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Utilization of Jackfruit as a Potential Supplement in Yoghurt and Evaluation of Its Nutritional and Commercial Aspects

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Abstract

This study aimed to formulate fruit juice yoghurt by incorporating nutritious and flavorful jackfruit juice, known for its health benefits. Jackfruit juice was added at different levels (5%, 10%, and 15%) to yoghurt, and various chemical, microbiological, bioactive compounds, and sensory quality characteristics were analyzed. Statistical analysis revealed that panelist acceptability decreased with increasing fruit juice level. Among the samples, yoghurt with 10% jackfruit juice showed significantly different sensory characteristics compared to 5% and 15% jackfruit juice yoghurt, while 5% jackfruit juice yoghurt was similar to plain yoghurt. Chemical analysis indicated increased total solids and acidity with jackfruit juice incorporation, while protein and fat content decreased. Microbiological quality remained acceptable, with microbial counts reduced due to the high acidity of jackfruit juice. The research focused on assessing yoghurt using different levels of jackfruit juice, conducting analyses encompassing proximate composition, sensory attributes, microbial contents, bioactive compounds and mineral contents of the resulting product. To establish their significance level at P<0.05, the results were compared using one-way analysis of variance (ANOVA). The study's results indicated significant variations (P < 0.05) among the prepared yoghurt, encompassing moisture (ranging from 65.39% to 68.32%), total solid (31.37%–34.06%), carbohydrate (19.24%–22.85%), protein (4.06%–4.41%), fat (6.32%–7.13%), ash (0.83%–0.89%), acidity (0.94%–1.12%), and ph (4.37%–4.48%) content, as well as sensory characteristics , microbial contents (TVC, TCC, and TFC) and mineral contents (Potassium, Iron, and Phosphorus) highlighting the diverse nutritional and sensory attributes of different yoghurt samples. The total flavonoid content in jackfruit juice (11.441 mg/QE 100 gm) and (1.077 mg/QE 100 gm) in yoghurt (milk + 10% jackfruit juice). The total polyphenol content in jackfruit juice (0.04467 mg GAE/100 gm) and (0.0373 mg GAE/100 gm). Both samples displayed comparable antioxidant capacities. The sensory analysis revealed notable distinctions among the yoghurt samples in terms of color, taste, texture, appearance, and overall acceptance. Overall, the findings suggest that yoghurt can be successfully prepared by adding different proportions of jackfruit juice with milk, with 10% jackfruit juice yoghurt showing slightly better taste due to its higher acid content.

Keywords: Yogurt, jack fruit juice, milk, organoleptic test, microbial test

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INTRODUCTION

"Jackfruit" is the official name of Bangladesh's national fruit. Many tropical countries rely on it as a major fruit crop, including the Philippines, Malaysia, Indonesia, Burma, Sri Lanka, and

Bangladesh. Jackfruit is the third most cultivated fruit and the second highest in output in Bangladesh. There are 25,110 hectares of land dedicated to cultivating jackfruit, with an annual production of 469,500 tons. The mature fruit of the jackfruit is delicious, but the seed is much more popular as a treat or ingredient in Asian cooking. Jackfruit flour is used for baking, while jackfruit seeds are used in meals that are called for cooking. The seeds of jackfruit are rich in carbohydrates. As a vegetable, ripe jackfruits are great in salads and curries. When ripe, jackfruit may be eaten raw or cooked in creamy coconut milk for a delicious snack, or it can be made into candied jackfruit or edible jackfruit leather. As a delicacy, the seeds are boiled in sugar in India [1]. More processing is done with jackfruit. Some things that can be made from dried jackfruit pulp are jackfruit chips and jackfruit leather. Candies, fruit rolls, marmalades, and ice cream are all made from jackfruits. Innovations in processing technologies have paved the way for new products in many different industries, including canning. Modern jackfruit products may be preserved using techniques, such as vacuum-frying, freeze-drying, and cryogenic processing [2]. There is medicinal use for the jackfruit tree, and the timber industry relies heavily on its wood. Jackfruit, scientifically known as *Artocarpus heterophyllus*, is the second most significant fruit in Bangladesh, accounting for around 17% of the country's total fruit production, following bananas. Jackfruit trees are abundant in the wild in districts, such as Tangail, Mymensingh, Dhaka, and nearby forest margins. Jackfruit juice is high in carbohydrates and serves as an excellent medium for fermentation [3]. The food item has a variety of nutrients like fat, dietary fiber, protein, calcium, vitamin A, vitamin C, thiamin, riboflavin, niacin, vitamin B6, folate, and more. Bangladesh serves as a secondary center of diversity for jackfruit, indicating that the crop was originally domesticated in another location and later transported to Bangladesh, where it underwent further diversification. With its widespread cultivation, culinary versatility, nutritional richness, and historical significance, jackfruit emerges as a vital component of tropical agriculture, serving as a symbol of cultural heritage and economic prosperity across nations like Bangladesh and beyond.

Studies have shown that acidic milk is more easily absorbed than regular milk. Yoghurt can be therapeutically beneficial for people who commonly have stomach and intestinal issues. This concept is based on the idea that acid-producing bacteria and lactose in milk can create an environment in the intestines that inhibits the growth of harmful bacteria, therefore preventing gas generation and a condition called autointoxication [4]. Fermented milk products offer many health benefits due to their lactic acid bacteria concentration. Experimental data suggest that lactic acid bacteria may have a beneficial impact on preventing colon tumor growth. Various health benefits include enhanced lactose digesting, diarrhea prevention, immune system regulation, and lowering of serum cholesterol. Fermented milk products are generally safe due to their high acidity, which prevents the growth of disease-causing organisms. However, they can still be contaminated with molds and coliforms. Yoghurt, a popular fermented milk product in Bangladesh, is typically made in mud pots using cow milk, and occasionally buffalo milk. The bacteria utilized are Lactobacillus bulgaricus, Lactobacillus plantarum, and either Streptococcus thermophilus or Streptococcus lactis. Yoghurt preparation necessitates a lower temperature range of 37–42°C and an extended incubation period of 8–15 hours. Yoghurt output from milk in this subcontinent is approximately 7% in India, 4–5% in Pakistan, and Bangladesh [5].

Fortified yoghurt is yoghurt that is produced with several types of fruit juice like strawberry, mango, orange, grape, and so on. This type of yoghurt is typically made with a combination of Streptococcus lactis, Streptococcus diacetilactis, and Streptococcus cremoris cultures. Alternatively, a more fragrant and sweet yoghurt can be achieved by substituting Lactobacillus planetarium for Streptococcus citrofilus. Adding juice enhances the quality and taste of the yoghurt, while also improving the individual fruit flavor utilized.

Jackfruit is rich in protein, carbohydrates, calcium, and thiamine. The product includes Vitamin C, which functions as an antioxidant, protecting the body from free radicals and enhancing the immune system. The plant is a rich source of phytonutrients such lignans, isoflavones, and saponins, which provide health benefits, such as anticancer, antihypertensive, antiulcer, and antiaging qualities. Phytonutrients in jackfruit can inhibit cancer cell growth, reduce blood pressure, combat stomach ulcers, and slow down cell degradation for youthful skin. Carotenoids found in jackfruit are crucial in preventing several chronic degenerative diseases like cancer, inflammation, cardiovascular disease, cataracts, and age-related macular degeneration [6].

Jackfruit contains phenolic chemicals that act as antioxidants and prevent the fast oxidation of milk fat. Milk is an agricultural commodity that is produced in enormous quantities but often spoils due to inadequate processing and preservation methods. A balanced diet is very desirable. A substantial portion of milk can quickly become disfigured due to the oxidation of milk fat, leading to rancidity. Currently, a variety of milk products are being introduced in both local and global markets. Yoghurt is the most preferred milk product among these options. Yoghurt is a nutritious and delightful food known for its strong nutritional and therapeutic benefits [7].

AIM AND OBJECTIVES

Aims

This study focuses on creating jackfruit yoghurt and assessing its acceptability among consumers. This will enhance understanding of processing and using jackfruit, thus decreasing postharvest losses. Enhancing the product’s value will encourage extensive use of jackfruit nutrients. Post-harvest processing will boost the demand for jackfruit, leading to higher output in current growing areas and potential introduction to new areas. Therefore, consuming more processed jackfruit products will enhance the nutritional and health advantages for the Bangladeshi population year-round. Individuals involved in the jackfruit industry will increase their earnings by working and selling products. This will help enhance household food security and livelihood [8].

Objectives

1. To determine physiochemical qualities of jackfruit yoghurt.
2. To evaluate the sensory qualities and customer acceptance of the formulated yoghurt.
3. To evaluate bioactive properties (total fecal coliform (TFC), total phenolic content (TPC)) and antioxidant properties of jackfruit pulp and jackfruit yoghurt.
4. To reduce the postharvest loss of yoghurt.

MATERIALS AND METHODS

Study Area

The study took place from July 2023 to December 2023. The investigation took place in various departments at Chattogram Veterinary & Animal Sciences University (CVASU), including the Department of Applied Chemistry and Quality Assurance, Department of Food Processing and Engineering, Department of Physiology, Biochemistry and Pharmacology, Department of Microbiology and Veterinary Public Health, and the Poultry Research and Training Centre [9].

Sample Accumulation

Three fresh ripe jackfruits (*Artocarpus heterophyllus*) were bought at Reazuddin Bazar, New Market, Chattogram. Milk, sugar, and curd (for starter culture) were bought at Khulshi Mart, located in West Khulshi, Chattogram. The plastic cup and lid were bought from RFL Plastic in Pahartoli, Chattogram. Food grade reagents and chemicals were acquired from the Department of Applied Chemistry & Chemical Technology at CVASU.

Methods

Study Design

The entire study was divided into three major categories: production jackfruit of Yoghurt, nutritional evaluation of jackfruit and jackfruit yoghurt, developing a new variety food product by using jackfruit. A purposive sample method was employed to select a fresh, ripe jackfruit from Reazuddin Bazar to ensure high-quality fruits. Three jackfruits were gathered and turned into yoghurt, while the rest of the fresh sample was saved for additional examination. Crude protein, moisture content, dietary fiber, crude fat, ash content, carbohydrate, minerals content, pH, bioactive properties, minerals (iron, potassium and phosphorus) were determined of jackfruit and jackfruit yoghurt. A new variety of food products was developed by using jackfruit. In this study Statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS) program.

Preparation of Jackfruit Juice Yoghurt

The milk was initially heated to 70℃ for 15–30 minutes. After adding sugar, the mixture was heated to around 80℃ and concentrated by lowering its original volume to one third of the original milk volume through continuous stirring for 5 minutes. Additionally, jackfruit juice was added in different proportions: 5%, 10%, and 15%. Previous inoculation enhanced the nutritional quality of yoghurt, resulting in a product with improved texture and consistency. Four types of products were created using different combinations of milk and jackfruit juice: A (milk with 0% jackfruit juice), B (milk with 5% jackfruit juice), C (milk with 10% jackfruit juice), and D (milk with 15% jackfruit juice). The mixtures were cooled in containers filled with cold water, inoculated with a spoon of yoghurt, and kept at a temperature of 35–37℃ for approximately 8 hours until the desired level of acidity and coagulation was reached. Cool down quickly to 5–10℃. The desired yoghurt was finally produced (Figure 1).

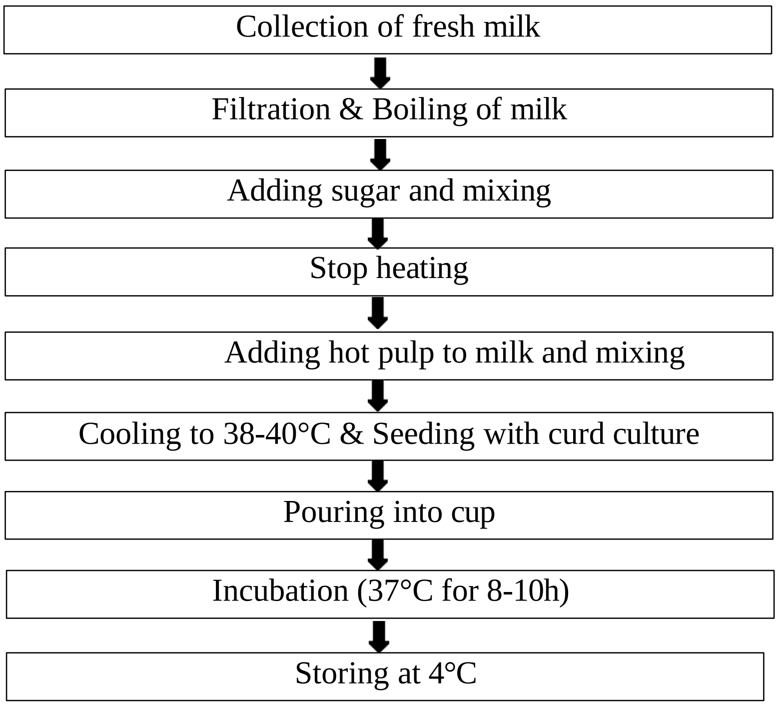

Figure 1. Production of jackfruit yoghurt chemical analyses for jackfruit and jackfruit yoghurt.

Proximate Analysis

The proximate components of samples (yoghurt and jackfruit yoghurt) were evaluated in accordance with AOAC standard technique (DM Basis) [9]. The moisture, ash, crude protein, crude fiber, and crude fat contents were analyzed using the dry ash, oven drying, Kjeldahl's, gravimetric, and Soxhlet methods, respectively [10, 11].

Moisture Content

The moisture content was calculated using the standard technique established by the Association of Official Analytical Chemists.

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- *Principle:* Food staff usually contain moisture. Moisture estimation is achieved by heating at 104–105°C for 3–4 hours in the oven and then cooling in a desiccator to absorb moisture. The procedure is performed numerous times until the sample exhibits a stable weight.
- *Apparatus:* Desiccator, hot air oven, crucible, and weighing scale.
- *Calculation:* This is how the percentage of moisture was determined:

$$Moisture\ \% = \frac{\text{Initial weight} - \text{Final weight}}{\text{Sample Weight}} \times 100$$

Ash Content

The total ash content was determined using the AOAC method 14.006 (2005). All mineral components are blended in the ash fraction. This approach involves burning all organic material to oxidize it and then measuring the remaining ash.

- *Apparatus:* Porcelain, a gas burner, and a muffle furnace
- *Calculation:* The following phrase was used to determine the ash content:

$$Ash\ \% = \frac{\text{The amount of ash in the supplied sample}}{\text{Sample Weight}} \times 100$$

Crude Protein

The protein content of beetroot was calculated using AOAC method (2005).

Principle

The Kjeldahl method is employed to calculate nitrogen. By measuring the material's nitrogen content and multiplying the N (nitrogen) factor by 6.25, the 22-protein content of food items can really be determined. Plant protein is thought to contain 16% nitrogen on average. As a result, the plant protein factor is 100/16 = 6.25. A known amount of the sample is almost always digested with H_2SO_4 in the presence of the digestion mixture ($CuSO_4$ and K_2SO_4 in the ratio of 1:20). Following diluting the digested material and trapping the released ammonia in a 2% boric acid solution; surplus acid is neutralized with alkali (40% NaOH, w/v). A standard (0.1N) HCl solution is used to titrate the recovered distillate. By multiplying by 6.25, one can calculate crude protein and calculate the percent nitrogen [12].

Apparatus

Kjeldahl digesting unit, condenser, and flask are examples of equipment.

Reagent

- Sulfuric acid is concentrated form.
- Digestion blend.
- Solution of boric acid 21.
- Solution of alkali.
- Mixture of indicators.
- 0.1 N standard HCI.

Calculation

Calculated nitrogen and protein percentages are as follows:

$$Protein\ \% = \frac{\text{Titrate value} \times \text{Normality of HC}(0.1) \times 0.014 \times 6.25}{\text{Sample Weight}} \times 100$$

Crude Fiber

The AOAC method (2005) was used to calculate crude fiber.

Basic Principle

Crude fiber is the water-insoluble portion of carbohydrates, mostly composed of cellulose, hemicellulose, and lignin. The estimation of crude fiber in a fat-free food sample involves a sequential process. First, a known quantity of the sample is boiled in a diluted acidic solution (1.25% H_2SO_4) for 30 minutes. Then, it undergoes boiling in a dilute alkali solution (1.25% NaOH) for another 30 minutes while maintaining a constant volume. Finally, the ash content is subtracted from the obtained residue to calculate the crude fiber content through this digestion process [13].

Apparatus

Leibig condenser, Reflux condenser, and Gooch crucible are the instruments.

Reagent

- 0.255 N Sulfuric acid solution, 22
- 10% Potassium sulfate solution, grade Asbestos-Gooch.

Calculation

The weight loss reflects crude fiber.

$$Crude\ fiber\ \% = \frac{\text{Weight of residue with crucible} - \text{Weight of ash with crucible}}{Weight\ of\ sample\ (moisture\ and\ fat\ free)} \times 100$$

Total Carbohydrate

The carbohydrate content was calculated by subtracting the combined values of moisture, ash, protein, and fat from 100/100gm (AOAC, 2016). Therefore, it was computed using the following formula:

% Carbohydrate = 100 − (Moisture % + Ash% + Protein% + Fat % + Fiber %)

Crude Fat

The crude fat content of yoghurt and jackfruit yoghurt were analyzed using the Soxtec System AOAC method number 920.65. The process included extracting crude fat from the samples using petroleum spirit (40–60°C), evaporating it, and measuring the weight of the crude fat [14]. Approximately 6 grammes of predried materials were weighed and then placed into an extraction thimble. The thimbles were enveloped in cotton free of fat and positioned in the core of the Soxtec apparatus. An amount of 60 ml of petroleum ether was added to the predried and preweighed cups and placed in the Soxtec extractor for extraction for around one hour. After extraction, the cups containing the fat extract were dried in an oven at 105°C for 30 minutes, then cooled in desiccators for another 30 minutes before weighing. The percentage of crude fat content was determined using the following equation:

$$\%\ Crude\ Fat = \frac{\text{Weight of Crude Fat (gm)}}{\text{Weight of Dry Sample (gm)}} \times 100$$

The acidity, measured as total titratable acidity, was assessed following the AOAC (1995) method 942.15 and 920.49 standard procedures. This involved titrating 5 ml of jackfruit yoghurt and plain yoghurt diluted in 250 ml of boiled water with 0.1 M NaOH standard solution, using 0.3 ml of phenolphthalein indicator for every 100 ml of solution until a pink endpoint persisted for 30 seconds (AOAC, 2000). The reported acidity in milliliters of 0.1N NaOH per 100 milliliters was determined using the following equation:

$$\text{Total Titratable Acidity gm/100gm} = \frac{\text{Trite Volume} \times \text{N}}{\text{Sample Weight}} \times 100$$

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where,

N = Normality of the alkali used.

Determination of pH

pH in chemistry is a measure of the acidity or basicity of a solution containing water. Substances having a pH below 7 are considered acidic, whereas those with a pH over 7 are classified as basic or alkaline. Water in its pure form typically has a pH level very near to 7. pH is the negative logarithm of the activity of the solvated hydronium ion, commonly used to indicate the concentration of hydronium ions. The pH scale is calibrated using standard solutions with pH values determined by international consensus. Primary pH standard values are established by a concentration cell with transference, by measuring the potential difference between a hydrogen electrode and a standard electrode such the silver chloride electrode. pH in aqueous solutions can be measured using a glass electrode and pH meter or indicators. It is defined as the decimal logarithm of the reciprocal of the hydrogen ion activity in a solution. pH is the primary parameter for ensuring the quality and safety of food products [15, 16].

Sensory Evaluation

Yoghurt samples that were created and managed were evaluated through sensory analysis using a 9-point hedonic scale, which ranged from extreme dislike to extreme like (1 = dislike extremely, 2 = Dislike moderately, 3 = Dislike slightly, 4 = Neither like nor dislike, 5 = Like slightly, 6 = Like moderately, 7 = Like very much). Ten consumer panelist members were selected randomly within CVASU to perform consumer test where plain yoghurt was used as a control. All evaluation sessions were held in the laboratory of Food Science & Technology at CVASU. The samples were displayed to the panelists in white disposable plastic cups at room temperature and under normal lighting circumstances. Each sample was labelled with a three-digit code. Panelists were given spoons for their use and water for cleaning their mouths. The features evaluated in the samples were color, texture, taste, aroma, spread ability, sweetness, and overall acceptability [17].

Microbiological Analysis

Plain yoghurt and jackfruit yoghurt samples were analyzed for bacterial viability using plate count agar, Eosin Methylene Blue agar, and Potato Dextrose Agar. The pour plate method was utilized to count the total number of live microorganisms in the different yoghurt samples. A serial dilution was performed with normal saline to achieve a 10-6 dilution. Subsequently, 1 ml of the 10-6 dilution was transferred into each sterile petri dish. Molten plate count agar was poured onto the plates, mixed, left to solidify, and then placed in an incubator at temperatures of 28 and 37°C for 48 hours. The colony count on the plates was adjusted for the dilution factor [18].

Mold Counts

Peptone water (0.1%) containing 5 ml of yoghurt was kept at room temperature (26 ± 2°C) for 48 h for enumeration. Diluents were made using 0.1% peptone water, and 1 ml from each diluent was poured on Sabo round dextrose agar plates, and the plates were incubated at room temperature for 48 h after which colonies were counted manually [19].

Standard Plate Counts

A Standard Plate Count (SPC) was utilized to assess the microbial level in the yoghurt that was made and kept. This data could serve as indicators of food quality or forecasts for the product's shelf life. With a sterile pipette, 1 ml of the diluted sample was transferred into each sterile empty petri dish containing nutrient agar media (Plate count agar) at a temperature of 45°C. Plates were combined by whirling on a level surface. The plates were inverted when the media solidified and then incubated at 37°C for 24 hours in an incubator.

Counting and Recording

Following incubation, the plates were examined to count the bacterial colonies based on their number and ease of counting. The plate with distinct, overlapping, and unclear colonies was not used. Plates with 30–250 distinct, visible, and quantifiable colonies were chosen [20].

$$\text{Number of colony forming unit}\frac{\text{cfu}}{\text{g}}\text{ or ml.} = \frac{\text{Average Cfu}}{\text{Plate}} \times \text{dilution factor}$$

The viable bacterial count was determined by following the processes of sample preparation, sample dilution, standard plate counts, and counting and recording. The incubation took place at 37°C for 24 hours.

Determination of Bioactive Compounds

Measurement of Flavonoids (TFC)

The total flavonoid content in the samples was determined using the aluminum chloride colorimetric method outlined. For the preparation of the extract stock solution at a concentration of 1 mg/ml, a test tube was employed, initially filled with 1.5 ml of 95 percent C_2H_5OH, and subsequently diluted in 0.5 ml increments. Subsequently, 0.1 ml of 10% $AlCl_3$, 0.1 ml of 1 mol/L potassium acetate, and 2.8 ml of distilled water were introduced into the test tube. This mixture was left at ambient temperature for a duration of 30 minutes [21].

Measurement of Polyphenols (TPC)

The determination of TPC in the extracts was conducted using a modified version of the Folin-Ciocalteu (FC) reagent method, as outlined with slight adaptations. In this procedure, 1 milliliter of the ethanoic extract was combined with 1.5 milliliters of FC reagent within a falcon tube and allowed to stand at room temperature for three minutes. Subsequently, 1.5 ml of 7.5% Na_2CO_3 was introduced, and the mixture was left to settle for 60 minutes. The absorbance was measured at a wavelength of 765 nm using a UV-VIS Spectrophotometer with C_2H_5OH employed as the reference blank. TPC in the extracts was determined through calculations establishing the equivalence of TPC to milligrams of gallic acid equivalents (GAE) per gram of extracts. To ensure precision and reliability, the measurements were repeated three times, and the means and standard deviation were computed [22].

Antioxidant Capacity Measurement

The antioxidant activity of the extracts was evaluated using the DPPH test, with slight modifications. Approximately 6 mg of DPPH was dissolved in 100 ml of 100% methanol to prepare a methanol for a methanoic DPPH solution. Subsequently, 1 ml of the methanoic extract was mixed with 2 ml of the DPPH solution. The mixture was gently shaken and allowed to stand at room temperature in the dark for 30 minutes. Using a UV-VIS spectrophotometer, the absorbance was measured at a wavelength of 517 nm. For the control, 1 ml of methanol was mixed with 2 ml of the DPPH solution, and methanol served as the blank. To assess the scavenging activity of the samples, the decrease in absorbance relative to the DPPH standard solution was used as an indicator. The antioxidant capacity of the extracts was evaluated based on their ability to scavenge DPPH free radicals. A standard calibration curve was created using TEAC composite (Trolox equivalent antioxidant capacity), which was also used as the standard. The results were expressed as milligrams of Trolox equivalents per gram of powder on a dry weight basis. For enhanced accuracy, the measurements were replicated three times to calculate means and standard deviation [23].

Mineral Content Analysis

Minerals containing phosphorus, potassium, and iron were subjected to nitric-perchloric digestion in temperature-controlled digestion blocks to determine their composition. The chromogen in the reagent reacts with the important mineral to create a soluble, colored compound that can be analyzed by irradiating it with a specific wavelength of radiation. The concentration of the crucial mineral was determined using the standard curve correlating absorbance with concentration. The conventional method for mineral analysis was employed to determine the minerals found in yoghurt.

Statistical Analysis

Data on proximate, sensory, and carotenoids was gathered in a Microsoft Excel 2007 spreadsheet. The data was subsequently transferred to SPSS 17 (SPSS Inc., 233 South Wacker Drive, 11th Floor, Chicago, IL 60606-6412). Prior to statistical analysis in SPSS 17 software, the data was organized, coded, and documented. Proximate and sensory data were analyzed using a one-way ANOVA test to determine the level of variance with a 95% confidence interval. A post hoc Tukey test was conducted to determine the differences among sample groups. Descriptive statistics, including frequency, means, standard deviation, and mean error, were calculated for samples of plain yoghurt and jackfruit yoghurt. The results were reported as the mean ± standard deviation and displayed in tables and graphs [24].

RESULT

Proximate Composition

Table 1 displays the mean percentage of the proximate composition value which includes moisture, protein, fat, crude fiber, ash, and carbohydrate content of different samples of plain yoghurt and jackfruit yoghurt [25].

Table 1. Proximate composition of yoghurt samples.

Constituent	A	B	C	D
Moisture (%)	68.32 ± 0.27^{a}	67.26 ± 0.214^{ab}	66.57 ± 0.66^{bc}	65.93 ± 1.08^{c}
Total Solid	31.37 ± 0.01^{a}	32.73 ± 0.00^{b}	33.48 ± 0.25^{c}	34.06 ± 0.006^{d}
Carbohydrate	19.24 ± 1.32^{a}	21.86 ± 1.21^{b}	22.03 ± 0.76^{b}	22.85 ± 1.71^{b}
Protein	4.41 ± 0.02^{a}	4.32 ± 0.12^{a}	4.19 ± 0.45^{a}	4.06 ± 0.00^{a}
Fat	7.13 ± 0.09^{a}	6.43 ± 0.14^{b}	6.41 ± 0.13^{b}	6.32 ± 0.07^{b}
Ash	0.89 ± 0.03^{a}	0.87 ± 0.01^{ab}	0.85 ± 0.00^{bc}	0.83 ± 0.00^{c}
Acidity	0.94 ± 0.03^{a}	0.96 ± 0.02^{a}	0.99 ± 0.02^{a}	1.12 ± 0.05^{b}
pH	4.48 ± 0.00^{a}	4.43 ± 0.00^{a}	4.41 ± 0.01^{a}	4.37 ± 0.00^{a}

Mean of three replicates ± standard deviation. Options include A (milk with 0% jackfruit juice), B (milk with 5% jackfruit juice), C (milk with 10% jackfruit juice), and D (milk with 15% jackfruit juice).

Table 1 displays the statistics comparing the chemical quality of yoghurt samples. Among the samples, it was noted that sample A (plain yoghurt with 0% jackfruit constituents) had a higher moisture content of 68.32 ± 0.27% compared to yoghurt with D (15% jackfruit constituents). Moisture content of Jackfruit juice is 65.93 ± 1.08%. The moisture level of yoghurt decreases when jackfruit juice is added because jackfruit juice has a higher total solid content. The D sample of yoghurt had the highest total solid content (34.06 ± 0.006%) compared to other varieties of yoghurt prepared, attributed to the addition of jackfruit juice. Sample A had the lowest total solid content (31.37 ± 0.01%) due to the absence of jackfruit juice. The protein, lipid, and ash levels of yoghurt samples decreased due to the addition of jackfruit juice to milk. Jackfruit juice contained reduced levels of protein, fat, and ashes. Jackfruit juice had a higher total solids content than milk, hence adding jackfruit juice enhanced the total solids content of the yoghurt samples. Adding jackfruit juice reduced the protein, fat, and ash levels of yoghurt [26].

The acidity content of yoghurt samples A, B, C, and D were 0.94%, 0.96%, 0.99%, and 1.12% correspondingly. The statistical analysis indicated that there was no significant difference in acidity across the various varieties of produced yoghurt samples. The addition of jackfruit juice somewhat enhanced the acidity level. This was due to the rapid fermentation process of jackfruit juice.

Sensory Analysis

Organoleptic evaluations of the yoghurt are based on its visual appearance, color, taste, texture, consistency, syneresis, and overall flavor. Table 2 presents a comparison of the organoleptic quality characteristics of different types of prepared yoghurt. The organoleptic hedonic scale in its general form was utilized in the following evaluations:

The overall quality of all varieties of prepared yoghurt was deemed good, while their individual qualities varied slightly according to the test panel.

Table 2. Physical qualities comparison of various types of prepared yoghurt.

Constituents	**A**	**B**	**C**	**D**
Appearance	7.4 ± 0.10[a]	7.6 ± 0.10[ab]	8.4 ± 0.20[c]	7.8 ± 0.10[b]
Color	7.5 ± 0.26[a]	7.4 ± 0.17[a]	7.8 ± 0.15[b]	7.4 ± 0.20[c]
Flavor	7 ± 0.26[ab]	7.2 ± 0.20[b]	7.7 ± 0.17[c]	6.7 ± 0.30[a]
Texture	7 ± 0.20[a]	7.3 ± 0.11[ab]	7.6 ± 0.10[b]	7.2 ± 0.26[a]
Mouthfeel	7.5 ± 0.17[a]	7.6 ± 0.26[a]	8.5 ± 0.17[b]	7 ± 0.36[a]
Body & consistency	7.3 ± 0.26[ab]	7.1 ± 0.20[a]	8.3 ± 0.10[c]	7.5 ± 0.10[b]
Overall acceptance	7.3 ± 0.17[a]	7.36 ± 0.03[a]	8.05 ± 0.09[b]	7.26 ± 0.12[a]

Calculate the mean of three replicates. Options include A (milk with 0% jackfruit juice), B (milk with 5% jackfruit juice), C (milk with 10% jackfruit juice), and D (milk with 15% jackfruit juice) (Figure 2).

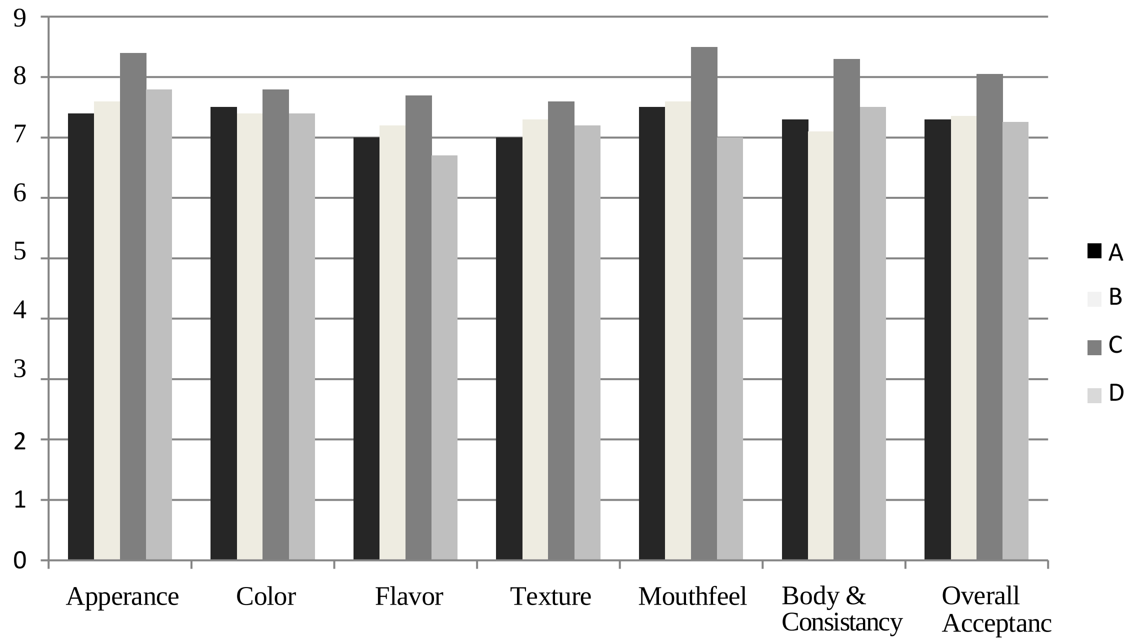

Figure 2. Comparison of the sensory evaluation of different types of yoghurt.

Bioactive Properties Analysis Test Result

Bioactive components and antioxidant capacity were analyzed by using a UV-visible spectrophotometer. The results for the bioactive components TPC, TFC, and TAC are shown in Table 3. The values of each sample were found to be significantly different. When compared to plain yoghurt (yoghurt + 0% jackfruit juice) and jackfruit yoghurt (yoghurt + 10% yoghurt) had the greatest levels of total phenolic, flavonoids compound and antioxidant capacity.

Table 3. Bioactive composition of plain yoghurt and jackfruit yoghurt.

Sample	**Total Flavonoids Content (TFC) (mgQE/100 gm)**	**Total Polyphenol Content (TPC) (mg GAE/100 gm)**	**Antioxidant Capacity (% Inhibition)**
A (jackfruit juice)	11.441 ± 0.049[a]	0.04467 ± 0.00351[a]	1.009 ± 0.003[a]
B (yoghurt+ 10% jackfruit juice)	1.077 ± 0.004[b]	0.0373 ± 0.001528[b]	0.048 ± 0.003[b]

According to the results, there were differences between jackfruit juice and jackfruit yoghurt in total flavonoid and polyphenol content. Jackfruit juice contained the flavonoid concentration (11.441 mg QE/100g) where jackfruit yoghurt had (1.077 mg QE/100g). Jackfruit yoghurt had the highest total Antioxidant capacity (0.045 mg GAE/100 g). Jackfruit yoghurt had the lowest result (0.037 mg GAE/100 g). There were no significant differences in terms of polyphenol content between jackfruit juice and jackfruit yoghurt. The polyphenol contents of jackfruit juice and jackfruit yoghurt are 0.045 mg GAE/100 gm and 0.037 mg GAE/100 gm, respectively.

Microbiological Quality Assessment

Three separate tests, shown in (Table 4) total viable count (TVC), total coliform count (TCC), and TFC, were performed to assess the microbiological quality of several types of prepared jackfruit juice yoghurt samples in this study.

Table 4. Microbiological quality assessments of different types of prepared yogurt.

Microbiological Parameter	**A**	**B**
TVC (cfu/ml)	2.48×10^7	1.69×10^7
TCC (cfu/ml)	Nil	Nil
TFC (cfu/ml)	1.65×10^4	1.48×10^4

Average three replications. A (milk+ 0% jackfruit juice), B (milk+10% jackfruit juice).

The TVC of a yoghurt sample provided information on the total number of viable cells (microorganisms) in the yoghurt. The total viable count of various types of prepared jackfruit juice yoghurt samples A and B were 2.48 × 107 and 1.69 × 107 cfu/ml, respectively, as shown in Table 4. The total volatile compound (TVC) was higher in type A yoghurt compared to type B yoghurt due to the addition of jackfruit juice, which can elevate the acidity levels. Type A yoghurt does not contain jackfruit juice. Yoghurts made from jackfruit juice were deemed safe for people to eat.

Mineral Content of Yoghurt and Jackfruit Yoghurt

The mineral content (potassium, iron, phosphorus) of plain yoghurt and jackfruit yoghurt are shown in Table 5.

Table 5. Mineral content of plain yoghurt and jackfruit yoghurt.

Parameter	**A**	**B**	**C**	**D**
Potassium (mg/gm)	2.2 ± 0.10[a]	2.533 ± 0.1528[ab]	2.8 ± 0.10[bc]	3.0 ± 0.173[c]
Iron (µg/gm)	1.5 ± 0.20[a]	2.2 ± 0.20[a]	2.733 ± 0.1528[b]	3.067 ± 0.208[c]
Phosphorus (mg/gm)	16.233 ± 0.252[a]	21.167 ± 0.764[a]	23.167 ± 0.569[b]	24.467 ± 0.723[c]

Average three replications. A (milk with 0% jackfruit juice), B (milk with 5% jackfruit juice), C (milk with 10% jackfruit juice), and D (milk with 15% jackfruit juice).

DISCUSSION

Proximate Analysis

The proximate analysis of plain and jackfruit-enriched yoghurt highlights significant compositional changes. Moisture content decreased with increasing jackfruit juice, from 68.32 ± 0.27% in plain yoghurt (A) to 65.93 ± 1.08% in 15% jackfruit yoghurt (D), attributed to higher total solids in jackfruit juice. Consequently, total solids increased from 31.37 ± 0.01% (A) to 34.06 ± 0.006% (D). Carbohydrate content rose from 19.24 ± 1.32% (A) to 22.85 ± 1.71% (D), aligning with previous studies [21]. Protein content declined from 4.41 ± 0.02% in A to 4.06 ± 0.00% in D due to the lower protein content in jackfruit juice [23]. Fat levels also decreased, with A containing 7.13 ± 0.09% and D at 6.32 ± 0.07%, likely due to fruit juice dilution. Ash content followed a similar trend, reducing from 0.89 ± 0.03% in A to 0.83 ± 0.00% in D.

Acidity increased with jackfruit juice (0.94 ± 0.03% in A to 1.12 ± 0.05% in D), suggesting enhanced fermentation. However, pH remained relatively stable (4.37 ± 0.00 to 4.48 ± 0.00) [21]. These findings indicate that jackfruit juice enhances total solids and carbohydrates but reduces protein, fat, and ash content while contributing to a more acidic environment beneficial for fermentation.

Sensory Analysis

Sensory evaluation revealed that jackfruit yoghurt samples were well-accepted. Appearance scores ranged from 7.4 (A) to 8.4 (C), with sample C rated highest. Flavor scores increased with jackfruit juice, peaking at 7.7 for C but decreasing to 6.7 for D. Texture scores varied from 7.0 (A) to 7.6 (C), influenced by acidity development and fermentation.

Color scores ranged from 7.4 (A) to 7.8 (C), showing jackfruit juice’s influence. Judges preferred yoghurt with up to 10% jackfruit juice, significantly enhancing sensory attributes, such as appearance, flavor, texture, and consistency.

Bioactive Compounds

Jackfruit juice exhibited higher flavonoid content (11.441 mg QE/100g) than jackfruit yoghurt (1.077 mg QE/100g), confirming its strong antioxidant potential. The total antioxidant capacity of jackfruit juice (1.009 mg GAE/100g) was significantly higher than in jackfruit yoghurt (0.048 mg GAE/100g), reinforcing its functional benefits. However, polyphenol content remained similar between both, ranging from 0.037 to 0.045 mg TE/100g [26].

Microbial Quality

Coliform bacteria were undetectable in all yoghurt samples, meeting safety standards (≤10 CFU/ml). TVC was 1.65×10^4 CFU/ml in A and 1.48×10^4 CFU/ml in B. Fungal counts were within the permitted range ring microbial safety. Jackfruit juice improved the microbial quality of yoghurt by lowering TVC and fungal counts, enhancing both safety and shelf life [27, 28].

Mineral Analysis

Potassium, iron, and phosphorus levels increased with jackfruit juice supplementation. Potassium rose from 2.2 ± 0.10 mg/gm (A) to 3.0 ± 0.173 mg/gm (D), iron from 1.5 ± 0.20 µg/gm (A) to 3.067 ± 0.208 µg/gm (D), and phosphorus from 16.233 ± 0.252 mg/gm (A) to 24.467 ± 0.723 mg/gm (D). These minerals contribute to essential physiological functions, enhancing the nutritional value of jackfruit yoghurt [29, 30].

CONCLUSIONS

The study compared jackfruit juice yoghurt at different concentrations (5%, 10%, and 15%) with plain yoghurt (0% jackfruit juice) based on organoleptic, chemical, microbiological, bioactive compound, and mineral content (potassium, phosphorus, and iron) analyses. A nine-point hedonic scale was used to evaluate the organoleptic qualities of yoghurt with 10% jackfruit juice. The results indicated that this yoghurt had a superior appearance, color, flavor, texture, and overall acceptability compared to yoghurt with 0%, 5%, and 15% jackfruit juice. Microbiological quality measures guarantee product safety, and the TVC, TCC, and TFC were within permissible limits. All the yoghurt samples prepared were deemed appropriate for ingestion. Consistently drinking high-quality jackfruit juice mixed with yoghurt can fulfil our nutritional needs and serve as a beneficial source of carbohydrates. It has higher digestion compared to plain yoghurt.

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