeds, cow milk powder and freeze dried lactic acid producing bacteria (mixed culture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus*) were purchased from local markets in Makurdi, Benue state.

2.2. Sample Preparation

2.2.1. Preparation of Bambaranut Milk

Bambaranut seeds was manually sorted, cleaned with potable water and soaked in (4.1 w/v) potable water for 24 hrs, while water used in soaking was changed at every 6 hrs interval during the soaking duration. The seed coat of the nuts were dehulled after 24 hrs of soaking by rubbing the seeds with the palm and the husks were sieved out of the water and subsequently wet milled using hammer mill. Cheese cloth was used in the extraction of milk from the bambaranut mash by triple filtered by folding the cheese cloth thrice.

2.2.2. Preparation of Soymilk

The method described by Udeozor (2012) with slight modification was used to prepare the soymilk. One kg of soybeans was soaked overnight for 18 hrs in a 3 L of warm portable water to give a bean: water ratio of 1:3. The beans were then drained, rinsed with potable water and blanched for 5 min in boiling water. The blanched beans were drained, dehulled and ground with 750 ml of potable water using attrition mill. The resulting slurry was filtered through a muslin cloth and the extract (milk) was obtained.

2.2.3. Preparation of *Moringa oleifera* Seed Milk

Moringa oleifera seeds were sorted, dehulled, 1 kg weighed, washed with potable water, soaked for 6 hrs, drained, blanched for 10mins, wet milled and filtered.

2.2.4. Preparation of Mother Culture

Cow milk powder was reconstituted by dissolving 800 g in 3.5 litres of water as recommended by the manufacturer. The whole milk was heated to 95°C for 5 min, then cooled rapidly to 45°C and inoculated with 0.2 % (w/v) of freeze-dried culture. The inoculated mix was incubated for 6 hours at 40-45°C to develop proper acidity, then cooled and stored at 6°C.

2.3. Yoghurt Formulation

Eight yoghurt formulations were produced by varying the proportions of soymilk, bambaranut milk and *Moringa oleifera* seed milk. Formulation 716 (100 % cow milk was used as control). The mixed samples were pasteurized at 95°C for 5 min, then rapidly cooled to 45°C and inoculated with 15 % (w/v) mother culture. These samples were incubated at 40-45°C for 6hours and then cooled rapidly (Figure 1). Thereafter, they were stored at refrigeration temperature (6°C) for 14days.

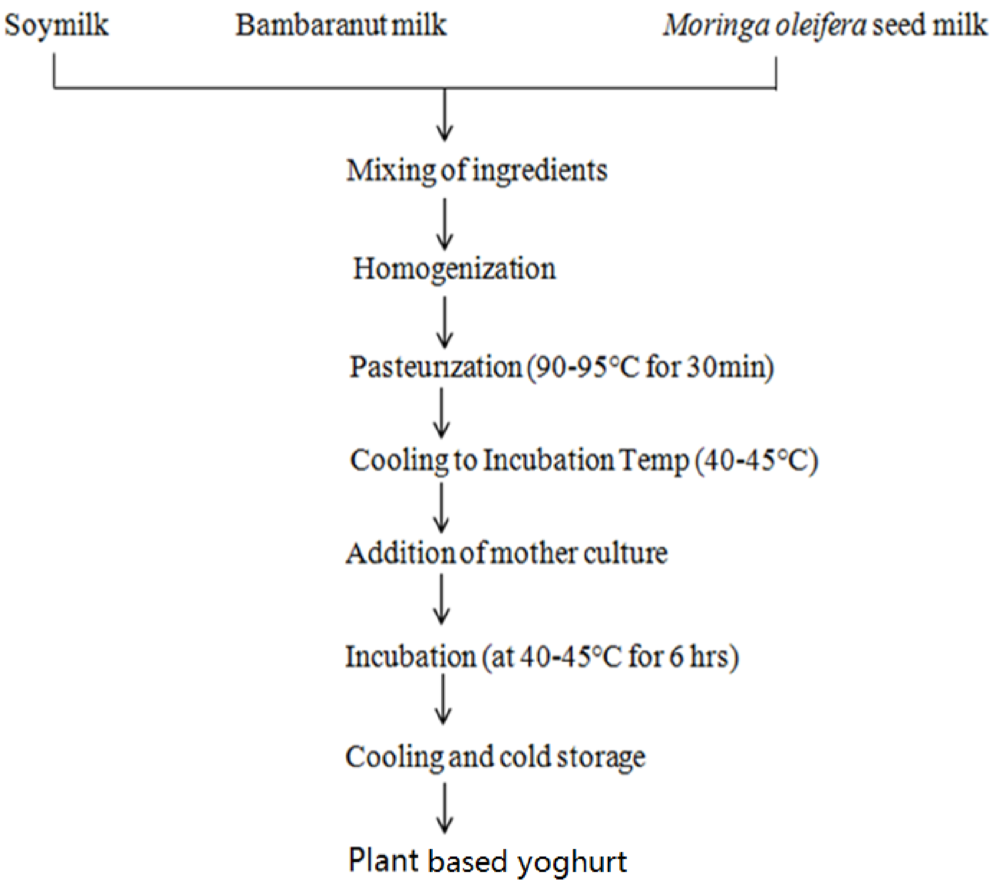

Figure 1. Flow Chart for the Production of plant-based yoghurt from Bambaranut, Soy and *Moringa Oleifera* Seed Milks

Table 1. Yoghurt formulation from Bambaranut, Soy and *Moringa oleifera* Milks

Ingredients	Formulations							
	716	424	839	746	958	469	577	985
Cow milk	100	-	-	-	-	-	-	-
Soymilk	-	95	-	70	30	45	50	35
Bambaranut milk	-	-	95	25	60	45	35	50
Moringa oleifera milk	-	5	5	5	10	10	15	15
Total	100	100	100	100	100	100	100	100

2.3.1. Determination of Physicochemical Properties

Total Titratable Acidity (TTA): The titratable acidity was determined using the AOAC [23] method. Ten mL of the samples was measured into conical flasks and two drops of Phenolphthalein indicator (2 mL) were added to each yoghurt sample and titrated with 0.I M NaOH to the first permanent pink colour. The acidity was reported as the percentage lactic acid by weight.

$$\text{Titrable acidity } (\%) = \frac{\text{Quantity of NaOH (ml) x 0.009x100}}{\text{Quantity of sample}}$$

pH: pH was determined according to AOAC [23], using a pocket pH meter. The pH meter was calibrated using a 7.0 buffer solution and rinsed with water; it was then put into 25 ml of sample and reading recorded after stabilization

Viscosity: The viscosity was measured using viscometer (Model 800, OFITE; OFI Testing Equipment, Inc., Houston, Texas, U.S.A). Samples were put in a stainless measuring cylinder and viscosity readings taken on the viscometer at 600 rev/min

Peroxide Value: Peroxide value was determined by the method of Kirk and Sawyer [24]. Two millilitres of sample was weighed into a 250 ml conical flask, 10ml of chloroform was added and swirled gently until fat was dissolved. To it, 15 ml of glacial acetic acid and 1ml of fresh saturated aqueous KI solution were also added. The flask was stoppered, shaken for 1min and placed for exactly 1min in the dark. Five millilitres of water was added, mixed, and titrated with 0.01 M $Na_2S_2O_3$ using soluble starch solution (1 %) as indicator. A reagent blank determination (V_0) was carried out; it did not exceed 0.5 mL of 0.01 M $Na_2S_2O_3$ solution.

2.3.2. Determination of Total Solids

The Total Solids was determined using the method described by AOAC [23]. Three grams of the sample was weighed into a dry Petri dish of a known weight. The total portion was pre-dried for 25 minutes on steam bath and then dried for 3 hours at 100°C in forced draft air oven. The Total Solid sample is the weight of the dried sample residue and was calculated as:

$$\%\text{ Total Solid} = \frac{W_2 - W_1}{W_1 - W} \times 100$$

Where:
W = Weight of the dish
W_1 = Weight of dish and sample test portion
W_2 = Weight of dish and dry sample.

Total solids (dry matter) were checked by subtracting % moisture content from the mass (100) as described by AOAC [23].

2.3.3. Determination of Total Solids-Non-Fat

The total solids-not-fat was determined as described by AOAC [23]. It was obtained by taking the difference between % Total Solids and % Fat content. That is: % Solids-Non-Fat = % Total Solids - % Fat content.

2.4. Microbial Analysis

Preparation of Diluent and Media: Diluent (peptone water) and media (Nutrient Agar, MacConkey Agar and Potato Dextrose Agar) were prepared according to manufacturer's specification.

Microbiological Analysis of Samples: One milliliter (1 mL) of each sample was serially transferred into nine milliliters (9 mL) of the sterile diluent (peptone water) with a sterile pipette and shaken vigorously. Serial dilution was continued until 10^6 dilution was obtained. Aliquot portion (0.1 mL) of the 10^6 and 10^5 dilutions were inoculated onto freshly prepared, surface-dried nutrient agar (NA) and MacConkey agar (MCA) respectively. The same quantity (0.1 mL) of the 10^4 dilution was inoculated onto potato dextrose agar (PDA). The inoculi were spread with a sterile (hockey stick-like) glass spreader to obtain even distribution of isolates after incubation. Nutrient agar and MacConkey agar plates were incubated for 24-48 hrs at 37°C, while potato dextrose agar plate was incubated at ambient temperature (28± 02°C) for 3-5 days.

Enumeration of Microbial Population: Total plate counts for the nutrient and MacConkey Agar were done by counting colonies at the reverse side of the culture plates. Total colony count was expressed in colony forming units per millilitre (cfu/ mL) Harrigan and McCance, [25]. Plate counts for PDA plates was done using colony counter for the yeasts and hand lens for moulds.

Characterization and identification of Microbial Isolates: Microbial isolates (bacteria, yeasts and moulds) were characterized based on colonial, microscopic and biochemical characteristics to know the genera. Thus, the identities of the isolates were determined using a reference manual.

2.5. Sensory Evaluation

Samples were assessed for sensory characteristics based on appearance, aroma, taste, mouth feel and overall acceptability using a 20-member semi-trained panelists on 9-point hedonic scale, with (9) = extremely like and (1) = extremely dislike. The ratings from hedonic scale were subjected to analysis of variance (ANOVA). The significant differences between means were determined by Least Significant Difference (LSD) test as described by Ihekoronye and Ngoddy [26].

2.6. Storage Study

The packaged yoghurt samples were stored at 6 °C for 0, 7, and 14 days. Samples were monitored for peroxide value, total solid non-fat, total titratable acidity, total solids, viscosity, pH, microbial quality and sensory attributes.

2.7. Statistical Analysis

All data obtained from the experiments were statistically analysed using one way Analysis of Variance (ANOVA) and means separated by Duncan's Multiple Test. The significant differences between means were determined by Least Significant Difference (LSD) test as described by Ihekoronye and Ngoddy [26] Significant difference was accepted at 5 % level of probability.

3. Result and Discussion

3.1. Physicochemical Properties of Plant-based yoghurt Produced from Bambaranut, Soybean and *Moringa oliefera* Seed Milks for 0, 7 and 14th Day (mEq/kg).

Table 2 shows the physicochemical properties of Plant-based yoghurt produced from bambaranut milk, soymilk and *Moringa oliefera* seed milk for the zero day. There was no significant difference (p>0.05) in the physico-chemical properties of all the products for the zero day expect viscosity which differs significantly (p<0.05) among the samples. The peroxide value ranged from 10.00 – 11.00 mEq/kg with control sample (100 % cow milk) having highest value of 11.00 meq/kg while sample 469 (45 % Soymilk + 45 % Bambaranut milk + 10 % *Moringa* Seed milk) recorded the least value 10.00 mEq/ kg. The lower peroxide values obtained for Plant-based yoghurt might be due to slower rate of rancidity for vegetable fats compared to animal fats. According to World Food Logistics Organization [27], Vegetable fats, although unsaturated, are usually more stable than animal fats because they contain natural antioxidants such as vitamin E.

Peroxide value (PV) was measured to determine primary lipid oxidation of Plant-based yoghurt from bambaranut milk, soymilk and moringa seed milk during storage. Peroxide value monitors the development of rancidity through the evaluation of the quantity of peroxides generated in the product. Fresh oils usually have peroxide values below 10 mEq/kg. The onset of rancid taste begins when peroxide value is between 20 and 40 mEq/Kg [28]. Therefore, it can be inferred that the peroxide values of the Plant-based yoghurt from bambaranut milk, soymilk and *Moringa* seed milk obtained in this work from zero to 14days of storage were within the acceptable limits.

The pH is a determining factor in the decrease or increase in the Titratable acidity of the yoghurt samples. The pH of the Plant-based yoghurt from bambaranut milk, soymilk and moringa seed milk ranged from 4.00 – 4.50. The values obtained in this work were almost in the same range with those reported by Ukwo [29]. The author reported values of pH ranging from 4.28-4.50. Also, Ndife *et al*. [30] reported the same trend (4.32-4.50) in their work titled "Production and quality assessment of functional yoghurt enriched with coconut"**.** Eke *et al*. [31] reported pH of Plant-based yoghurt ranging between 3.41-3.82 indicating acidity of the samples. The pH values obtained in this work (4.00-4.50) were within the recommended pH of (3.9-4.5) yoghurt. Lactic acid bacteria produce lactic acid during fermentation of milk-lactose, thus lowering the pH [31]. Food Standard Code requires that the pH of yoghurt be a maximum of 4.50 in order to prevent the growth of any pathogenic organisms [32].

As shown in Table 2, pH of yoghurt samples stored at 6°C decreased significantly (p>0.05) over the storage period from 0 to 14 days. Osundahunsi *et al*. [33] reported a decrease in pH of plain soy-yoghurt refrigerated and stored at 6 °C for 8 days, pH value of 4.7 and 4.3 was reported for day 1 and day 8, respectively. Similarly, Falade *et al.* [34] reported that pH of Soy yoghurt stored at 7 °C decreased significantly (p<0.05) over the storage period from 4.97 (day 0) to 4.20 (day 9). In contrast, Stijepić *et al.* [35] reported stable pH value for probiotic yoghurt made from soymilk during storage (up to 20th day) at 4°C. Murevanhema [36] reported a fairly stable pH for fermented bambara milk beverage (probiotic yoghurt) during storage period at 5°C, and a significant decrease in pH during storage at 15 and 25°C.

The total solid not-fat (TSNF) of the Plant-based yoghurt produced from bambaranut, soy and *Moringa* seed milks ranged from 12.06 – 14.29 %. Ndife *et al.* [30] reported TSNF value in the range of 11.82 – 18.40 % for coconut enriched yoghurt. Similarly, Olugbuyiro and Oseh [37] reported Solids-not-fat values of yoghurt in the range 9.49- 18.77 %. According to FDA [38], yoghurt should contain not less than 8.25 % SNF before the addition of bulky flavor. The present findings conform to this specification.

Total solid content of the Plant-based yoghurt produced from bambaranut milk, soymilk and *Moringa* seed milk ranged from 16.25 – 17.91 % day zero. The findings of this study were slightly lower than those reported by Ndife *et al*. [30] who recorded total solid of 14.77-19.90 %. Although, the values obtained in this study were higher than those reported by Brimstone *et al*. [39], 8.50-13.56 %; Adelodun and Abiodun [40], 7.91-9.06 % in their work on "Effect of Different Concentrations of Coconut Milk on the Chemical and Sensory Properties of Soy-coconut Milk Based Yoghurt". The total solids of the products reported in this study were higher than some of those cited above probably due to the contribution of monosaccharide-sugars from soymilk, and bambaranut milk. Carbohydrate monohydrates are abundant in soybean and bambaranut milk and are responsible for their sweet taste. Also, the total solids are an indication of the dry matter content of the yoghurt samples [41,42].

As shown in Table 6, total solid contents of yoghurt products obtained in this study increased significantly as the storage time increased. Total solid contents varying from 10.62 to 11.49 % have been reported for soymilk-based yoghurts [43]. Also, similar trend was observed by [34]. The researchers obtained a total solid contents of soy plain yoghurt stored at 7 °C from 10.4 % (day 0) to 14.3 % (day 9) over the storage period. A similar trend was observed for bambaranut plain yoghurt stored at 7 °C over the storage period by the same authors. Total solid contents increased significantly (p<0.05) from 9.7 % (day 0) to 12. 4 % (day 9) for bambara plain Yoghurt. Decrease in soluble solid contents of some flavoured-yoghurts stored at 6°C for 8 days have been reported [33]. Rasdhari *et al.* [44] reported that the total solid contents of some probiotic yoghurt samples decreased during storage at 4°C for 7 days.

The TTA of the products ranged from 0.65 – 0.78 %. Sample 746 (70 % Soymilk + 25 % Bambaranut milk + 5 %) had the highest TTA value of 0.78 % followed by samples 985 with TTA value of 0.76 % for day zero. Ndife *et al*. [30] reported TTA of 0.52-0.67 in the yoghurt samples and the enriched-yoghurt samples had lower acidity values (0.59%) than plain-yoghurt (0.67 %). Ukwo *et al*. [29] reported higher TTA than the ones obtained in the study (1.02-1.42 %). Also, Bristone *et al*., [39] recorded TTA of 0.01-1.13 %. The values obtained for titratable acidity are generally within the standard which is 0.7 % [38]. There was direct relationship between pH values and titratable acidity as has been previously reported [45].

As expected, decreased pH values of yoghurt samples resulted in increased total titratable acidity values over the storage period. Falade *et al*. [34] observed a similar trend in total titratable acidity of plain Soy and Bambara yoghurts stored at 7 °C for 9 days which increased significantly ($p<0.05$) from 1.63–2.02 % to 1.53–1.94 %, respectively. Also, increase in titratable acidity (lactic acid) of plain soy-yoghurt refrigerated and stored at 6 °C for 8 days has been reported [33]. These researchers reported titratable acidity (lactic acid) of 1.08 and 1.60 % for day 1 and day 8, respectively. These values are higher than total titratable acidity values for yoghurt samples during the storage period obtained in this study. Stijepić *et al*. [35] reported stable acidity value for probiotic yoghurt made from soymilk during storage (up to 20^{th} day) at 4°C. Murevanhema [36] reported a gradual increase in titratable acidity of bambaranut milk beverage during storage at the 5 °C. In contrast, a faster increase in titratable acidity was reported when the samples were stored at 15 and 25 °C [36].

The decreased pH and simultaneous increased in total titratable acidity yoghurt products during the storage period could be attributed to the starter culture's activity, such as post acidification due to formation of lactic acid or growth of the bacteria used during fermentation [35,36]. Growth rate of microbes has been associated with acidification and depended on the culture used [46].

The viscosity of the plant-based yoghurt produced from bambaranut milk, soymilk and moringa seed milk ranged from 526.43 – 659.26 cP. The most viscous of the products was sample 716 with viscosity of 659.26 cP while sample 746 had the least viscosity (526.43 cP). The cow milk yoghurt was more viscous than other sample because of higher interaction between the molecules. The interactions in plant-based yoghurt are electrostatic and hydrophobic ones, which are considered as weak physical bonds [39]. Although, the values of viscosity reported in this work were higher than those reported Eke *et al*. [31] who reported viscosity of 80-170 cP. The highest viscosity of 659.26 cP was recorded in the product with 100 % milk and the lowest viscosity of 526.46 cP was recorded in the sample 746 (70 % Soymilk + 25 % Bambaranut milk + 5 % Moringa seed milk).

Table 2. Physicochemical Properties of Plant-based yoghurt Produced from Bambaranut, Soybean and *Moringa oliefera* seed milks for Day 0, 7 and 14th day.

Days	Samples	Peroxide (meq/Kg)	TSNF (%)	TTA (%)	Total solids (%)	Viscosity (cP)	pH
0	716	11.00a±1.41	13.49ab±1.76	0.65a±0.00	16.71a±2.83	659.26a±0.17	4.50a±0.28
	424	10.23a±0.02	13.15ab±0.35	0.68a±0.03	16.94a±0.05	552.82cd± 1.43	4.45a.28
	839	10.41a±0.14	14.29a±0.02	0.75a±0.14	17.53a±0.28	617.00b±4.24	4.11a±0.00
	746	10.31a±0.44	12.58ab±0.47	0.78a±0.01	16.43a±0.28	526.43e±14.14	4.00a±1.41
	958	10.30a±0.28	13.99a±1.14	0.72a±0.03	17.91a±0.08	560.46c±0.042	4.25a±0.01
	469	10.00a±2.283	12.54b±0.311	0.70a±0.28	16.42a±1.71	547.64d± 0.70	4.28a±0.00
	577	10.50a±0.28	12.06b±0.66	0.70a±0.01	16.25a±0.04	548.63cd±0.35	4.45a±0.02
	985	10.51a±0.01	13.34ab±0.28	0.76a±0.01	17.35a±0.07	558.02cd±1.42	4.05a±0.01
	LSD	**2.63**	**1.97**	**0.83**	**2.72**	**12.17**	**1.19**
7	716	11.12a± 0.01	13.97a±0.05	0.86a±.00	17.30a±0.21	609.28a±0.14	4.27a±0.169
	424	10.56a± 0.28	13.64a±0.14	0.90a±0.14	17.54a±0.03	502.86d±0.05	4.08ab±0.07
	839	10.63a± 0.16	14.78a±1.40	0.95a±0.75	18.11a±1.41	567.04b±1.41	3.75cd±0.28
	746	10.73a±0.14	13.08a±0.01	0.99a±0.01	17.00a±2.12	476.47e±4.24	3.66d±0.01
	958	10.95a±1.14	14.50a±1.41	0.93a±0.1	18.51a±0.06	512.76c±1.41	3.89bcd±0.15
	469	10.24a±0.84	13.06a±1.41	0.92a±0.14	17.01a±1.41	497.62d±0.77	3.87bcd±0.14
	577	10.76a±0.14	12.54a±0.05	0.94a±0.01	16.85a±0.14	498.63d±2.12	4.04abc±0.14
	985	10.89a±0.06	13.83a±1.41	0.97a±0.01	17.93a±0.03	508.08±c2.88	3.69d±0.27
	LSD	**1.19**	**2.32**	**0.63**	**2.38**	**5.02**	**0.33**
14	716	11.30a±1.14	14.42a±1.41	1.08d±0.03	17.84e±0.23	568.90a±0.14	3.85a±0.00
	424	10.76a±0.00	14.07a±0.01	1.09d±0.01	18.03d±0.01	453.37c±0.01	3.67ab±0.01
	839	10.81a±0.01	15.19a±0.01	1.16ab±0.01	18.59b±0.13	518.67b±0.00	3.33cd±0.01
	746	10.93a±0.14	13.50a±0.04	1.17ab±0.01	17.49f±0.00	428.15d±14.14	3.21d±0.28
	958	11.10a±0.07	14.89a±2.82	1.13cb±0.02	19.02a±0.03	465.34c±14.14	3.45bcd±0.00
	469	10.40a±0.14	13.48a±0.00	1.11c±0.01	17.52ef±0.07	447.78c±0.06	3.49bc±0.01
	577	10.90a±0.14	12.96a±0.13	1.12c±0.01	17.34f±0.01	448.99c±1.14	3.65ab±0.00
	985	11.01a±0.06	14.23a±2.83	1.18a±0.00	18.41c±0.02	461.46c±0.06	3.27cd±0.07
	LSD	**1.17**	**3.46**	**0.02**	**0.22**	**16.35**	**0.24**

Values are means ± SD duplicate determinations

Values with different superscript within the same column are significantly different ($p<0.05$)

Key: 716 = 100 % cow milk (control), 424= 95 % Soymilk + 5 % Moring seed milk; 839= 95 % Bambaranut milk + 5 % Moringa seed milk; 746= 70 % Soymilk + 25 % Bambaranut milk + 5 % Moringa seed milk; 958= 30 % Soymilk + 60 % Bambaranut milk +10 % Moringa seed milk; 469= 45 % Soymilk + 45 % Bambaranut milk + 10 % Moringa Seed milk; 577= 50 % Soymilk +35 % Bambara milk + 15 % Moringa seed milk; 985 = 35 % Soymilk + 50 % Bambaranut milk +15 % Moringa seed milk.

3.2. Microbiology of Plant-based yoghurt Produced from Bambaranut, Soy and *Moringa oliefera* Seed Milks for 0, 7 and 14th Day

The microbiological quality assessment of yoghurt is mainly concerned with two aspects: 1) protection of the consumers against exposure to any health hazard; and 2) ensuring that the material is not suffering microbiological deterioration during its anticipated shelf-life [47].

As shown in Table 3, there was a decrease in total viable count (TVC) as the substitution level of *Moringa* seed milk increased. The total viable count (TVC) of the yoghurt and Plant-based yoghurt ranged from 2.10 x 10^3 to 4.75 x 10^3cfu/ml, 1.80x 10^3 to 4.46x 10^3cfu/ml and 1.60x 10^3 to 4.26x 10^3 cfu/ml for 0, 7 and 14th day respectively. Sample 577 (50 % Soymilk +35 % Bambara milk + 15 % *Moringa* seed milk) recorded the lowest TVC while sample 839 (95 % Bambaranut milk + 5 % *Moringa* Seed milk) had the highest TVC. This might be attributed to the fact that *Moringa* seeds have anti-microbiological effect [48-53]. The values of TVC obtained in this work are in accordance with those obtained by Ihemeje *et al*. [54]. The authors recorded total bacterial count of 0.8x10^3 to 1.4x10^3 cfu/ml in their work titled "Production and quality evaluation of flavored yoghurts using carrot, pineapple, and spiced yoghurts using ginger and pepper fruit". Also, similar results were obtained by Makwin *et al*. [55] who reported bacterial count of 0.0x10^3-4.4x10^3 cfu/ml in their work "An Assessment of the Bacteriological Quality of Different Brands of Yoghurt Sold in Keffi, Nasarawa State, Nigeria". The results obtained were lower than those obtained by these authors: Ndife *et al*. [30]; Bristone *et al*. [39]; Chimezie *et al*. [56]; Oyeniyi *et al*. [57] and Balogun *et al*. [58].

The total viable count decreased significantly by the 7th and 14th day of storage while the pH values also decreased during the storage period for all the samples. The pH drop created a highly acidic environment which led to the loss of viability or death of the microorganism present. This might also be attributed to low temperature of refrigeration which inhibits the growth of bacteria e.g. lactic acid bacteria which grow well at temperatures between 20 and 40°C with an optimum temperature range of 30–32°C. This trend conforms to the results obtained by [32] who observed a decrease in LAB counts of both soy and bambaranut yoghurts after 9 days of storage at 7°C. The counts of LAB decreased by 0.6 log10 cfu/mL and 1.0 log10 cfu/mL in the plain soy and bambaranut yoghurt samples respectively, after 9 days of cold storage at 7 °C. Also, Aminigo *et al*. [59] reported decrease in the lactic acid bacteria count in African yam bean yoghurt stored at refrigeration temperature for 4 weeks. Similar trend was also reported by Balogun *et al* *[58]* in effect of partial substitution of cow milk with bambaranut groundnut milk on the chemical composition, acceptability and shelf life of yoghurt**.**

The total viable count of yoghurts and Plant-based yoghurt obtained in this study were within acceptable standard <1x10^6 cfu/ml [60,61]. The standard count is 10^6-10^7cfu/mL [62,63].

Yeast and mold were not detected on the zero and 7th day but, were detected on the 14th day of storage which ranged from 0 to 3 cfu/ml. This trend is agreeable with the observation made by Falade *et al*. [34]. The authors reported that yeast and mold count increased with increase in storage time of Plant-based yoghurt from Soymilk and bambaranut milk. The increase in the population of yeasts and moulds can be attributed to an increase in acidity or reduction in potential oxygen during fermentation process which probably provided suitable conditions for growth of yeasts and moulds [64]. Levels above 10.0 cfu/g yeast and mold [47]are capable of producing toxic metabolites (mycotoxin e.g aflatoxin) leading to food poisoning and can cause cancer of the liver in humans. According to [6], the presence of lactic acid bacteria in yoghurt prevents the proliferation of fungi in yoghurt. Similar results were obtained by [33] who reported 2.0 cfu/ml of yeast and mold on the 8th day of storage in their work "Quality Evaluation and Acceptability of Soy-yoghurt with Different Colours and Fruit Flavours". Also, the results obtained in this study were comparable to those recorded by Olakunle, [66]. In his work titled "Production and Quality Evaluation of Soy-Corn Yoghurt", he recorded yeast and mold count of 2.21 to 2.29 cfu/mL. The presence of yeast and mould is attributed to poor handling during production [67,68,69,70].

Coliforms were not detected in any of the yoghurt and Plant-based yoghurt from day zero to 14th day of storage. The absence of coliform bacteria (TCC) signifies that the yoghurt samples are free from fecal contamination due the hygienic conditions employed during production [33]. This corresponds with the statement of MacGraw [71] who remarked that processed milk should contain no trace of coliform. Mbaeyi-Nwaoha and Egbuche [72] had reported based on the standard stipulated by the National Agency of Food and Drug Administration Control (NAFDAC) that *E. coli* and coliforms generally must not be detectable in any 100 ml of yoghurt sample. The presence of coliforms indicates fecal contamination and the poor level of hygiene after processing. The absence of coliform is a good indication of the Good Manufacturing Practices employed by the producers [73]. Coliforms were not supposed to be present in yoghurt because of high temperature short time pasteurization and effective cleaning and good hygienic procedures as corroborated by Karagul-Yuceer *et al.* [74] and Kawo *et al*. [67]. Coliforms (except *E. coli*) do not pose danger for consumers, but are indicators of presence of dangerous and pathogenic species in food and water. They can indicate fecal contamination. There is a zero tolerance for coliform presence in yoghurt [75], and a count of 4000 is of serious concern [76].

In this study, *Staphylococcus aureus* was not detected in any of the samples. Results obtained are in agreement with the results of Omola *et al*. [77]. This could be due to the pasteurization of the milk prior to yoghurt production. *Staphylococcus aureus* is a normal flora of the human nose, throat, buccal cavity, palms and mucus membrane [78]. Some strains of this bacterial species are known to cause illness such as food poisoning, osteomyelitis, bronchopneumonia and septicemia, which are often very severe infections [79]. Abdelhameed and Elmalt [80] reported that the presence of *Staphylococcus aureus* in any food article is an index of its contamination probably from personnel involved in production and handling. The microbial status of the yoghurt and Plant-based yoghurt conforms to the accepted standard.

Table 3. Microbiology of Plant-based yoghurt Produced from Bambaranut, Soy and *Moringa oliefera* seed milks Day 0, 7 and 14th (cfu/mL)

Day	Parameters	Samples							
		716	424	839	746	958	469	577	985
0	TVC	2.15 x10^3	4.10x10^3	4.75 x10^3	4.20 x10^3	3.53 x10^3	3.25 x10^3	2.10 x10^3	2.20 x10^3
	YMC	-	-	-	-	-	-	-	-
	Coliform	-	-	-	-	-	-	-	-
	Staph.aureus	-	-	-	-	-	-	-	-
7	TVC	1.85 x10^3	3.81 x10^3	4.46 x10^3	3.90 x10^3	3.25 x10^3	2.97 x10^3	1.80 x10^3	1.91 x10^3
	YMC	-	-	-	-	-	-	-	-
	Coliform	-	-	-	-	-	-	-	-
	Staph.aureus	-	-	-	-	-	-	-	-
14	TVC	1.65 x10^3	3.61 x10^3	4.26 x10^3	3.71 x10^3	3.05.x10^3	2.78 x10^3	1.60 x10^3	1.71 x10^3
	YMC	1	1	3	2	2	2	-	-
	Coliform	-	-	-	-	-	-	-	-
	Staph.aureus	-	-	-	-	-	-	-	-

Values are means ± SD duplicate determinations
Values with different superscript within the same column are significantly different (p<0.05)
Key: 716 = 100 % cow milk (control), 424= 95 % Soymilk + 5 % Moring seed milk; 839= 95 % Bambaranut milk + 5 % Moringa seed milk; 746= 70 % Soymilk + 25 % Bambaranut milk + 5 % Moringa seed milk; 958= 30 % Soymilk + 60 % Bambaranut milk +10 % Moringa seed milk; 469= 45 % Soymilk + 45 % Bambaranut milk + 10 % Moringa Seed milk; 577= 50 % Soymilk +35 % Bambaranut milk + 15 % Moringa seed milk; 985 = 35 % Soymilk + 50 % Bambaranut milk +15 % Moringa seed milk.

However, it is important to note that pathogenic bacteria such as *Staphylococcus aureus* and coliforms were not detected in any of the yoghurt from zero to 14th day of storage. This is in agreement with the study of Sengupta *et al.* [64], where absence of coliform, *Escherichia coli* and *Salmonella* spp were reported in fresh and fortified soy yoghurts at zero time and on 7th day of storage. The absence of enterobacteria signifies the degree of safety of the yoghurt samples as the presence of coliform in food is an indication of fecal pollution, which is of public health concern [81]. Furthermore, starter cultures are widely known for the production of organic acids and other secondary metabolites such as bacteriocins that act against the growth of spoilage and pathogenic bacteria during fermentation [82,83].

3.3. Sensory Attributes of Plant-based yoghurt Produced from Bambaranut, Soy and *Moringa oliefera* Seed Milks for 0, 7 and 14th Day

Table 4 shows the sensory attributes of the yoghurt and Plant-based yoghurt from Bambaranut milk, Soymilk and *Moringa oliefera* seed milk. There was significant difference (p<0.05) in the sensory scores between the samples. Apart from sample 716 (control), there was no significant difference (p>0.05) among the other samples in terms of appearance, aroma, taste, mouthfeel and overall acceptability for zero, 7 and 14th day. There were changes in the sensory characteristics of the yoghurt samples with storage time and this is caused by continuous activity of microorganisms in yoghurt.

The appearance of sample 716 (100 % cow milk) was rated very creamy while Plant-based yoghurt were rated moderately creamy during storage for zero day. The appearance scores decreased progressively as the storage time increased. The scores were highest during the 0 day and lowest values were recorded on the 14th day of storage. The decrease might be attributed to continuous breakdown of molecules of the components by micro-organisms. This observation is in agreement with [77] who reported that the length of fermentation period decreases the perceived characteristic of appearance yoghurt products.

Regarding the aroma, the Plant-based yoghurt were slightly pleasant while the aroma of the whole cow milk was very pleasant. The preference of whole cow milk yoghurt in terms of aroma might be attributed to sources of materials used in the production of the yoghurt-like product. The decreased likeness in terms of aroma might be due to the presences of bitter flavour in the coast of *Moringa* seeds. The sensory scores for aroma for all the samples decreased progressively as the storage time increased.

Furthermore, the study revealed that the sample 716 was rated best in terms of taste followed by sample 577. Sample 716 scored 8.38±0.48 (very sweet) and sample scored 7.35±1.01 (moderately sweet), although, all the Plant-based yoghurt were rated same in terms of taste but were rated slightly lower compared to sample 577. The results showed a marked decrease in the taste as storage time increased. All the samples tasted better during the zero day of storage compared to 7 and 14 day of storage. This finding is similar with those reported by Omueti *et al.* [84] who reported that bambaranut milk significantly (p<0.05) decreased the taste score of Plant-based yoghurt. Hence the findings in this study corroborated with that report.

The sensory scores for mouthfeel showed that sample 716 (100 % cow milk) was rated very thick while Plant-based yoghurt were rated moderately thick in terms of mouthfeel during storage for day 0. The mouthfeel sensory scores decreased significantly (p<0.05) as the storage time increased. The scores were highest during the 0 day and lowest values were recorded on the 14th day of storage. The decrease might be attributed to continuous breakdown of molecule of the components by micro-organisms.

Table 4. Sensory Attributes of Plant-based yoghurt Produced from Bambaranut, Soy and *Moringa oliefera* seed milks

Days	Samples	Appearance	Aroma	Taste	Mouthfeel	Overall Acceptability
0	716	8.45a±0.60	8.30a±0.65	8.38a±0.48	8.20a±0.52	8.50a±0.60
	424	7.25b±1.08	7.10b±0.92	7.05b±0.85	7.20bc±0.75	7.05b±0.98
	839	7.01c±1.31	7.15b±0.98	7.25b±1.09	7.15c±1.63	7.20b±1.23
	746	7.05b±0.95	7.08b±1.23	7.15b±1.31	7.20bc±1.23	7.15b±1.18
	958	7.15b±1.31	7.05b±1.19	7.10b±1.29	7.25bc±1.08	7.25b±1.14
	469	7.10b±1.03	7.09b±1.04	7.00b±1.16	7.30bc±1.30	7.20b±1.18
	577	7.45b±1.08	7.40b±0.85	7.35b±1.01	7.40b±1.07	7.42b±1.18
	985	7.20b±1.16	7.34b±1.08	7.05b±1.05	7.35bc±1.35	7.21b±0.95
	LSD	0.91	0.89	1.02	0.79	1.06
7	716	8.25a±0.60	8.15a±0.63	8.25a±0.510	8.15a±0.51	8.30a±0.72
	424	7.05b±0.82	7.00b±1.01	6.35b±0.98	7.03b±1.18	7.03b±0.83
	839	6.00c±1.08	7.05b±0.78	6.39b±1.05	7.09b±1.35	7.17b±1.31
	746	7.00b±0.96	7.02b±0.97	6.37b±0.99	7.08b±0.89	7.20b±0.81
	958	6.25c±1.08	7.01b±1.12	6.43b±0.88	7.20b±1.14	7.15b±0.93
	469	7.01b±0.88	7.03b±1.03	6.32b±0.97	7.13b±0.93	7.10b±1.09
	577	7.25b±0.68	7.25b±0.88	6.48b±1.09	7.27b±0.91	7.30b±1.01
	985	7.10b±1.07	7.15b±0.91	6.39b±0.99	7.16b±1.12	7.20b±0.85
	LSD	0.98	0.88	1.76	0.86	0.99
14	716	7.39a±0.82	7.20a±0.83	7.35a±0.87	7.10a±0.72	7.20a±0.69
	424	6.20b±0.615	6.06b0.81	4.20bc±0.69	6.09b±0.92	6.00b±0.72
	839	5.85b±0.81	6.09b±0.71	4.05b±0.60	6.07b±0.80	6.20b±0.89
	746	6.09b±0.82	6.05b±0.81	4.20b±0.76	6.05b±0.68	6.24b±0.85
	958	6.25c±0.60	6.03b±0.73	4.20b±0.76	6.09b±0.91	6.30b±0.64
	469	6.08b±0.68	6.08b±1.03	4.05b±0.68	6.10b±0.76	6.09b±0.85
	577	6.30b±0.73	6.10bc±0.69	4.65b±0.93	6.20b±0.76	6.39b±0.76
	985	6.27b±0.68	6.07b±0.71	4.55b±0.94	6.15b±0.72	6.15b±0.81
	LSD	1.08	1.06	2.57	0.89	0.80

Values are means ± SD duplicate determinations
Values with different superscript within the same column are significantly different (p<0.05)
Key: 716 = 100% cow milk (control), 424= 95% Soymilk + 5% Moring seed milk; 839= 95% Bambaranut milk + 5% Moringa seed milk; 746= 70% Soymilk + 25% Bambaranut milk + 5% Moringa seed milk; 958= 30% Soymilk + 60% Bamabaranut milk +10% Moringa seed milk; 469= 45% Soymilk + 45% Bambaranut milk + 10% Moringa Seed milk; 577= 50% Soymilk +35% Bamabara milk + 15% Moringa seed milk; 985 = 35% Soymilk + 50% Bambaranut milk +15% Moringa seed milk

The results of the study showed that sample 716 (100 % cow milk) was liked very much in terms of overall acceptability followed by sample 577 (50 % Soymilk +35% Bambaranut milk +15 % *Moringa* seed milk) which was liked moderately in terms of overall acceptability. Relative to overall acceptability, the product from 100 % cow milk was most accepted followed by sample 577 (50 % Soymilk +35 % Bambaranut milk + 15 % *Moringa* seed milk).

The preference of sample 716 (100 % cow) milk might be attributed to the fact that people are used to the quality attributes of commercially available yoghurts that are usually produced from 100 % cow milk but having Plant-based yoghurt that taste seemingly different might not be acceptable for regular consumers of yoghurt products as they would be marked difference in those attributes.

4. Conclusion

This study revealed that the physicochemical parameters; PV, TSNF, TTA, Total solids, Viscosity and pH of the products formulated from bambaranut milk, soymilk and *Moringa* seed milk were within the acceptable standards for commercial yoghurt products from zero to 14 days of storage. These products were microbiologically stable as TVC and YMC were significantly low and were found to be within the standards specified by NAFDAC and Codex Alimentarium. The absence of pathogenic bacteria such as *Staphylococcus aureus* and Coliform in all the yogurt samples confirmed the safety and acceptability of these products. Plant-based yoghurt produced from bambaranut and soybean partially substituted with *Moringa* seed milk was accepted by panelists, it is interesting to find out that sample 577 (50 % Soymilk +35 % Bamabara milk + 15 % *Moringa* seed milk) is more acceptable than other Plant-based yoghurt. Plant-based yoghurt produced from bambaranut milk, soymilk and *Moringa* seed milk can be stored up to two weeks under refrigeration conditions.

References

[1] Rasic J.L. and Kurmann J. A. (1978). Yoghurt Scientific Grounds, Technology, Manufacture and Preparation. Technical Dairy Publishing House, Denmark.

[2] Bakalinsky A. T., Nadathur S. R., Carney J. R. and Gould S. J. (1996). Antimutagenicity of yogurt. Mutation Research. 350: 199-200.

[3] Chandan, R. C. (2006). History and Consumption Trends In: Chandan R. C. (Ed) *Manufacturing Yoghurt and Fruit Milks.* Blackwell Publishing, Oxford UK. Pp. 3-15.

[4] Adolfsson, O., Meydani, S.N. and Russel, R.M. (2004). Yogurt and gut function. *Am. J. Clin. Nutr.*, 80: 245-256.

[5] Davies K.M., Heaney R.P. and Recker R.R. (2000). Calcium intake and body weight. *J Clin Endocrinol Metab* 85, 4635 – 4638.

[6] Wang H, Livingston, K.A., Fox, C.S., Meigs, J.B., Jacques, P.F.,(2013). "Yogurt consumption is associated with better diet quality and metabolic profile in American men and women", *Nutrition Research*. 33, 18-26.

[7] Atiku, A. A., Aviara, N. A. and Haque, M. A. (2004). Performance evaluation of a bambara groundnut sheller. Agricultural Engineering International: The CIGR *Journal of Scientific Research and Development*. Manuscript P 04002, VI, July, Texas Univ., Houston, USA.

[8] Nwanna, L.C., Enujiugha, V.N., Oseni, A.O. and Nwanna, E.E. (2005). Possible effects of fungal fermentation on Bambara groundnut (*Vigna subterranea* (L.) Verdc.) as a feedstuff resource. J. Food Technol., 3 (4): 572-575.

[9] Okonkwo S.I. and Opara F.M. (2010). The analysis of Bambara groundnut (Voandzeia subterranean (L) thouars) for sustainability in Africa. Research Journal of Applied Sciences 5(6): 394-396, 2010.

[10] Mune, M.M.A., Minka, S.R., Mbome, I.L. and Etoa, F.X. (2011). Nutritional potential of Bambara bean protein concentrate. *Pak. J. Nutr.* 2011, *10*, 112-119.

[11] Alozie Y.E., Mary A.I. and Olajumoke L. (2009). Utilization of Bambara groundnut flour blends in bread production. *J of Food Technol* 7(4):111-114.

[12] Goli A.E. (1997). Bibliographical review. In: Bambara groundnut. Vigna subterranean (L.) Verdc. Proceedings of the workshop on Conservation and Improvement of Bambara Groundnut (Vigna subterranea(L.) Verdc.). Heller J., Begeman F. and Mushonga, J., eds. 14-16 November 1995, Harare, Zimbabwe, pp. 4-10.

[13] Snyder, H.E. and Kwon, T.W. (1987). Soybean Utilization. Van Nostrand Reinhold Company Inc, New York, New York.

[14] USDA-ERS. Foreign Agriculture Service-Commodity Intelligence Report. (2009). Found at http://www.pecad.fas.usda.gov/.

[15] Islam M.S., Fauzia L.A.R. and Parween S. (2007). Oviposition preference of callosobruchus maculatus (f.) To common pulses and potentiality of triflumuron as their protectant. *J. bio-sci.* 15: 83-88.

[16] Serrem, C., Kock, H. and Taylor, J. (2011). Nutritional quality, sensory quality and consumer acceptability of sorghum and bread wheat biscuits fortified with defatted soy flour. *Int. J. Food Sci. Technol., 46:* 74-83.

[17] Glami, S.Y. (2002). Chemical composition and nutritional Level attributes of selected newly developed lines of Processing of Soyabean, (Glycine max (L) Merrill). *Journal of the Science of Food and Agriculture* 82: 1735-1739.

[18] Lui, I. (1997). Chemistry and Nutritional Value of Soyabean Components: *In Soyabean: Chemistry, Technology and Utilization*. Lui K. Champman and Hall; New York 26-113.

[19] Khawaja, T. M., Tahira, M. and Ikram, U.K. (2010). *Moringa oleifera*: a natural gift - A review. *J. Pharm. Sci. Res.* 2:775-781.

[20] Anwar, F. S., Latif, M. A. and Gilani, A. H. (2007). *Moringa oleifera:* a food plant with multiple bio-chemical and medicinal uses- a review. *Phytother. Res.*, 21: 17-25.

[21] Compaoré, W.R., Nikièma,P.A., Bassolé, H.I.N.,A. Savadogo, A., Mouecoucou,J., Hounhouigan D.J. and Traoré , S.A. (2011). Chemical Composition and Antioxidative Properties of Seeds of Moringa oleifera and Pulps of Parkia biglobosa and Adansonia digitata Commonly used in Food Fortification in Burkina Faso. Current Research *Journal of Biological Sciences* 3(1): 64-72, 2011.

[22] Rahman M.M., Sheikh M.M.I., Sharmin S.A., Islam M.S., Rahman M.A., Rahman M.M. and Alam M.F. (2009). Antibacterial activity of leaf juice and extracts of Moringa oleifera Lam. Against some human patho-genic bacteria. Chiang Mai Unversit Journal of Natural Sciences. 8, 219-227.

[23] AOAC (2012). Official Methods of Analysis. 20th edition. Association of Official Analytic Chemists. Washinton D.C.

[24] Kirk, R.S. and Sawyer, R. (1991). Pearson's Composition and Analysis of Foods. Longman Group LTD, UK. 9th edition, Pp.188-189.

[25] Harrigan, W.F. and McCance, M.E. (1990). Laboratory Methods in Food and Dairy Microbiology. Academic Press, London, pp: 210.

[26] Ihekoronye A. I and Ngoddy, P. O (1985). Integrated Food Science and Technology for the Tropics. (2nd ed.) Macmillan Publishers Ltd. London.

[27] WFLO (World Food Logistics Organization) Commodity Storage Manual. (2008). Nuts and Nutmeats. WFLO, Alexandria,VA. http://www.gcca.org/resources/wflo-commodity-storage-manual commodities.

[28] Onwuka, G.I., (2005). Food Analysis and Instrumentation: Theory and Practice. Naphthali Prints, Surulere, Lagos, Nigeria, pp: 30-203.

[29] Ukwo, S. P. (2015). Physicochemical profile and sensory attributes of plain yoghurt from cow and soy milk blends. Nigerian Journal of Agriculture, Food and Environment. 11(2): 20-23.

[30] Ndife J., Idoko F. and Garba R. (2014). Production and quality assessment of functional yoghurt enriched with coconut. *International Journal of Nutrition and Food Sciences.* 3(6): 545-550.

[31] Eke, M. O., Olaitan, N. I. and Sule, H. I. (2013). Nutritional Evaluation of Yoghurt-Like Product from Baobab (*Adansonia digitata*) Fruit Pulp Emulsion and the Micronutrient Content of Baobab Leaves. Advance Journal of Food Science and Technology. 5 (10): 1266-1270.

[32] Donkor, O. N., Henriksson A., Vasiljevic T. and Shah N. P. (2006). Effect of acidification on the activity of probiotics in yoghurt during cold storage. *Int. Dairy J.* 16:1181-1189.

[33] Osundahunsi O.F., Amosu D. and Ifesan B.O.T. (2007). Quality evaluation and acceptability of soy-yoghurt with different colours and fruit flavours. *American Journal of Food Technology, 2: 273-280.*

[34] Falade K.O., Ogundele O.M., Ogunshe A.O., Fayemi O.E., and Ocloo F.C.K. (2014). Physico-chemical, sensory and microbiological characteristics of plain yoghurt from bambara groundnut (Vigna subterranea) and soybeans (Glycine max). *J Food Sci Technol.* 52(9):5858-5865.

[35] Stijepić M., Glušac J., Đurđević-Milošević D. and Pešić-Mikulec D. (2013). Physicochemical characteristics of soy probiotic yoghurt with inulin addition during the refrigerated storage. Rom Biotechnol Lett 18(2): 8077-8085.

[36] Murevanhema Y.Y. (2012). Evaluation of bambara groundnuts (Vigna subterrenea (L.) Verdc.) milk fermented with lactic acid bacteria as a probiotic beverage. M. Tech. Dissertation. Cape Peninsula University of Technology, South Africa, p 183.

[37] Olugbuyiro A.O. and Oseh J.E. (2011). Physico-chemical and Sensory Evaluation of Market Yoghurt in Nigeria. Pakistan Journal of Nutrition, 10: 914-918.

[38] FDA, 2009. Milk and cream products and yogurt products. Food and Drug Administration Federal Register, 74: 2448.

[39] Bristone C., Badau M.H., Igwebuike J.U. and Igwegbe A.O. (2015). Production and Evaluation of Yoghurt from Mixtures of Cow Milk, Milk Extract from Soybean and Tiger Nut. World Journal of Dairy & Food Sciences. 10 (2): 159-169.

[40] Adelodun L. K. and Abiodun O. O. (2012). Effect of Different Concentrations of Coconut Milk on the Chemical and Sensory Properties of Soy-coconut Milk Based Yoghurt. *Food and Public Health* 2(4): 85-91.

[41] Belewu, M.A., Belewu, K.Y. and Bamidele, R.A. (2010). Cyper-coconut yoghurt: preparation, compositional and organoleptic qualities. *African Journal of Food Science and Technology* Vol. 1(1) pp. 010-012.

[42] Khalifa, M.E.A., Elgasim A.E., Zaghloul A.H. and Mahfouz M.B. (2011). Applications of inulin and mucilage as stabilizers in yoghurt production. *Am. J. Food Technol*., 6: 31-39.

[43] Lee SY,Morr CV, Seo A (1990) Comparison of milk-based and soymilkbased yogurt. *J Food Sci* 55(2):532-536.

[44] Rasdhari M., Parekh T., Dave N., Patel V. and Subhash R. (2008). Evaluation of various physico-chemical properties of Hibiscuss abdariffa and L. casein incorporated probiotic yoghurt. Pak J Biol Sci 11: 2101-2108.

[45] Dublin-Green, M. and Ibe, S. N. (2005). Quality Evaluation of Yoghurts produced commercially in Lagos, Nigeria. *African Journal of Applied Zoology and Environmental Biology* 7:78-82.

[46] Zare F., Champagne C.P., Simpson B.K., Orsat V. and Boye J.I. (2012). Effect of the addition of ingredients to milk on acid production by probiotic and yoghurt starter culture. LWT – Food Sci Technol 45:155-160.

[47] Caballero, B. (2003). Encyclopedia of Food Sciences and Nutrition. Academic Press, London, UK.

[48] Faizi S., Siddiqui B. S., Saleem R., Aftab K., Shaheen F. and Gilani A. H. (1998). Hypotensive constituents from the pods of *Moringa oleifera*. Planta Med. 64, 225-228.

[49] Fuglie L.J. (1999). The Miracle Tree: Moringa oleifera: Natural Nutrition for the Tropics. Revised edition. Church World Service, Dakar. p. 68

[50] Fuglie, L.J. (2000). New Uses of Moringa Studied in Nicaragua. ECHO Development. http://www.echotech.org/network/modules.php.

[51] Fuglie, L. J. (2001). Combating malnutrition with Moringa. Pp. 117-136 in J. Lowell Fugile, ed. The miracle tree: the multiple attributes of Moringa. CTA Publication, Wageningen, the Netherlands.

[52] Fahey, J.W., Dinkova-Kostova A.T. and Talalay P. (2004). The 'Prochaska' Microtiter Plate Bioassay for Inducers of NQO1. In:Sies, H. and L.Packer (Eds.), Methods in Enzymology.Chap.14 Elsevier Science,San Diego, CA. CAN, 382(B): 243-258.

[53] Costa-Lotufo, L.V., Khan M.T.H., Ather A., Wilke D.V. and Jimenez P.C. (2005). Studies of the anticancer potential of plants used in Bangladeshi folk medicine. *J. Ethnopharmacol*., 99: 21-30.

[54] Ihemeje A., Nwachukwu C.N. and Ekwe C.C. (2015). Production and quality evaluation of flavoured yoghurts using carrot, pineapple and spiced yoghurts using ginger and pepper fruits. *African Journal of Food Science.* Vol.9(3) pp.163-169.

[55] Makwin D. M., AbigailIfy O. and Habiba D. (2014). An Assessment of the Bacteriological Quality of Different Brands of Yoghurt Sold in Keffi, Nasarawa State, Nigeria**.** Journal of Natural Sciences Research. ISSN 2224-3186 (Paper) ISSN 2225-0921 Vol.4, No.4.

[56] Chimezie G. D., Gloria L. and Ebere I. (2015). Microbiological load of yoghurt sold in Omoku Schools, Rivers State, Nigeria. *African Journal of Microbiology Research.* Vol. 9(34), pp. 1960-1963.

[57] Oyeniyi A.O., Aworh O.C., and Olaniyan J.O. (2014). Effect of Flavourings on Quality and Consumer Acceptability of Soy-Yoghurt. *IOSR Journal Of Environmental Science, Toxicology And Food Technology (IOSR-JESTFT) e-ISSN: 2319-2402, p- ISSN: 2319-2399. Volume 8, Issue 1 Ver. III PP 38-44.*

[58] Balogun M. A., Arise A. K., Kolawole F. L. and Ijadinboyo M. (2017). Effect of partial substitution of cow milk with bambara groundnut milk on the chemical composition, acceptability and shelflife of yoghurt. *Annals. Food Science and Technology.*

[59] Aminigo E.R., Metzger L. and Lehtola P.S. (2009). Biochemical composition and storage of a yoghurt–like product from African yam bean (*Sphenostylis stenocarpa*) *Int J Food Sci Technol.;* 44: 560-566.

[60] Lourens-Hattingh, A. and Viljoen, B.C. (2001). Yogurt as Probiotic Carrier Food. International DairyJournal, 11, 1-17.

[61] El Bakri J.M. and Zubeir I.E.M. (2009). Chemical and microbiological evaluation of plain and fruit yoghurt in khartoum state, sudan. *International Journal of Dairy Science*, 4(1): 1-7.

[62] Codex Alimentarius. (2003). CODEX standard for fermented milks 242- 2003. 2nd ed. Available at: www.codexalimentarius.net/download/standards/400/CXS_243e. pdf (accessed 12/8/2015).

[63] Rodrigues, L.A, Ortolani, M.B.T. and Nero, L.A. (2010). Microbiological quality of yoghurt commercialized in Vicosa, Minas Gerais, Brazil. *Afr. J. Microbiol. Res.*4: 210-213.

[64] Sengupta S., Bhowal J. and Bhattacharyya D.K. (2013). Development of new kinds of soy yogurt containing functional lipids as superior quality food. Annals Biol Res 4(4):144-151.

[65] Loralyn H. L. and Robert T. M. (2009). Microbiological Spoilage of Dairy Products. *Compendium of the Microbiological Spoilage of Foods and Beverages.* Kraft Foods, Inc., 801 Waukegan Road, Glenview, IL 60025, USA. Vol. 10.1007. Pp. 978-1-4419-0826.

[66] Olakunle M. M. (2012). Production and Quality Evaluation of Soy-Corn Yoghurt. *Advance Journal of Food Science and Technology* 4(3): 130-134, 2012.

[67] Kawo A. H., Omole E. M. and Na'aliya, J. (2006). Quality assessment of some processed yoghurt products sold in Kano Metropolis, Kano, *Nigeria BEST Journal* 3(1): 96-99.

[68] Oyeleke S. (2009). Microbial assessment of some commercially prepared yoghurt retailed in Minna, Niger State. Afr. J. Microbiol. Res.3:245-248.

[69] Amakoromo E.R., Innocent-Adiele H.C. and Njoku H.O. (2012). Shelf-life study of a yoghurt-like product from African Yam bean. *Nature Sci*. 2012; 10(5):6-9.

[70] Ifeanyi, V. O., Ihesiaba, E. O., Muomaife, O. M. and Ikenga, C. (2013). Assessment of Microbiological Quality of Yorghurt sold by Street Vendors in Onitsha Metropolis, Anambra State, Nigeria. *British Microbiology Research Journal*, 3(2): 198-205.

[71] MacGraw, H. (1977). *Dairy Milk Substitutes. Encyclopedia of Sci & Tech. (5th ed).* New York: MacGraw Hill Publisher Inc. Vol III

[72] Mbaeyi-Nwaoha, I.E. and Egbuche N.I. (2012). Microbiological evaluation of sachet water and street-vended yoghurt and Zobo drinks sold in Nsukka metropolis. *International Journal of Biology and Chemical Sciences, 6*(4): 1703-1717

[73] Igbabul B.D., Shember J. and Amove J. (2014). Physicochemical, microbiological and sensory evaluation of yoghurt sold in Makurdi metropolis. *African Journal of Food Science and Technology* ((ISSN: 2141-5455) Vol. 5(6) pp. 129-135.

[74] Karagul-Yuceer Y., Wilson J.C. and White C.H. (2001). Formulations and Processing of Yorghurt Affect the Nutritional Quality of Carbonated Yoghurt. *Journal of Dairy Science* 84(3): 543-450.

[75] ICMSF-International Commission on Microbiological Specifications for Foods (1986). Microbial Ecology of Foods, Vol. 1-2. University of Toronto Press, Toronto

[76] Yabaya, A. and Idris, A. (2012). Bacteriological quality assessment of some yoghurt brands sold in Kaduna metropolis. *Afr. J. Microbiol. Res*., 10: 35-39.

[77] Omola, E.M., Kawo, A.H. and Shamsudden. (2014): Physicochemical, sensory and microbiological Qualities of Yoghurts brands sold in Kano Metropolis, Nigerian. Journal BAJOPAS 7(2) 26-30.

[78] Brooks, G. F., Caroll, K. C., Butel, J. S. & S. A. Morse (2004) Jawets, Melnick and Adelberg's Medical Microbiology. 24th edition. McGraw-Hill. Pp 54-55.

[79] Arora, D.R. and Arora B. (2012). Textbook of Microbiology, 3rd editon. CBS Publishers, New Delhi

[80] Abdelhameed K.G. and Elmalt M.L. (2009). Public health hazard of Staphylococcus aureus isolated from raw milk and ice cream in Qena governorate. *Assiut Veterinary Medical Journal*, 55(121): 191-200.

[81] Farinde E.O., Adesetan T.O., Obatolu V.A. and Oladapo M.O. (2009). Chemical and microbial properties of yogurt processed from cow's milk and soymilk. *J Food Proc Preserv* 33(2): 245-254.

[82] Borregaard, E. and Arneborg, N. (1998). Interactions between Lacto-coccus lactis subs. lactis and Issatchenkia orientalis at milk fermentation. *Food Technol. Biotechnol*. 36, 75-78.

[83] Jayeola C.O., Yahaya L.E. and Igbinadolor R.O. (2010). Cocoa powder supplementation in yoghurt production. *J Food Technol.* 2010; 3: 82-85.

[84] Omueti, O., Otegbayo, B., Jaiyeola, O. & Afolabi, O. (2015). Functional properties of beverage developed from Bambaranut, soybean (Glycine Max), groundnut (Arachis Hypogea) and crayfish (Macrobrachium Spp). Electronic Journal of Environmental, Agricultural & Food Chemistry, 8: 563.