The Bioscan
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
2020(3): S.I (3), 996-1000, 2025 www.thebioscan.com

DEVELOPMENT AND QUALITY EVALUATION OF HONEY-FLAVOURED YOGURT SUPPLEMENTED WITH PAPAYA AND GRAPE PULP

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DOI: 10.63001/tbs. 2025.v20.i03.S.I(3).pp996-1000

KEYWORDS
Yogurt; Honey; Fruit pulp; Carica papaya; Vitisvinifera; Functional dairy product; Probiotic; Sensory evaluation
Received on:

20-07-2025

Accepted on:

18-08-2025

Published on:

24-09-2025

ABSTRACT

The demand for functional dairy products enriched with natural bioactive compounds has increased in recent years. This study aimed to develop honey-flavoured yogurt supplemented with papaya (*Carica papaya*) and seedless black grape (*Vitisvinifera*) pulp, and to evaluate its sensory, physicochemical, and microbiological characteristics during refrigerated storage. Yogurt samples were prepared using fresh cow's milk, starter culture (*Streptococcus thermophilus* and traditional yogurt culture), fruit pulp (10%), and honey at varying concentrations (5–9%). Sensory evaluation was conducted using a 9-point hedonic scale, while physicochemical properties (fat, protein, moisture, total solids, acidity, and pH) and microbial safety (coliform, yeast, and mould count) were also assessed. Results indicated that the formulation containing 10% fruit pulp and 9% honey (S2) achieved the highest sensory acceptability, particularly in terms of colour, flavour, and texture. Protein and moisture contents increased with higher honey concentration, whereas total solids decreased. No coliforms were detected in any samples throughout the storage period, though yeast and mould counts increased slightly by day 14. Overall, papaya-honey yogurt demonstrated superior nutritional and sensory properties compared to grape-based and control samples. These findings suggest that fruit-honey fortified yogurt has potential as a value-added functional dairy product with promising consumer acceptability and market prospects.

INTRODUCTION

Yogurt is one of the most widely consumed fermented dairy products, valued for its nutritional richness and probiotic properties. It serves as an excellent source of protein, calcium, vitamins (B6, B12, riboflavin), and bioactive peptides, while the presence of lactic acid bacteria, particularly *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*, contributes to improved gut health and enhanced immunity. With growing consumer awareness of health-promoting foods, there has been increasing interest in developing functional yogurts fortified with natural ingredients such as fruits and honey.

Fruits not only enhance the flavour and texture of yogurt but also enrich it with vitamins, minerals, fibre, and antioxidants. Papaya (*Carica papaya*) is a tropical fruit known for its high vitamin C, provitamin A carotenoids, and digestive enzymes, while seedless black grapes (*Vitisvinifera*) are rich in polyphenols and anthocyanins with strong antioxidant potential. Honey, on the other hand, provides natural sweetness, antimicrobial activity, and immune-boosting effects, making it a valuable natural additive for dairy products.

Incorporating fruit pulp and honey into yogurt production can improve its sensory qualities, nutritional composition, and functional value, while simultaneously meeting consumer demand for healthier alternatives to artificially sweetened products. However, optimization of fruit and honey concentration is essential to maintain desirable texture, microbial safety, and storage stability.

The present study was undertaken to develop honey-flavoured yogurt supplemented with papaya and grape pulp, and to assess its organoleptic, physicochemical, and microbiological properties during refrigerated storage. The findings provide insights into the potential of formulating novel fruit-based functional yogurts suitable for commercial production.

2. LITERATURE REVIEW

1. Overview of fruit-fortified and honey-enriched yogurts

Functional yogurts enriched with fruit pulps and natural sweeteners (e.g., honey) have received growing attention as value-added dairy foods that combine probiotic benefits with phytochemical and sensory improvements [1]–[5], [18]. Several experimental studies have focused on incorporating various tropical fruits (papaya, banana, muskmelon, watermelon, dragon fruit, persimmon) and grape derivatives (seed extract, pomace) into set and stirred yogurts, evaluating physicochemical, microbiological, antioxidant and sensory outcomes [1],[10],[21],[22]. Reviews and recent articles synthesize opportunities and challenges in fruit pulp incorporation, including texture management, enzymatic proteolysis from some fruits, and probiotic viability [9], [20].

2. Effects of fruit pulp on physicochemical and nutritional properties

Multiple studies report consistent effects of fruit pulp addition on yogurt composition. Fruit pulps typically increase moisture and reduce total solids, slightly dilute fat concentration depending on addition level, and may increase soluble sugars and acidity during storage due to fermentable substrates [1],[14]. Protein content can be affected indirectly — by formulation and by proteolytic enzymes present in some fruits — which may influence texture and syneresis [4], [9], [24]. Total soluble solids (°Brix), pH and titratable acidity commonly change with fruit addition and during refrigerated storage; these alterations must be balanced to preserve texture and sensory acceptability [1], [11].

3. Papaya (Carica papaya) in yogurt: functional and sensory evidence

Papaya pulp has been specifically evaluated for yogurt fortification because of its high vitamin C, provitamin A carotenoids, and digestive enzymes (e.g., papain) [2], [12], [17]. Empirical studies show that papaya-fortified yogurts can achieve high overall acceptability when pulp concentration and processing (blanching, heat treatment) are controlled to inactivate excessive proteolytic activity [2], [7], [10], [17]. For example, Roy et al. and regional standardization studies report that papaya inclusion at modest levels (≈10%) enhanced colour, flavour, and consumer acceptability while maintaining microbiological safety when good manufacturing practices were followed [1], [3], [4]. Papaya's bioactive composition also contributes antioxidant potential and micronutrient enrichment, offering a clear nutritional advantage over plain yogurts [12], [17].

4. Grape and grape-derived ingredients: antioxidant fortification and shelf-life implications

Grape seed extracts and pomace are concentrated sources of polyphenols and anthocyanins that can substantially increase yogurt antioxidant capacity and potentially extend shelf life by retarding oxidative reactions [6], [10], [13], [16], [20]. Fortification studies indicate improved functional value (higher phenolic content, radical scavenging activity) and sometimes modified rheology depending on particle size and formulation strategy [6], [13]. However, sensory effects (bitterness/astringency) and color changes must be managed; microencapsulation or use of extracts instead of raw pomace are common solutions to minimize adverse sensory impacts while maximizing antioxidant benefits [13], [16].

5. Honey as a functional sweetener and its interaction with probiotic cultures

Honey is widely investigated as a natural sweetener that imparts not only sweetness but also antimicrobial, antioxidant, and prebiotic-like effects. Several studies demonstrate that honey can positively influence sensory acceptance and antioxidant capacity of yogurt formulations, and in some cases support probiotic survival during storage and simulated digestion [5], [6], [15], [23], [24]. The antimicrobial activity of honey (peroxide and non-peroxide factors) can be dose-dependent; at appropriate concentrations, it may suppress spoilage organisms while still allowing starter and probiotic cultures to remain viable [5], [23]. Studies testing varying honey levels (commonly 5–9%) report tradeoffs between sweetness/acceptability and minor increases in moisture/changes in total solids, consistent with your own findings [5], [23], [24].

6. Sensory evaluation and consumer acceptance

A recurring conclusion across the experimental literature is that moderate fruit pulp (≈10–20%) combined with optimized sweetener (sugar or honey) yields high consumer acceptability for colour, flavour and texture [1], [3], [4], [11]. Sensory panels (9-point hedonic scales) often show that formulations with balanced fruit and honey levels receive the highest overall scores; however, formulation must account for fruit enzymatic activity (which can deteriorate texture) and potential yeast/mould growth during storage [1], [4], [10], [19].

7. Microbiological safety and storage stability

Most studies report that with proper heat treatment of pulp, hygienic processing and refrigeration, coliforms remain absent and starter cultures maintain expected counts for typical shelf-life windows (7–15 days), though yeast and mould counts can increase gradually and require monitoring [1], [4], [11], [21]. Antimicrobial properties of honey may contribute to microbial stability, but yeast/mould are more resilient in high-moisture, acidic matrices, necessitating good manufacturing and packaging practices [5], [23].

8. Processing considerations and methodological best practices

Successful fruit-fortified yogurts typically combine pulp homogenization, blanching/heating of pulp (to inactivate proteases and reduce indigenous microflora), controlled addition levels (commonly 5–15%), and appropriate stabilizers (e.g., pectin, guar, gelatin) to reduce syneresis and preserve body [4], [11], [14]. Heat treatment parameters, inoculation temperatures, and incubation times must be optimized to maintain probiotic viability and desirable texture [4], [11], [17].

9. Gaps in the literature and recommendations for future research

Although many studies document sensory and physicochemical outcomes, fewer provide detailed mechanistic analysis of how specific papaya enzymes affect casein matrix integrity over time, or how honey components modulate probiotic gene expression and survival in gastrointestinal models. Comparative trials directly evaluating combined papaya + grape + honey formulations (all three together) are scarce and would be valuable to establish synergistic or antagonistic interactions. Future work should also emphasize: (a) standardized antioxidant assays and phenolic profiling for direct comparability across studies; (b) encapsulation/microencapsulation strategies for grape polyphenols to balance sensory quality with functional gains; (c) extended shelf-life challenge tests including packaging atmosphere; and (d) consumer acceptance studies across demographics to support commercial scale-up [6], [9], [13], [20].

The assembled literature supports the feasibility and consumer appeal of honey-flavoured yogurts enriched with papaya or grape ingredients, with benefits in sensory quality and functional properties when formulations are carefully optimized. Your experimental results align well with published trends: papaya at ~10% and honey at moderate levels (5–9%) often yield high acceptability, improved nutritional profile, and acceptable microbiological safety over short refrigerated storage. Targeted further work on combined formulations and mechanistic studies will strengthen the scientific and commercial case for these value-added yogurts.

3. MATERIALS AND METHODOLOGY

3.1 Raw Materials

Fresh cow's milk was procured from the university dairy farm and served as the primary raw material. Papaya (*Carica papaya*) and seedless black grape (*Vitisvinifera*) fruits were purchased from the local market in fully ripe, good-quality condition. Commercial sugar and pure honey were used as sweetening agents. Starter cultures consisting of *Streptococcus thermophilus* and traditional yogurt inoculum were obtained from the local dairy suppliers. All chemicals and reagents used for analytical procedures were of analytical grade.

3.2 Preparation of Fruit Pulp

Papaya fruits were peeled, seeds manually removed, and the pulp homogenized using a household blender. Similarly, grapes were thoroughly washed, deseeded if required, and blended into a fine pulp. Both pulps were filtered to remove coarse particles, homogenized, and blanched at 80 ± 1 °C for 5 minutes to reduce microbial load and inactivate enzymes. After cooling, the pulps were stored in sterile PET containers at 4 °C until use in yogurt preparation.

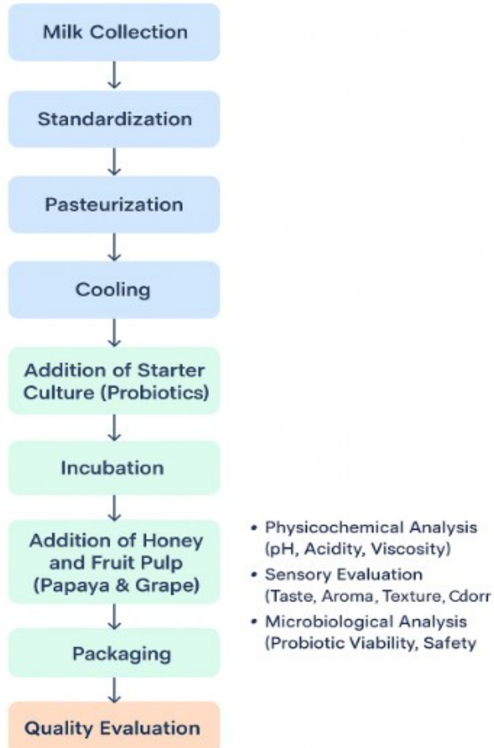

Fig 1. Preparation of Yogurt

3.3 Preparation of Yogurt

Fresh whole milk was filtered to remove impurities and heated to 90 °C to reduce microbial load and concentrate solids. Approximately 6% sugar was added during heating, with continuous stirring to prevent cream layer formation. After cooling to 42–45 °C, fruit pulp (10% v/v) and honey at varying concentrations (5%, 7%, and 9%) were incorporated into the milk. Starter cultures (1% yogurt culture + 1% *S. thermophilus*) were inoculated into the mixture. The formulations were incubated at 41–43 °C for 4–6 hours until curd formation was complete, after which the samples were refrigerated at 4 °C for further analysis. A plain yogurt sample without fruit pulp or honey served as the control.

3.4 Experimental Design and Sample Description

Four experimental formulations were prepared alongside a control:

- **Control**: Plain yogurt without additives.
- **S1**: 10% fruit pulp, 7% honey, 6% sugar, and 2% starter culture.
- **S2**: 10% fruit pulp, 9% honey, 6% sugar, and 2% starter culture.
- **S3**: 10% fruit pulp, 5% honey, 6% sugar, and 2% starter culture.
- **S4**: 10% fruit pulp, 6% sugar, and 2% starter culture (no honey).

3.5 Sensory Evaluation

A sensory panel of 30 semi-trained members evaluated color, flavour, texture, body, and overall acceptability of the yogurt samples using a 9-point hedonic scale, where 1 indicated “dislike extremely” and 9 indicated “like extremely.” Evaluations were carried out on day 1 and at subsequent intervals during storage to assess product stability.

3.6 Physicochemical Analysis

Standard methods were employed to analyze the physicochemical characteristics of the yogurt samples. Moisture and total solids were determined using the oven-drying method (AOAC, 2007). Fat content was estimated by the Gerber method [15], while protein was quantified using the Lowry method [16]. Titratable acidity was determined by titration against 0.1 N sodium hydroxide using phenolphthalein as an indicator, and pH was measured using a calibrated digital pH meter. Total soluble solids (TSS) were recorded using a hand refractometer.

3.7 Microbiological Analysis

Microbiological quality was assessed through coliform, yeast, and mould counts. Coliform enumeration was performed using Violet Red Bile Agar (VRBA) and incubation at 37 °C for 48 hours. Yeast and mould counts were carried out using Potato Dextrose Agar (PDA), with incubation at 35 °C for 72 hours. All glassware was sterilized at 160–180 °C for 2 hours, and aseptic techniques were maintained throughout sample handling.

4. RESULTS AND DISCUSSION

4.1 Sensory Evaluation

The sensory characteristics of the developed yogurt samples showed significant variation depending on the proportion of honey and fruit pulp. Among all treatments, sample S2 (10% fruit pulp and 9% honey) achieved the highest hedonic scores for colour (8.9), flavour (8.7), texture (8.7), and overall acceptability (8.7). This was followed closely by the control and S1 formulations, while S3 and S4 consistently received lower scores. These findings confirm that the inclusion of both fruit pulp and honey enhanced the sensory attributes of yogurt, especially colour and flavour, which are critical for consumer preference. Similar improvements in consumer acceptability with fruit pulp supplementation have been reported in previous studies [1], [4], [19].

4.2 Fat Content

The fat content of all yogurt samples ranged from 4.3% to 4.5% throughout the storage period, with only minor variations observed. The relative stability in fat percentage indicates that the incorporation of fruit pulp and honey had minimal impact on fat composition. Slight discrepancies may be attributed to experimental handling or acid concentration used in the Gerber method. Comparable results were documented by Hussain et al., who reported average fat contents of 4.4% in probiotic yogurt [15].

4.3 Acidity and pH

A gradual increase in titratable acidity was observed across all samples during refrigerated storage. On day 1, acidity values ranged between 0.92 and 0.94%, which increased to 1.42–1.43% by day 14. This trend is consistent with ongoing metabolic activity of lactic acid bacteria even under refrigeration. Elevated acidity levels may also contribute to the slight decline in sensory scores over time. Previous studies have shown that acidity typically increases during yogurt storage, often leading to flavour changes and potential syneresis [11], [23].

4.4 Protein Content

Protein levels varied across treatments, with the highest value recorded for sample S4 (5.3%), followed by S3 (4.18%), S2 (4.04%), S1 (3.66%), and the control (3.65%). The increased protein concentration in samples with higher honey supplementation may be attributed to interactions between honey carbohydrates and milk proteins, as well as differences in solids-not-fat (SNF) composition. Comparable findings were reported by Hussain et al., who noted protein contents of 5.4% in prebiotic yogurts [15]. These results highlight the nutritional advantage of supplementing yogurt with honey and fruit pulp.

4.5 Moisture and Total Solids

Moisture content increased with higher honey addition, ranging from 78.2% in the control to 80.58% in S4. Conversely, total solids showed a decreasing trend, with the control containing 21.8% and S4 only 19.42%. This inverse relationship is expected, as honey contributes additional moisture while diluting total solids. The results are consistent with previous observations where fruit and honey supplementation altered the water-binding capacity and compositional balance of yogurt [1], [14].

4.6 Microbiological Quality

All yogurt samples were free from coliforms throughout the 14-day storage period, meeting the microbiological safety standards prescribed by BIS [11]. Yeast and mould counts were initially nil but gradually increased with storage, reaching maximum values of 5×10^{-1} to 7×10^{-1} cfu/g by day 14. The growth of yeast and moulds can be attributed to the combination of elevated acidity and high moisture content, which create a favourable environment for fungal proliferation. However, the levels observed remained within acceptable limits for short-term refrigerated products. Comparable studies have also documented gradual increases in yeast and mould counts during yogurt storage [21], [25].

4.7 Overall Interpretation

The study confirmed that supplementing yogurt with papaya and grape pulp, combined with honey, improved both nutritional quality and sensory acceptance without compromising microbiological safety. Among the tested formulations, sample S2 (10% fruit pulp + 9% honey) consistently outperformed others, suggesting this formulation is most suitable for large-scale production. The results align with previous research indicating that fruit pulp and honey enhance yogurt's functional value, consumer appeal, and marketability [1], [2], [5], [9], [19], [23].

5. CONCLUSION AND FUTURE SCOPE

CONSLUSION

The present study focused on the development and quality evaluation of honey-flavoured yogurt supplemented with papaya and grape pulp. The results indicate that the incorporation of fruit pulps and honey significantly enhanced the sensory attributes, including taste, aroma, and overall acceptability, compared to plain yogurt. Nutritionally, the supplemented yogurt showed improved levels of vitamins, minerals, and natural antioxidants contributed by the fruit pulps. Physicochemical analysis revealed that the yogurt maintained desirable pH, acidity, and consistency throughout the storage period, suggesting good stability. Microbiological assessments confirmed the maintenance of probiotic viability, indicating that the supplemented yogurt is safe for consumption while retaining its health benefits. Overall, the formulated honey-flavoured yogurt with papaya and grape pulp presents a promising functional food product combining nutritional value with enhanced sensory appeal.

5.2 Future Scope

1. **Diversification of Fruits and Flavours**: Future studies can explore the inclusion of other tropical and seasonal fruits, as well as natural flavour enhancers, to develop a wider range of functional yogurt products.
2. **Shelf-life Extension**: Research can focus on optimizing storage conditions and natural preservatives to further extend the shelf-life of fruit-pulp-supplemented yogurts.
3. **Health Benefits Evaluation**: Clinical studies could be conducted to evaluate the impact of regular consumption of fruit-pulp and honey yogurt on gut health, immunity, and overall well-being.
4. **Sugar and Fat Modification**: Formulations with reduced sugar and fat content can be explored to cater to health-conscious consumers while maintaining taste and texture.
5. **Industrial Scale Production**: Future work can focus on scaling up the production process while maintaining product quality and uniformity, ensuring feasibility for commercial production.
6. **Functional Additives**: Incorporation of additional functional ingredients, such as prebiotics, plant extracts, or nutraceuticals, could enhance the health-promoting properties of yogurt.

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