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EVALUATING THE EFFECTS OF SWEETENERS ON THE QUALITY AND PROBIOTIC VIABILITY OF FRUIT-FLAVORED YOGHURTS

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ABSTRACT

The present study evaluated the effects of different sweeteners on the physicochemical, microbial, and sensory properties of fruit- and honey-enriched probiotic yoghurts. Yoghurt formulations incorporated papaya, mango, avocado, pineapple, or honey, combined with cane sugar, stevia, or aspartame, and probiotic cultures (ABT and ABY3). Physicochemical analyses included pH, titratable acidity, syneresis, , and proximate composition, while microbial quality was assessed via total viable counts, coliforms, and yeast/mould enumeration. Sensory evaluation employed a 9-point hedonic scale to assess color, flavor, texture, taste, and overall acceptability. Results indicated that fruit and honey addition significantly increased acidity and microbial load while moderately decreasing pH ($p < 0.05$); sweetener type had no significant effect on acidity or pH but influenced total viable counts. Among fruits, 10% papaya yoghurt showed optimal sensory scores, including the highest overall acceptability (8.81 ± 0.40). Probiotic yoghurt with ABY3 demonstrated superior microbial viability, lower syneresis, and higher sensory ratings compared to ABT and control samples. Papaya supplementation increased total solids, protein, ash, and solids-not-fat, while reducing fat and moisture content. The study concludes that papaya-enriched probiotic yoghurt formulated with ABY3 and appropriate sweeteners provides a functional, nutritionally enhanced dairy product with high consumer acceptability, hygienic quality, and potential for scale-up in the Ethiopian dairy sector.

KEYWORDS: Fruit yoghurt, Probiotic, Sweeteners, Papaya, Physicochemical properties, Sensory evaluation.

INTRODUCTION

Flavoured and fruit-enriched yoghurts continue to proliferate in global markets; however, many products rely on similar fruit additives and sweetness profiles, leading to sensory monotony and declining consumer acceptance when sweetness is excessive or sourness dominates (Greig et al., 1985; Barnes et al., 1991). The addition of fruits rich in vitamins, fiber and bioactive compounds has been widely explored in yoghurt development, enhancing nutritional and sensory quality (Al-Aswad & Shehata, 2025). At the same time, the incorporation of probiotics into yoghurt provides an effective route to deliver health benefits such as improved gut microbiota, reduced serum cholesterol and enhanced metabolic profiles (Li et al., 2025; Sarıtaş et al., 2024). Advances in formulation (e.g., increasing solids-not-fat, protein fortification) and processing help improve texture and stability (Mistry & Hassan, 1992; Early, 1992). Nonetheless, integration of different sweeteners, fruit bases and probiotic cultures in a unified formulation framework remains under investigated.

Objectives

GeneralObjective

To evaluate the effects of various sweeteners on the physicochemical, and sensory characteristics of honey and fruit-flavoured probiotic yoghurts.

Specific Objectives

1. To formulate probiotic yoghurts using different fruit bases and sweetener types.
2. To determine how sweetener type affects the physicochemical properties of honey and fruit yoghurts
3. To assess the impact of sweetener type on probiotic viability during storage of honey and fruit yoghurts.
4. To evaluate consumer acceptability and sensory attributes of honey and fruit-flavoured yoghurts sweetened with different sweeteners.

2. Review of Literature

2.1 Ingredients of Yoghurt

Milk and derived ingredients such as cream, skim milk powder, whey concentrate and casein remain the foundation of yoghurt manufacture. Additives including starter cultures, sweeteners, colourants, fruit-based flavourings and preservatives are used to tailor sensory and stability characteristics (Bankole et al., 2023). The selection of each additive must balance technological performance (consistency, whey separation, stability) with sensory acceptance and regulatory/health considerations such as sugar reduction and probiotic viability.

2.2 Sweeteners

Sweeteners play a pivotal role in fruit-flavoured yoghurts by masking acidity, enhancing sweetness perception and boosting consumer acceptance. Recent studies show that both the type and concentration of sweetener influence starter culture growth, metabolic activity, texture and flavour balance (Crown et al., 2024). For example, a 2025 study using Stevia in fruit yoghurt found acceptable physicochemical and sensory properties, supporting sugar reduction strategies. Another 2024 investigation of low-fat yoghurts sweetened with sucrose, stevia or xylitol found no significant difference in sensory acceptability though gel structure and syneresis did vary among sweeteners. These findings emphasize that when replacing sucrose, one must consider compatibility of the sweetener with the yoghurt matrix and fermentation process, effects on starter/probiotic viability, texture and water-holding capacity, and sensory acceptance.

2.3 Growth Promoting Substances in Probiotic Yoghurt

Beyond the base milk substrate, growth promoting nutrients such as simple sugars (glucose, fructose) and trace minerals (Mg, Mn) enhance growth of probiotic strains (Marshall, 1991). More recent reviews highlight that fortification with whey protein, fruit pulps and plant extracts can positively impact probiotic viability and functionality in yoghurt matrices (Li et al., 2025). Thus, in designing probiotic fruit yoghurts, the selection of adjuncts and sweeteners must integrate their interactions with the beneficial cultures.

2.4 Functional Yoghurt: Probiotics, Prebiotics and Health Benefits

Yoghurt has increasingly been positioned as a functional food providing benefits beyond basic nutrition (de Souza et al., 2024). A 2025 comprehensive review analysed the role of probiotic yoghurts in nutritional modulation, flavour development and health-promoting effects, and discussed relevant processing technologies (Li et al., 2025). For the formulation of fruit yoghurts with alternative sweeteners and probiotics, key considerations include maintenance of probiotic viability, interactions between additives and microbial cultures, sensory quality, and credible evidence of functional efficacy for the consumer.

3. Materials and Methods

3.1 Experimental Site

The study was conducted at Dairy Laboratory, Haramaya University, Ethiopia.

3.2 Materials

- **Milk:** Fresh whole cow's milk was sourced from Haramaya University dairy farm and analyzed for moisture, total solids, protein, fat, SNF, ash, titratable acidity, and pH.
- **Skim Milk Powder (SMP):** Spray-dried SMP was used for milk standardization and yoghurt preparation.
- **Sweeteners:** Cane sugar, stevia, and aspartame were procured locally.
- **Starter Cultures:** Commercial CHR-HANSEN cultures were used: Yo-flex (yoghurt culture), ABT (Lactobacillus acidophilus, Bifidobacteria, Streptococcus thermophilus), and ABY3 (L. acidophilus, Bifidobacteria, L. bulgaricus, S. thermophilus).
- **Fruits and Honey:** Fresh papaya, mango, avocado, pineapple, and honey were incorporated into yoghurt formulations.

3.3 Experimental Design

Three experiments were conducted under a Completely Randomized Design (CRD):

1. **Probiotic Yoghurt:** 3 × 4 factorial probiotic culture (Control, ABT, ABY3) × storage period (0, 7, 14, 21 days).
2. **Fruit Yoghurt:** 5 × 5 × 3 factorial fruit type (Papaya, Mango, Avocado, Pineapple, Honey) × fruit juice concentration (0–10 mL/100 mL milk) × sweetener (Cane sugar, Stevia, Aspartame).

All treatments were replicated three times. Analyses included physicochemical (pH, titratable acidity, syneresis), microbiological (total viable count), and sensory evaluation (9-point hedonic scale).

3.4 Yoghurt Preparation

All glassware and utensils were sterilized. Milk was preheated to 50 °C, standardized to 11% SNF with SMP, pasteurized at 90 °C for 15 min, and cooled to 45 °C.

3.4.1 Starter Preparation: Freeze-dried Yo-flex (0.02 U/100 mL) was reconstituted in sterile milk at 43 °C and stored at 4 °C following CHR-HANSEN guidelines.

3.4.2 Probiotic Yoghurt: Milk was sweetened (4% sugar), pasteurized (90 °C, 30 min), cooled to 45 °C, inoculated with Yo-flex (control), ABT, or ABY3, and incubated at 43 °C until pH 4.7. Samples were stored at 4 °C for 21 days.

3.4.3 Fruit Yoghurt: Fruits were peeled, blended, and mixed at 0–10% (w/v) with sweetened milk. The mixture was heat-treated (90 °C, 20 min), cooled, inoculated (0.02 U/100 mL), incubated at 43 °C to pH 4.7, and stored at 4 °C.

3.5 Physicochemical Analyses

- **Titratable Acidity (TA):** AOAC (1995, method 942.15), expressed as % citric acid.
- **pH:** Measured with a calibrated digital pH meter (Model 510, Oakton Instruments, USA).
- **Total Solids:** Oven-dried method (Richardson, 1985), neutralized with 0.1 N NaOH for yoghurt.
- **Moisture:** Calculated by difference (AOAC, 1990).
- **Fat:** Ether extraction method (AOAC, 1995, method 905.02).
- **Solids-Not-Fat (SNF):** SNF (%) = TS (%) − Fat (%) (O'Mahony, 1988).
- **Protein:** Kjeldahl method (AOAC, 2000; conversion factor 6.38).
- **Ash:** Dry ashing at 550 °C (AOAC, 1995).
- **Syneresis:** Measured by whey separation at 45 °C (Amatayakul et al., 2006).

Physicochemical evaluations were conducted at 0, 7, 14, and 21 days,.

3.6 Microbiological Analyses

Total lactic acid bacteria (LAB), coliforms (CC), and yeasts and molds (YMC) were enumerated at 0, 7, 14, and 21 days.

- **Media:** HYA for LAB, VRBA for coliforms, APDA (pH 3.5) for yeasts and molds.
- **Sample Preparation:** 11 g yoghurt blended with 99 mL 0.1% peptone water; serial dilutions up to 10^{-7} were prepared.
- **LAB Count:** Pour-plated on HYA, incubated 37 °C for 72 h; colonies expressed as $\log_{10}$ CFU/g.
- **Coliforms:** Pour-plated on VRBA, incubated 30 °C for 24 h; dark red colonies counted.
- **YMC:** Plated on APDA, incubated 25 °C for 5 days.

3.7 Sensory Evaluation

Sensory assessment followed Barnes et al. (1991a) using a semi-trained panel. Samples were coded with random three-digit numbers, served at 7 ± 1 °C, and evaluated for color, appearance, flavor, texture, and overall acceptability on a 9-point hedonic scale.

3.8 Statistical Analysis

Data were analyzed using SPSS v17.0. Results are expressed as mean ± SD. One-way ANOVA assessed treatment effects, and Duncan's multiple range test ($p < 0.05$) compared means. Repeated measures ANOVA was used for sensory data.

RESULTS

4.1 Chemical Composition of Raw Materials Used for Yoghurt Preparation

4.1.1 Chemical Composition of Milk

Fresh cow milk collected from Haramaya university dairy farm, Ethiopia, was analyzed prior to yoghurt production. The proximate composition was as follows: moisture 88.45 ± 0.05%, total solids 11.56 ± 0.01%, fat 3.61 ± 0.15%, protein 3.05 ± 0.03%, carbohydrate 4.51 ± 0.08%, ash 0.71 ± 0.04%, acidity 0.13 ± 0.01%, pH 6.62 ± 0.05, and solid-not-fat (SNF) 8.06 ± 0.01%.

4.1.2 Proximate Composition of Papaya

Papaya juice was analyzed for proximate composition. Values were: moisture 83%, protein 0.61%, carbohydrate 9.81%, fat 0.14%, and fiber 1.8%.

4.1.3 Proximate Composition of Mango

Mango juice composition was recorded as follows: moisture 81%, protein 0.50%, carbohydrate 17%, fat 0.27%, and fiber 1.8%.

4.1.4 Proximate Composition of Avocado

Avocado juice contained: moisture 76%, protein 2%, carbohydrate 8.53%, fat 14.66%, and fiber 6.7%.

4.1.5 Proximate Composition of Pineapple

Pineapple juice composition was: moisture 84%, protein 0.54%, carbohydrate 13.52%, fat 0.12%, and fiber 1.4%.

4.1.6 Proximate Composition of Honey

Honey was analyzed for proximate composition with the following results: moisture 17%, protein 0.67%, carbohydrate 82.3%, and fat 0.29%.

4.2 Physicochemical Properties of Fruit- and Honey-Enriched Yoghurt with Sweeteners

Fruits (Papaya, Mango, Avocado, Pineapple) and honey were incorporated into yoghurt with three different sweeteners: **Cane sugar, Stevia, and Aspartame**.

4.2.1 Syneresis of Yoghurt Samples

Syneresis, defined as the separation of liquid from the yoghurt gel, was monitored throughout the storage period. Results showed that **fruit- and honey-enriched yoghurts exhibited significantly higher ($p < 0.05$) syneresis** compared to the control. Sweetener type also significantly ($p < 0.05$) influenced syneresis, with **cane sugar showing the lowest values**, followed by Stevia and Aspartame.

The **lowest syneresis** was consistently observed in **2.5% fruit- and honey-enriched yoghurts** across all storage periods. Syneresis increased with higher fruit/honey concentration and longer storage time.

0-Day Storage

- Papaya 2.5%: 11.6 ± 2.31
- Mango 2.5%: 12.5 ± 3.06
- Avocado 2.5%: 14.1 ± 2.28
- Pineapple 2.5%: 14.9 ± 3.14
- Honey 2.5%: 19.1 ± 3.41

7th-Day Storage

- Papaya 2.5%: 12.1 ± 1.66
- Mango 2.5%: 12.9 ± 3.69
- Avocado 2.5%: 14.6 ± 2.11
- Pineapple 2.5%: 15.2 ± 2.97
- Honey 2.5%: 19.1 ± 3.41

14th-Day Storage

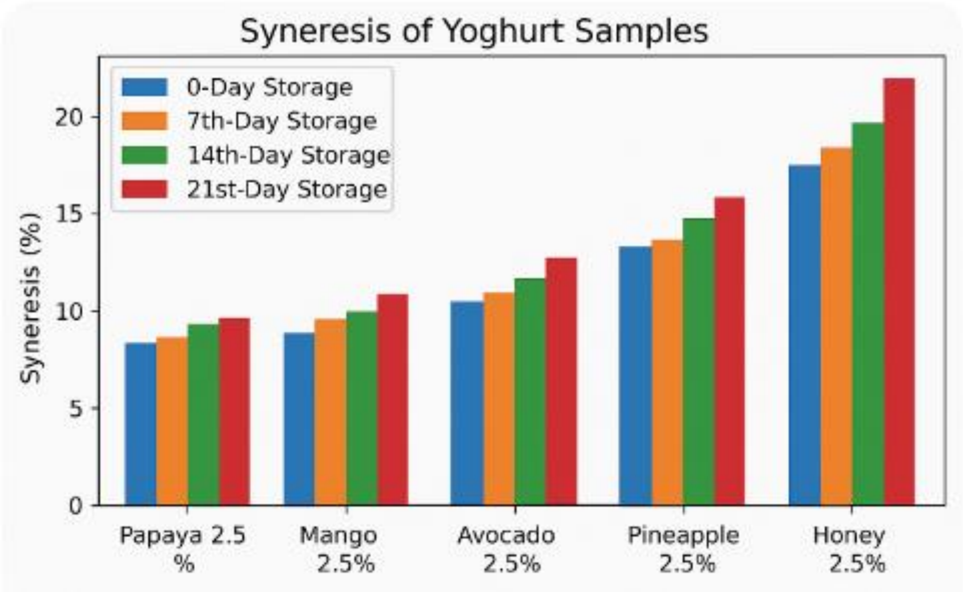
- Papaya 2.5%: 12.6 ± 1.95
- Mango 2.5%: 13.7 ± 1.82
- Avocado 2.5%: 14.7 ± 1.25
- Pineapple 2.5%: 15.5 ± 2.95
- Honey 2.5%: 19.3 ± 2.98

21st-Day Storage

- Papaya 2.5%: 13.0 ± 2.16

- Mango 2.5%: 14.1 ± 1.52
- Avocado 2.5%: 15.0 ± 0.94
- Pineapple 2.5%: 15.9 ± 2.42
- Honey 2.5%: 19.7 ± 2.58

The minimum syneresis consistently occurred at **2.5% fruit/honey incorporation**. Higher concentrations and longer storage significantly increased liquid separation.



4.2.2 Acidity of Fruit- and Honey-Enriched Yoghurt During Storage

The acidity of yoghurt enriched with fruits (Papaya, Mango, Avocado, Pineapple) and honey, sweetened with Cane Sugar, Stevia, or Aspartame, was evaluated over 21 days. Fruit and honey addition significantly increased acidity ($p < 0.05$), whereas sweetener type had no significant effect ($p > 0.05$).

10% Pineapple yoghurt consistently showed the highest acidity across storage (1.50 ± 0.99 on day 0 to 1.68 ± 0.28 on day 21), followed by 10% Honey yoghurt (0.99 ± 0.32 to 1.01 ± 0.28). Mango, Papaya, and Avocado yoghurts showed moderate acidity increases. Overall, acidity slightly increased over storage, but storage duration did not significantly affect the acidity within each yoghurt type.

4.2.3 pH of Fruit- and Honey-Enriched Yoghurt During Storage

The pH of yoghurt enriched with fruits (Papaya, Mango, Avocado, Pineapple) and honey, with Cane Sugar, Stevia, or Aspartame, was monitored over 21 days. Fruit and honey addition significantly decreased pH ($p < 0.05$), whereas the type of sweetener had no significant effect ($p > 0.05$).

10% Honey yoghurt consistently exhibited the lowest pH (3.45 ± 0.28 on day 7), followed by 10% Pineapple yoghurt (3.56 ± 0.22 on day 21). Avocado, Papaya, and Mango yoghurts showed higher pH values ranging from 4.13 to 4.32. Overall, pH slightly declined with storage, but storage duration did not significantly influence pH within each yoghurt type.

4.2.4 Total Viable Count (TVC) of Fruit- and Honey-Enriched Yoghurt During Storage

The microbial quality of yoghurt enriched with fruits (Papaya, Mango, Avocado, Pineapple) and honey, sweetened with Cane Sugar, Stevia, or Aspartame, was assessed by enumerating total viable counts (TVC) over the storage period. Fruit and honey addition significantly increased TVC compared to control yoghurt ($p < 0.05$), and different sweeteners also influenced microbial growth. TVC was highest on day 0 and gradually declined over storage .

- **Day 0:** 10% Avocado yoghurt with Cane Sugar showed the highest TVC (10.7 ± 1.88 cfu/g), followed by 10% Papaya with Aspartame (10.6 ± 1.84), 10% Pineapple with Cane Sugar (10.4 ± 2.31), 10% Honey with Aspartame (10.0 ± 3.16), and 10% Mango with Aspartame (9.9 ± 2.33).
- **Day 7:** Maximum TVC was observed in 10% Papaya with Cane Sugar and 10% Mango with Stevia (10 ± 2.26 cfu/g).
- **Day 14:** Highest TVC was recorded in 10% Papaya with Cane Sugar (9.5 ± 2.83 cfu/g).
- **Day 21:** 10% Avocado with Cane Sugar showed the maximum TVC (9.8 ± 1.31 cfu/g).

Overall, 10% Avocado and Papaya yoghurts with Cane Sugar consistently exhibited the highest microbial counts, indicating that both fruit type and sweetener influenced yoghurt microbial quality over storage.

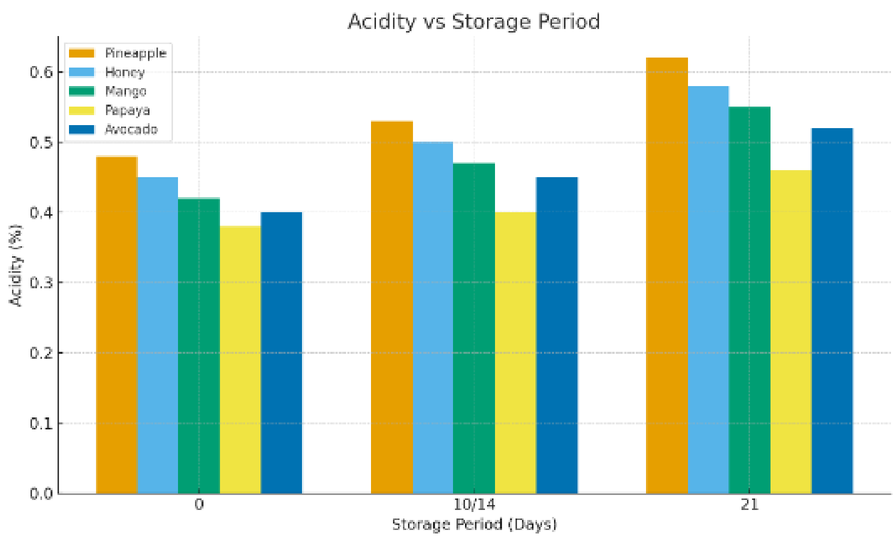
4.3 Physicochemical and Microbial Quality of Fruit- and Honey-Enriched Yoghurt

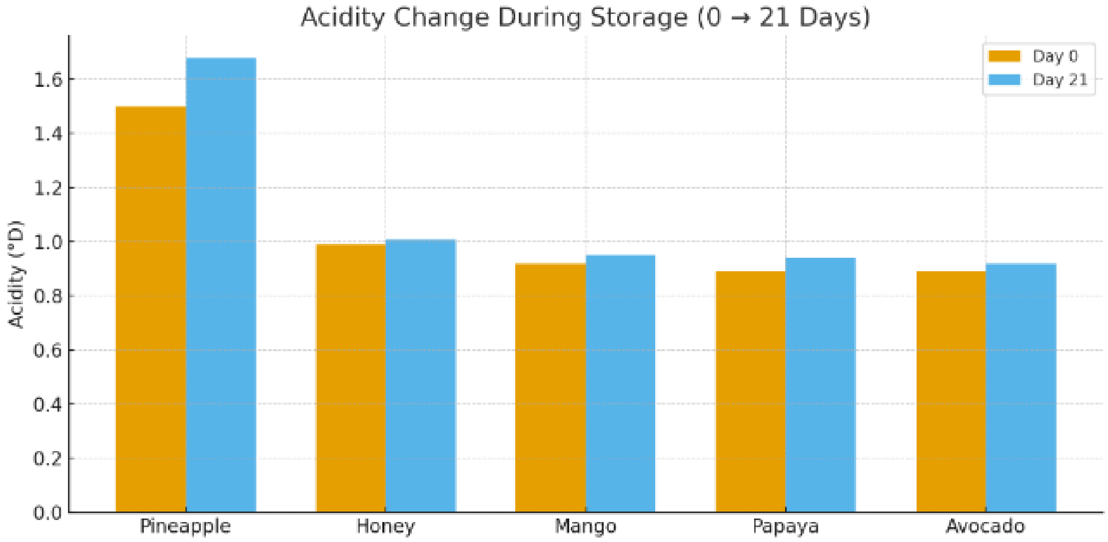
The effect of fruit (Papaya, Mango, Avocado, Pineapple) and honey addition, with sweeteners (Cane Sugar, Stevia, Aspartame), on yoghurt acidity, pH, and microbial quality was evaluated over 21 days. Fruit and honey significantly increased acidity ($p < 0.05$) and decreased pH, with 10% Pineapple yoghurt showing the highest acidity (1.68 ± 0.28) and 10% Honey yoghurt the lowest pH (3.45 ± 0.28), while sweetener type had no significant effect ($p > 0.05$). Total viable counts (TVC) were higher in all fruit- and honey-enriched yoghurts compared to control ($p < 0.05$), with maximum counts observed in 10% Avocado and Papaya yoghurts with Cane Sugar (10.7 ± 1.88 and 10 ± 2.26 cfu/g, respectively), and gradually declined over storage. Overall, fruit and honey addition enhanced acidity and microbial load, moderately lowered pH, while storage duration had minimal effect on these parameters.

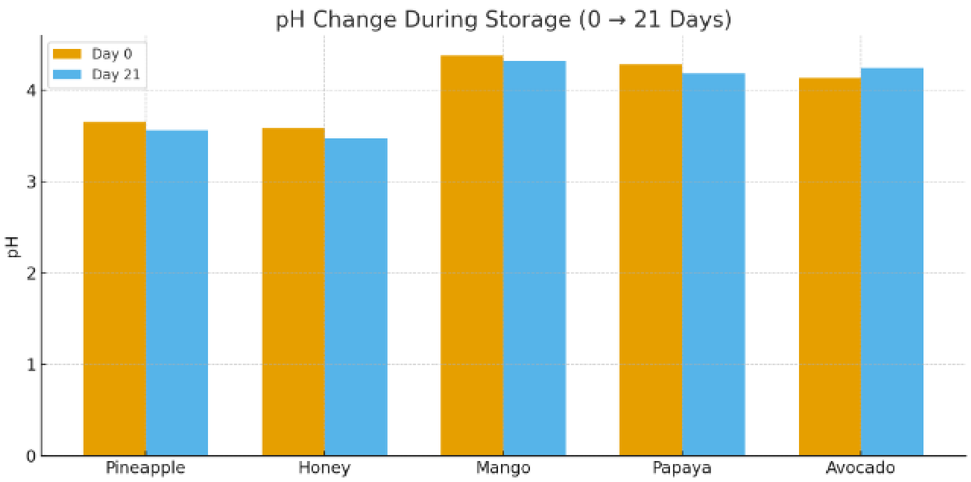
Following table summarizing acidity, pH, and TVC trends for all fruit- and honey-enriched yoghurt over 0, 7, 14, and 21 days.

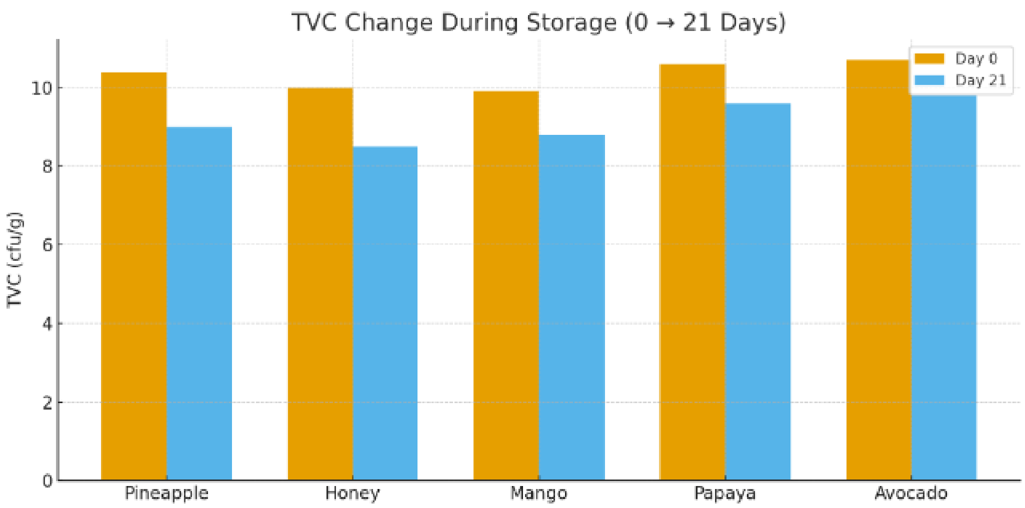
Yoghurt Type (10%)	Acidity (°D)	pH	TVC (cfu/g)
Pineapple	1.50 ± 1.68	3.65 ± 3.56	10.4 ± 9.0
Honey	0.99 ± 1.01	3.58 ± 3.47	10.0 ± 8.5
Mango	0.92 ± 0.95	4.38 ± 4.32	9.9± 8.8
Papaya	0.89± 0.94	4.28 ± 4.18	10.6 ± 9.6
Avocado	0.89± 0.92	4.13 ± 4.24	10.7 ± 9.8

- Acidity values are in °D (degrees Dornic) and increase slightly during storage.
- pH values slightly decline or remain stable depending on the fruit.
- TVC generally decreases over 21 days, though fruit type and sweetener influence microbial load.
- Sweetener type (Cane Sugar, Stevia, Aspartame) did not significantly affect acidity or pH but influenced TVC moderately




Acidity Change During Storage (0 → 21 Days)
Acidity (°D)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
Day 0
Day 21
Pineapple
Honey
Mango
Papaya
Avocado


pH Change During Storage (0 → 21 Days)
pH
0
1
2
3
4
Day 0
Day 21
Pineapple
Honey
Mango
Papaya
Avocado


TVC Change During Storage (0 → 21 Days)
TVC (cfu/g)
0
2
4
6
8
10
Day 0
Day 21
Pineapple
Honey
Mango
Papaya
Avocado

4.4.Sensory Attributes of Fruit- and Honey-Enriched Yogurt with Different Sweeteners

This study evaluated the sensory characteristics of yogurt samples enriched with various fruits (papaya, mango, avocado, pineapple) and honey, combined with three different sweeteners. The analyses focused on color and appearance, flavor, texture, taste, and overall acceptability.

ColorandAppearance

The highest scores for color and appearance were observed in yogurt samples containing 7.5% avocado (7.81 ± 1.32), followed closely by honey (7.72 ± 1.48), papaya (7.72 ± 1.27), pineapple (7.63 ± 1.56), and mango (7.36 ± 0.68). Notably, both higher and lower concentrations of fruits and honey resulted in lower scores. The type of sweetener did not significantly influence the color and appearance of the yogurt samples.

Flavor

Flavor intensity was most prominent in papaya-enriched yogurt sweetened with cane sugar, which recorded the highest mean score compared to control samples and other fruit varieties. The flavor generally improved with increasing fruit and honey concentrations. However, the effects of different sweeteners on flavor were not statistically significant, indicating that sweetener type did not markedly alter flavor perception.

Texture

Optimal texture was observed in yogurt samples containing 10% fruit or honey, particularly with cane sugar, which achieved the highest mean scores. Conversely, lower concentrations of fruit and honey yielded lower texture scores. The choice of sweetener did not significantly impact texture attributes.

Taste

Maximum taste scores were obtained in yogurt samples containing 10% papaya, with higher fruit and honey concentrations enhancing palatability. Similar to other attributes, the type of sweetener did not significantly influence taste profiles.

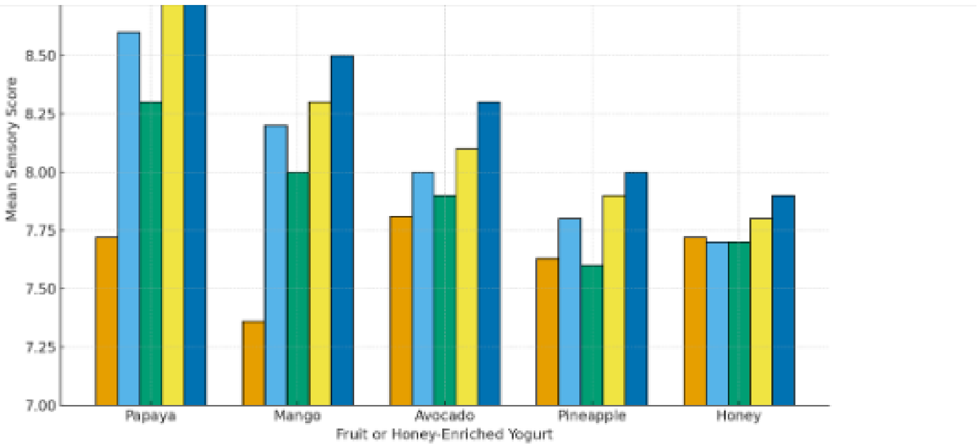
OverallAcceptability

The highest overall acceptability ratings were recorded for 10% papaya yogurt sweetened with cane sugar (8.81 ± 0.40), followed by mango, avocado, pineapple, and honey-based yogurts. Increased fruit and honey content correlated with higher acceptability scores.

Although cane sugar and aspartame did not differ significantly ($p > 0.05$), stevia processed samples exhibited significant differences, suggesting that sweetener choice may influence consumer preference under certain formulations.

AdditionalObservations

Among the fruit-enriched yogurts, papaya and mango demonstrated superior sensory scores, likely attributable to their availability throughout the year and nutritional benefits. Yoghurts containing honey and pineapple exhibited higher syneresis, acidity, and lower pH, leading to decreased palatability. Consequently, papaya fruit was prioritized for further optimization due to its favorable sensory and physicochemical properties.



Here's the bar diagram illustrating the sensory attributes of fruit- and honey-enriched yoghurts with different sweeteners. It clearly shows that papaya yoghurt achieved the highest scores across most parameters particularly in taste and overall acceptability followed by mango and avocado yoghurts.

4.5 Probiotic Yoghurt

4.5.1 Physico-chemical properties

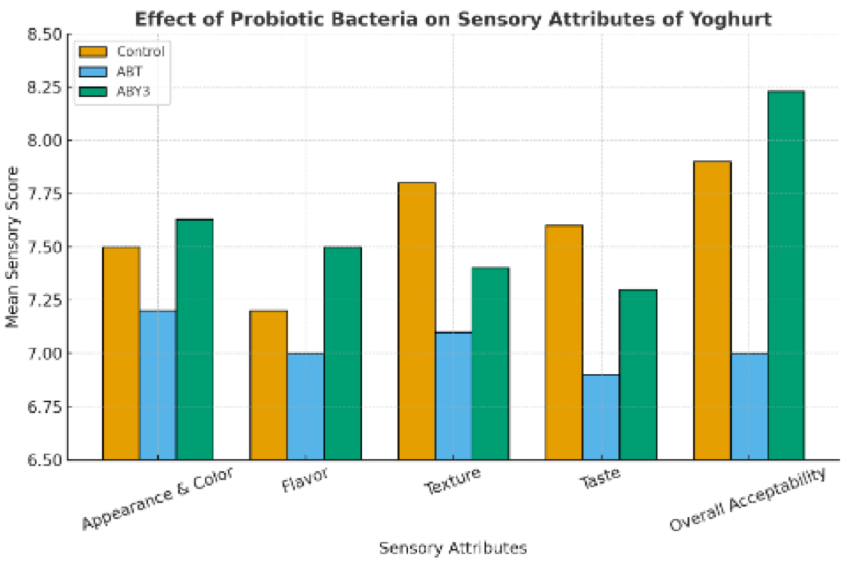
Probiotic yoghurt prepared using two probiotic cultures, ABT and ABY3, showed a gradual increase in syneresis and acidity with a corresponding decrease in pH during storage. Among the treatments, ABT yoghurt exhibited the lowest pH (4.13 ± 0.09) and highest acidity (1.19 ± 0.24) on the 21st day, followed by ABY3 (pH 4.22 ± 0.06; acidity 1.11 ± 0.25). Although probiotic yoghurts showed higher syneresis than the control, ABT-amended yoghurt recorded lower syneresis than ABY3.

4.5.2 Microbiological quality

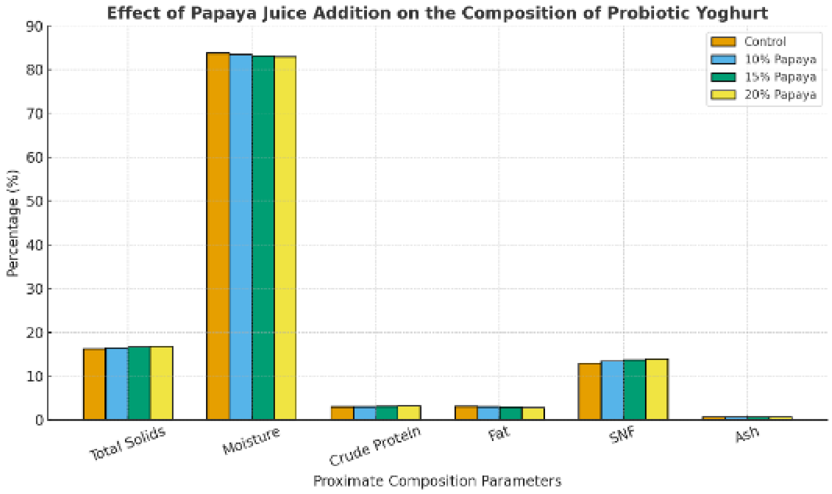
Total viable count (TVC) of probiotic yoghurts decreased gradually during storage and was lower than the control. Among probiotic samples, ABY3 yoghurt showed higher TVC than ABT throughout storage. Yeast, mould, and coliforms were absent in all probiotic yoghurts during the entire storage period.

4.5.3 Sensory evaluation

Sensory scores revealed significant differences ($p < 0.05$) among treatments. ABY3 yoghurt received the highest ratings for appearance, color (7.63 ± 0.11), flavor (7.50 ± 0.72), and overall acceptability (8.23 ± 0.42). Control yoghurt scored better in texture and taste, while ABT yoghurt had the lowest overall sensory acceptance.



Here's the bar diagram showing the effect of probiotic bacteria (ABT and ABY3) on the sensory attributes of yoghurt compared to the control sample. It clearly illustrates that ABY3-amended yoghurt achieved the highest scores in appearance, flavor, and overall acceptability



Here's the bar chart illustrating the effect of varying papaya juice concentrations on the proximate composition of probiotic yoghurt. It shows that total solids, protein, ash, and SNF increase with higher papaya levels, while fat and moisture decrease correspondingly.

DISCUSSION

Yoghurt remains a widely consumed fermented dairy product, increasingly tailored toward functional food applications such as fruit-flavoured or probiotic formulations. The incorporation of fruit pulps (e.g., papaya, mango, avocado, pineapple) into yoghurt can modify nutritional, physico-chemical and sensory attributes. For example, recent work shows that adding up to 15% of Dovyalis caffra fruit pulp resulted in lower fat and protein, decreased pH and increased titratable acidity during 21 days of refrigerated storage. MDPI In the present study, fruit- and honey-enriched yoghurts exhibited significant ($p < 0.05$) changes in syneresis, pH and acidity compared to controls. Our finding of increasing syneresis with fruit concentration aligns with a comprehensive review indicating that lower pH, high proteolytic activity and casein micelle contraction promote whey separation during storage. PMC+1 The progressive decline in pH and rise in acidity during storage mirror the typical post-acidification phenomena driven by starter and probiotic cultures metabolising residual lactose and other substrates (Tamime & Robinson, 1985; as corroborated by recent data).

Microbiologically, fruit- and honey-fortified yoghurts showed higher initial total viable counts (TVC) compared to control yoghurts, consistent with other studies where added plant-derived substrates support probiotic growth in early storage. For example, a 2024 study on yoghurt-like fermented milk enriched with Lactobacillus desidiosus and Lactobacillus fermentum reported TVC > 8 log CFU g^{-1} and no detectable coliforms during 28-day storage at 4 °C. SpringerLink In our work, absence of yeast, mould and coliforms further reflects good hygienic control.

Sensory evaluation revealed significant ($p < 0.05$) differences among treatments: addition of fruit and honey improved colour, flavour, texture, taste and overall acceptability. Notably, moderate fruit addition (10%) delivered optimum scores this observation is in line with a 2025 investigation which found that excessive fruit inclusion (>15%) significantly reduced acceptability and increased syneresis in yoghurt fortified with fruit pulp. Frontiers For the probiotic yoghurt component, the two bacterial combinations (ABT and ABY3) displayed expected trends: syneresis and acidity increased while pH declined during storage, as observed in earlier research. For example, the 2024 review of functional yoghurts notes that high acidity and low pH present challenges for probiotic viability. MDPI Compared to ABT, the ABY3-amended yoghurt exhibited better physico-chemical stability, higher viable counts and higher sensory ratings, indicating its suitability for further optimisation.

Nutritionally, papaya-juice supplementation of probiotic yoghurt enhanced total solids, protein, ash and solids-not-fat, while reducing fat and moisture outcomes aligned with the growing trend of using fruit matrices to improve dairy product nutrient profiles and functional appeal.

SUMMARY AND CONCLUSION

This study demonstrates that integration of fruit (particularly papaya) and probiotic cultures (especially ABY3) in yoghurt formulation yields a functional dairy product with improved nutritional, microbial, and sensory attributes.

- Fruit- and honey-fortified yoghurts exhibited higher total solids, protein, ash and SNF, and decreased fat and moisture levels compared to control yoghurts.
- Higher fruit concentration (up to 10–15%) resulted in improved sensory acceptance, but excessive levels may compromise texture and increase syneresis.
- Probiotic yoghurt produced with the ABY3 combination out-performed ABT in terms of stability, microbial viability and consumer acceptability.
- The absence of yeast, mould and coliforms throughout storage indicates hygienic processing and adequate shelf-life potential.

Given the year-round availability and low cost of papaya, and the rising consumer demand for functional dairy products, the formulated papaya-based probiotic yoghurt represents a viable option for scale-up in the Ethiopian dairy sector and similar contexts.

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