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Research Article

Effects of Adding Banana Juice on the Physical, Chemical, and Microbiological Quality of Yogurt

Md. Ridoy Chowdhury[1], Shamsul Morshed[1], Umme Salma Amin[2], Tanzina Hossain[3], A. K. M. Humayun Kober[2*]

[1]Department of Applied Chemistry and Chemical Technology, Chattogram Veterinary and Animal Sciences University (CVASU), Chattogram, Bangladesh

[2]Department of Dairy and Poultry Science, Chattogram Veterinary and Animal Sciences University (CVASU), Chattogram, Bangladesh

[3]Department of Applied Food Science and Nutrition, Chattogram Veterinary and Animal Sciences University (CVASU), Chattogram, Bangladesh

[*]**Corresponding to: A. K. M. Humayun Kober, Professor,** Department of Dairy and Poultry Science, Chattogram Veterinary and Animal Sciences University (CVASU), Chattogram, Khulshi 4225, Bangladesh. E-mail: akmhumayun@cvasu.ac.bd

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Abstract

Objective: Combining the intake of yogurt and fruit has the potential to provide a synergistic effect on health. Banana-stirred yogurt could provide good stuff like probiotics, prebiotics, high-quality protein, essential fatty acids, vitamins, minerals and fiber that have a positive impact on both the cardiovascular and digestive systems. Moreover, taste and flavor can also be enhanced by such modification of yogurt. The objective of the study was to develop banana-stirred yogurt and to assess the physicochemical and microbiological properties of the yogurt.

Methods: Six yogurt samples (T_0, T_1, T_2, T_3, T_4, and T_5) were prepared using different concentrations (0, 1%, 3%, 5%, 7%, 8%) of Banana juice. Sensory analysis (using 9-point hedonic scale), Physicochemical (titratable acidity, total soluble solids (TSS), moisture, ash, crude fiber, protein, fat, and mineral contents), microbiological (total viable count (TVC) and coliform) properties were measured to assess the quality of the developed yogurt.

Results: In sensory analysis, T_3 yogurt is significantly (P<0.05) preferred superior by the panelists. Considering the physicochemical properties, fat, crude fiber, protein, soluble solids and iron were found significantly (P<0.05) higher in T_5, whereas T_4 contains the maximum amount of titratable acidity and ash. Magnesium and potassium were found in the highest amount in sample T_1 and T_2 respectively. No coliform was found in these samples and the lowest amount of TVC was measured in sample T_5 while assessing the microbial characteristics.

Conclusion: Finally, incorporating bananas in yogurt can be proposed as a nutritive one to fulfill the

dietary requirement and a refreshing diet in our day-to-day life.

Keywords: banana juice, microbial analysis, physicochemical analysis, sensory analysis, yogurt

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1 INTRODUCTION

Yogurt is an acidified, custard-like semisolid dairy product that has been a popular diet food for thousands of years. It is usually prepared from the milk of several domestic milk-producing animals including cows, sheep, goats, buffalo, and camels[1]. The bacteria used to make yogurt are called "yogurt cultures", which convert lactose to produce lactic acid. Mainly, *Lactobacillus bulgaricus* and *Streptococcus thermophilus* are the two species involved in the aging of yogurt in combination with various other dairy ingredients like cream, milk, and skim milk[2]. Different types of yogurts are available worldwide according to flavor and texture and are continuously expanding and evolving[3]. Yogurt is considered a nutrient-dense food due to exceeding dietary esteem like essential amino acids, vitamin D, vitamin B_6, vitamin B_{12}, riboflavin, and calcium[4]. Consumption of yogurt helps to improve the overall quality of the diet and it is recommended for people with diseases like irritable bowel syndrome, inflammatory bowel disease, and lactose intolerance[5,6]. Studies have shown that yogurt is considered a probiotic, which enhances digestion, metabolic health, and immunity, and can prevent a carcinogenic response or delay the onset of cancer in the body[7]. Yogurt is a good source of natural protein and is tolerated by people with lactose malabsorption. It also reduces vaginal infections and strengthens collagen in the skin[8].

Flavoring of yogurt is a popular concept of value addition and is achieved by incorporating natural or artificial flavors and colors. Fruit-stirred yogurt seems to be a healthy diet as it contains minimal added sugar and no artificial sweeteners, color, or preservatives. Banana, a popular tropical fruit, is one of the financially important fruit crops grown in Bangladesh both in residence and commercial farms. *Musa paradisiaca* (*M. paradisiaca*) and *Musa sapientum* (*M. sapientum*) are mainly cultivated in the tropical and subtropical regions and are widely utilized because of their nutritional value worldwide[9]. Traditional uses of the fruit of *M. paradisiaca* and *M. sapientum* include the treatment of diarrhea (unripe), dysentery, intestinal damage in ulcerative colitis, diabetes (unripe), sprue, uremia, nephritis, gout, hypertension, and cardiac disease[10]. Tryptophan, indole compounds[11], and pectin have been found in banana pulp. Serotonin, nor-epinephrine, tryptophan, indole compounds, tannin, starch, iron, crystallizable and non-crystallizable sugars, vitamin C, vitamin B, albuminoids, lipids, and mineral salts were also found in the pulp of *M. paradisiaca* and *M. sapientum*[12]. So, in a nutshell, banana fruit has numerous medicinal and functional properties if we can utilize it to our utmost.

Fruits and yogurt have been recognized as indications of a healthy diet for a long time. Banana, for instance, is high in iron, antioxidants, prebiotic fibers, and polyphenols, all of which can help with digestive health. Yogurt contains milk protein, calcium, magnesium, vitamin B_{12}, and conjugated linoleic acid that results in the best assembly of nutrients in such a food. It also includes helpful bacterial cultures, making it a possible probiotic source. Consumption of yogurt and banana together may offer probiotics, prebiotics, high-quality protein, essential fatty acids, and a mix of vitamins and minerals that may have synergistic benefits on the body. Consuming yogurt has been connected to less weight gain and a lower prevalence of type-2 diabetes, whereas eating fruits has been linked to a decreased risk of cardiovascular disease[13]. Yogurt and fruits can be consumed together and may provide additional health advantages due to the actions of prebiotics and probiotics. Given the positive cardio-metabolic effects of fruit and yogurt, as well as their link to healthy dietary patterns, initiations had been taken to produce this yogurt by adding banana juice, which can provide us with calcium, iron, phosphorus, fiber, protein, and a diet that has a positive impact on both the cardiovascular and digestive systems. Hence, the present research was undertaken to develop banana-stirred yogurt enriched with dietary fiber, potassium, iron, and magnesium and to assess the physicochemical and microbiological properties of the prepared product.

2 MATERIALS AND METHODS

2.1 Statement of the Experiment

The experiment was carried out at different laboratories namely Applied Chemistry and Chemical Technology, Food Processing and Engineering, Dairy and Poultry Science, Physiology, Biochemistry and Pharmacology, Animal Science and Nutrition Department and Poultry Research & Training Centre (PRTC) of Chattogram Veterinary and Animal Sciences University (CVASU), Bangladesh from July to December 2022.

2.2 Sample Collection

Yogurt culture, fresh ripe bananas, and grocery items (milk, sugar and cups) were collected from the nearby local market in Chattogram. Other materials and chemicals were collected from laboratory stocks.

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Table 1. Sensory Evaluation of Banana Stirred Yogurt

Groups	Appearance	Taste	Smell	Texture	Overall Acceptability
T_0	8.00±0.70^a	7.20±0.44^a	7.60±1.14^a	7.60±0.89^{ab}	8.00±0.70^a
T_1	7.80±0.44^a	7.00±0.00^a	6.80±0.83^a	7.40±1.14^{ab}	7.20±0.44^{ab}
T_2	6.80±0.83^a	6.80±0.83^a	7.00±0.70^a	7.80±0.83^a	7.00±0.70^{ab}
T_3	7.00±0.70^a	7.80±0.83^a	7.80±1.30^a	8.00±1.00^a	7.60±0.55^a
T_4	7.00±0.70^a	6.80±1.92^a	6.80±1.48^a	7.00±0.70^{ab}	7.00±1.22^{ab}
T_5	6.80±0.83^a	5.40±1.95^a	5.80±1.79^a	5.80±1.09^b	5.80±1.09^b

Notes: Mean ± SD and values in the same column with different superscripts are significantly different (P<0.05).T_0: Yogurt without adding banana puree (Control), T_1: Yogurt with 1% banana puree, T_2: Yogurt with 3% banana puree, T_3: Yogurt with 5% banana puree, T_4: Yogurt with 7% banana puree, T_5: Yogurt with 8% banana puree.

2.3 Formulation of Banana Stirred Yogurt

At first, the banana puree or juice was prepared by blending the banana and then preserved in a fresh container. After filtration, milk was heated with continuous stirring until it reduced to approximately 30-40% of its original volume. Then, it was allowed to cool down to 40°C, followed by the addition of 1.5% mixed culture (yogurt) and 10% table sugar (w/v) to the milk and then mixed the mixture properly. Further, six different samples (T_0, T_1, T_2, T_3, T_4, T_5) were prepared with the requisite amount of banana puree (v/v). T_0 (No Banana Puree), T_1 (1% Banana Puree), T_2 (3% Banana Puree), T_3 (5% Banana Puree), T_4 (7% Banana Puree), T_5 (8% Banana Puree) was summed up with the milk and stirred properly so that there exists no clot. Then the solution were poured into clean cups and incubated at 37°C for 12h. Finally, the cups of yogurt were placed at around 2°C in the refrigerator for preservation.

2.4 Sensory Analysis

The sensory characteristics of the developed banana-stirred yogurt samples were evaluated by the panel experts following the method described by Ackbarali et al.[14] using "9-point hedonic scale".

2.5 Physicochemical Analysis of Banana Stirred Yogurt

The developed yogurt was analyzed for titratable acidity, total soluble solids (TSS), moisture, ash, crude fiber, protein, fat, and mineral contents. All the determinants were done in triplicates and the results were expressed as the average. The acidity percentage was determined following the procedure described by AOAC[15]. The TSS of the prepared yogurt sample was measured by using a hand refractometer. The value obtained was presented as degree brix or the percentage of total soluble solids. The developed yogurt samples were tested for proximate analysis to determine moisture (%), ash content, crude fiber (CF%), and crude protein (CP%)[15]. Fat determination was conducted according to the literature of Majhenič[16].

2.6 Determination of Mineral Content

The mineral contents (iron, magnesium, potassium) were determined by spectrophotometer (Humalyzer 3000). 1g of properly mixed yogurt sample was digested by adding 7mL of concentrated nitric acid and 3mL of perchloric acid to the solution and heated at 200°C for 1-2h. After cooling, samples were transferred to a volumetric flask and diluted up to 100mL mark with distilled water. Finally, the required amount of solution was transferred to Eppendorf tube for mineral quantification[17,18].

Iron was determined according to Okoduwa[19] and El-Alameey[20]. The determination of magnesium[21] and potassium[22,23] was done following a specific procedure.

2.7 Microbial Analysis

For microbiological analysis, MRS agar was used to determine total viable count (Lactic Acid Bacteria)[24] and the count was done after the incubation for 48h at 37°C. Coliform count were determined by the methods described in the "Standard Methods for Examination of Dairy Products" published by APHA[25]. The microbial counts were expressed in log cfu/gm.

2.8 Cost Analysis

In this study, cost analysis was made for the batch of 10 cups of yogurt for each sample.

Costing consists of the followings:

Average costing for a cup $= \frac{A+B+C}{D}$

A: Raw materials (milk, sugar, banana)

B: Culture

C: Processing cost

D: Total sample in a batch (10)

Considering: Milk: 80bdt/liter, Banana: 10bdt (100gm/piece), Culture: 35bdt/120mL, Sugar: 80bdt/kg, Cup with lid: 4bdt/ per piece

2.9 Statistical Analysis

Data obtained in this study was analyzed with Minitab version 21.3.1 and Microsoft Excel 2010. The mean and standard deviation of the data were calculated. One-way analysis of variance (ANOVA) was done and their statistical significance (P<0.05) was carried out by Tukey's pairwise comparison.

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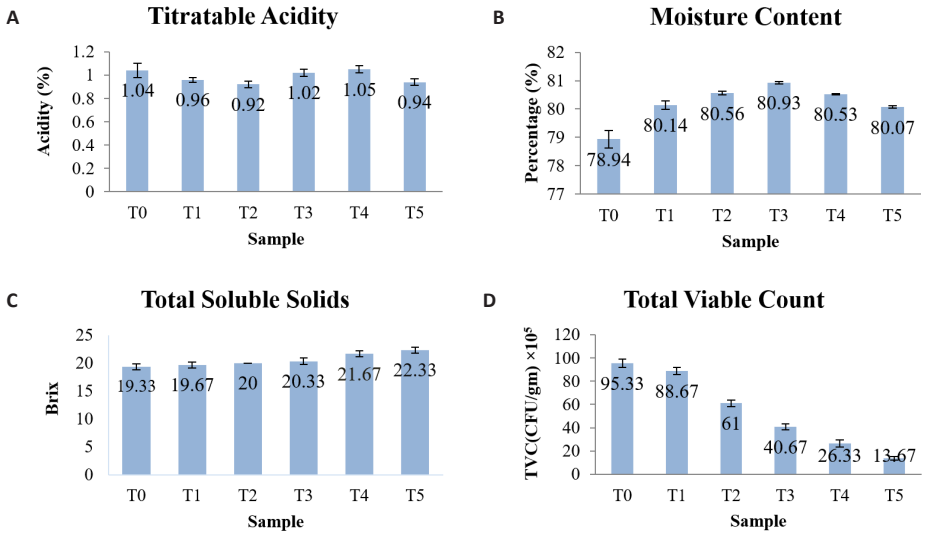

Figure 1. Physicochemical characteristics of yogurt. A: Titratable acidity of the developed yogurt on day 1; B: Moisture content of the developed yogurt; C: Total Soluble Solids of the developed yogurt; D: Total Viable Count of the developed yogurt.

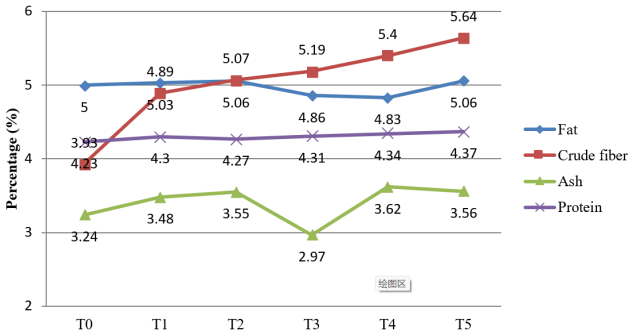

Figure 2. Proximate composition (Fat, Crude fiber, Ash, Protein) of the developed yogurt.

3 RESULTS

3.1 Sensory Analysis

In our study, the highest score (8.00±0.70) obtained in both appearance and overall acceptability in case of control (T_0), whereas (T_5) was the lowest. T_3 got the maximum point in taste (7.80±0.83), smell (7.80±1.30), and texture (8.00±1.00). T_5 got the lowest marks in all the segments. Again, no significant difference was observed among the samples in such parameters as appearance, taste and smell. Considering the texture, a significant difference (P<0.05) was found between T_5 and the pair of T_2 and T_3. Additionally, no significant difference was observed among the sample except T_5, as it showed differences (P<0.05) with control (T_0) and sample T_3 while judging the overall acceptability. (Table 1)

3.2 Physicochemical Properties of Banana Stirred Yogurt

Titratable acidity and total soluble solids are two of the important parameters of the physicochemical characteristics of yogurt. From Figure 1A, it can be seen that T_2 had the lowest acidity value at 0.92±0.03%, while T_4 had the highest with 1.05±0.03%. T_0 (19.33±0.57%) and T_5 (22.33±0.57%) had the respectively lowest and highest amount of total soluble solids among the samples. See Figure 1C.

3.3 Proximate Composition

Among the samples, T_0 had the lowest amount of crude fiber (3.93±0.00%) and protein (4.23±0.05%), while T_5 had the highest with 5.64±0.03% and 4.37±0.00% respectively. Additionally, all the samples were significantly different from one another (P<0.05) considering the crude fiber.

Considering the fat, T_2 and T_5 had the highest with 5.06±0.06% and T_4 was the lowest with 4.83±0.06%. T_4 (3.62±0.04) and T_3 (2.97±0.11) had the highest and lowest percentage of ash respectively. Moreover, T_0 and T_3 were significantly (P<0.05) different from the remaining samples while judging the ash percentage. See Figure 2.

Lastly, there remained significant difference among T_0, T_3 and T_5, while T_0 had the least amount of moisture (78.94±0.31%), whereas T_3 had the most (80.93±0.04%). See Figure 1B.

3.4 Mineral Contents

Among the samples, there was a gradual increase in the amount of iron except T_3, where T_5 had the highest amount of iron with 187.60±4.86μg/dL, and control had the lowest (71.17±5.01μg/dL). There was no significant difference between T_2 and T_3, but a difference (P<0.05) was found among the remaining samples.

A minimum amount (0.26±0.02mg/dL) of magnesium was obtained from the control and a maximum (1.51±0.07mg/dL) from T_1. T_3 and T_4 showed no significant difference, but the rest others showed differences (P<0.05) among themselves. Considering the potassium, no significant difference prevailed among them, just the difference was between T_2 and T_5. Moreover, T_5 had the least amount (5.00±0.00mmol/dL) of

Table 2. Mineral Contents of Banana Stirred Yogurt

Sample	Iron (μg/dL)	Magnesium (mg/dL)	Potassium (mmol/dL)
T_0	71.17±5.01^{e}	0.26±0.02^{e}	5.33±0.57^{ab}
T_1	105.50±3.31^{d}	1.51±0.07^{a}	6.67±1.52^{ab}
T_2	138.77±3.40^{c}	1.31±0.02^{b}	7.33±0.57^{a}
c_3	134.33±4.42^{c}	0.63±0.03^{d}	5.33±0.57^{ab}
T_4	161.63±4.45^{b}	0.54±0.01^{d}	5.67±0.57^{ab}
T_5	187.60±4.86^{a}	1.15±0.06^{c}	5.00±0.00^{b}

Notes: Mean ± SD and values in the same column with different superscripts are significantly different (P<0.05).T_0: Yogurt without adding banana puree (Control), T_1: Yogurt with 1% banana puree, T_2: Yogurt with 3% banana puree, T_3: Yogurt with 5% banana puree, T_4: Yogurt with 7% banana puree, T_5: Yogurt with 8% banana puree

potassium, whereas T_2 had the highest (7.33±0.57mmol/dL). See Table 2.

3.5 Microbial Analysis

Among the samples, control (T_0) showed the highest number of colony-forming unit/gm with 95.33±3.51×10^5 and T_5 contained the lowest (13.67±1.52×10^5), illustrated in Figure 1D. There was no significant difference between the control and T_1 regarding total viable count (TVC), but except for the pair, there was a significant (P<0.05) difference among the samples. No coliform was identified in the samples till 2 weeks.

3.6 Cost Analysis

Considering the raw material and processing cost, the average cost for a cup of: T_0=16.2bdt, T_1=16.1bdt, T_2=16.1bdt, T_3=16bdt, T_4=16bdt, T_5=16bdt.

4 DISCUSSION

4.1 Sensory Analysis

In sensory analysis, control (T_0) was liked (8.00±0.70) most by the panelists, while 7.80±0.44, 6.80±0.83, 7.00±0.70, 7.00±0.70, 6.80±0.83 were the score of the sample T_1, T_2, T_3, T_4 and T_5 respectively, while considering the appearance. Study of Roy et al.[26] supported our findings as control got the highest point (8.50) and yogurt with highest percentage of banana (20%) got the lowest (8.14) and a significant difference was found between the control and yogurt sample of 15% banana pulp. On the other way, variation was observed while considering the flavor or smell, as a gradual increment (8.70<8.89<8.97<9.00) was observed with the addition of banana (0%, 5%, 10%, 15%) in the yogurt prepared by Roy et al[26]. But from our study, in terms of smell, T_3 got the highest (7.80±1.30) preference, while T_5 was the lowest (5.80±1.79). A sweet aroma was created by the particular amount of banana puree, mainly in T_3 which was preferred much more than the control. Here, no significant difference was found among the samples. Same as for smell, the texture of T_3 had the highest preference (8.00±1.00) and T_5 was the lowest (5.80±1.09). Moreover, a significant difference was found between the samples of T_5 with T_2 and T_3. Considering the overall acceptability, control (T_0) and T_5 got the highest (8.00±0.70) and lowest (5.80±1.09) preferences respectively. T_5 has a bitter taste and pungent smell compared to the variations. Moreover, significant differences were found between T_0 and T_3 with the sample T_5, and Roy et al.[26] found that the addition of banana pulp resulted in gradual decrease in overall acceptability (8.80>8.79>8.69>8.65) which supported our findings.

4.2 Physicochemical Properties of Banana Stirred Yogurt

Being an acidic food, titratable acidity is one of the major parameters of the physicochemical properties of our developed banana stirred yogurt. From our study, it was found that there was a bit of ups and downs in the titratable acidity of our developed product. The highest percentage of acidity (1.05±0.03%) was found in T_4, whereas T_2 (0.92±0.03%) was the lowest. Both the values exceeded the acidity range (0.55-0.69) from EI-Bialy et al.[27], but within the acidity range (0.88-1.22) done by Islam et al[28]. The primary cause of the increase in acidity in yogurt is the lactic acid bacteria found in yogurt cultures, which convert lactose to lactic acid. Fruit juice addition may have sped up the milk's fermentation process[29].

TSS increased with the addition of banana concentration as the TSS content of banana stirred yogurt ranged between 19-23%, whereas EI-Bialy et al.[27] found the range of TSS of their developed yogurt was 14.50-20.09% and Islam et al.[28] described the range between 20.67-23%. So, no such difference was observed from the data of Islam et al.[28] TSS increased gradually due to the increase of bananas in every next consecutive sample and the addition of sugar and heating, which reduced the volume of milk to around 65-70%.

Among the samples, control (T_0) had the least (78.94±0.31%) amount of moisture content, and T_3 had the highest (80.93±0.04%). Islam et al.[28] found that the moisture of banana-stirred yogurt was (77.00-79.33%). Although the moisture content was around the range, it minimally differed from our findings. According to Shiga et al.[30] increment of moisture content of the yogurt sample comes from the soluble fiber of banana, which has moisture absorbing ability. There was a significant difference among the samples of T_0, T_3, and T_5.

Considering the fat, samples T_3 and T_4 are significantly different from the others. T_2 and T_5 yogurt samples had the highest percentage of fat at 5.06±0.06% and the lowest (4.83±0.06%) in T_4, which was a bit high (4.45-4.7%) compared to a previous study[28]. In this study, fat percentage increased to a certain concentration and then decreased. The reduced proportion of fat in bananas is

the explanation behind this. The decrease in fat during storage seems to be brought on either by the acidic pH that developed during storage or by the lipolytic activity of microflora. Nonetheless, due to the low storage temperature, no rancidity was noticed[31].

Abdalla et al.[32] stated that the fiber increased with the increasing amount of dried banana powder compared to the control. Our study agreed with that as the control had 3.93±0.00% fiber and 5.64±0.03% was present in the yogurt sample T_5, but the values were higher than the study done by Abdalla et al.[32]. A significant difference was also present in all samples.

A significant difference was found in ash content among the samples namely the yogurt sample of T_0 and T_3, with the remaining samples. The highest (3.62±0.04%) and lowest (2.97±0.11%) ash were found in the T_4 and T_3 sample respectively. Gradual increase was seen among most of the samples as banana contains a good amount of minerals. However, the amount of ash content was a bit lower than the findings done by Islam et al.[28], as they found the value between (3.33-6.89%).

The protein content of yogurt significantly increased with the increase of the added banana puree. The highest and lowest values of the protein content of these value-added yogurts were 4.37±0.00% and 4.23±0.05% for the treatments of T_5 and T_0 respectively, which was similar with another study[28]. This investigation yielded different results from Mustafa (1997) and Desai et al., who discovered that plain dahi had more protein than fruit dahi. The reduced proportion of protein found in bananas is the explanation behind this. Bananas partially substitute milk, thus the proportion of protein in the blended drink is lower than in regular dahi[31,33].

4.3 Microbial Analysis

A gradual decrease of microbial population was obtained the samples. The development of acidity may be the cause of this decline[34]. It is observed that during the first few days of storage, the total bacterial counts of all samples grew, and then steadily declined until the conclusion of the storage period. Among the samples, control demonstrated the highest number of cfu/gm with $95.33\pm3.51\times10^5$, while T_5 contained the lowest ($13.67\pm1.52\times10^5$), which was much lower than the TVC count reported by EI-Bialy et al.[27]. There was no significant difference between the control and T_1, but except for the pair, all the remaining samples were significantly different. On the other hand, no coliform was identified in the samples after 14 days of storage period.

4.4 Mineral Contents

We incorporated bananas in yogurt to make some fortifications in mineral compositions. From the Table 2, we have seen a gradual increase in the amount of iron that comes from the incorporation of banana, whereas the value ranged from 105-187μg/dL. On the other hand, magnesium didn't show a sequential approach, as it went high (1.51±0.07mg/dL) for the sample T_1 and became low for the control (0.26±0.02mg/dL), and the magnesium content somehow fluctuated due to the addition of banana puree. For potassium, it was highest for the sample T_2 (7.33±0.57mmol/dL) and lowest for T_5 (5.00±0.00mmol/dL). Bananas are high in essential nutrients like potassium which is a vital mineral. So, banana-stirred yogurt can be a wholesome snack choice for all age groups individuals.

5 CONCLUSION

The banana-stirred yogurt was developed to provide a portion to fulfil the daily nutritional requirement. It was found that the T_3 (5% banana juice) yogurt is preferred mostly in sensory characteristics, whereas integration of banana juices of 8% (T_5) results in an elevation of nutritional facts (fat, crude fiber, protein, soluble solids and mainly iron). TVC was gradually decreased with the addition of banana juice. The most important thing of this study is the low-cost modification of plain yogurt to incorporate bananas and to provide much more nutritional increment without any complex procedure. So, it can be highly demandable if the consumers allow it in their diet considering its nutritional parameters and cost efficiency.

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Conflicts of Interest

The authors declared no conflict of interest.

Author Contribution

Chowdhury MR conducted the planning, accomplished the analytical tasks and wrote the article. Kober AKMH and Morshed S supervised the project and revised the papers for important intellectual content, Amin US and Hossain T were employed in supervising the methods of the study and assisting analytical tasks respectively. Finally, all authors approved the final version.

Abbreviation List

TSS, Total soluble solids
TVC, Total viable count

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