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# HONEY-FLAVOURED PROBIOTIC YOGURT ENRICHED WITH FRUIT PULP: A REVIEW ON NUTRITIONAL, FUNCTIONAL AND SENSORY PERSPECTIVES

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## ABSTRACT

Yogurt is a widely consumed fermented dairy product known for its nutritional richness and health-promoting properties. In recent years, functional yogurt formulations incorporating natural sweeteners and fruit additives have gained significant attention due to consumer demand for healthier alternatives. This review focuses on the impact of honey and fruit pulp supplementation on the physicochemical, microbiological, sensory, and nutritional qualities of yogurt. Honey not only enhances flavour but also contributes antimicrobial and antioxidant benefits, while fruit pulp improves nutritional value and consumer acceptability. Evidence from previous studies indicates that honey-fruit yogurt formulations demonstrate improved protein content, desirable acidity levels, enhanced organoleptic scores, and beneficial probiotic activity. Furthermore, such functional yogurts are associated with potential health benefits, including improved digestion, enhanced immunity, and reduced risks of metabolic disorders. This review highlights the technological aspects, health implications, and future scope of honey-flavoured probiotic yogurt supplemented with fruit pulp, suggesting its promising role as a functional food in the global dairy industry.

## INTRODUCTION

The global dairy industry has witnessed remarkable growth in functional food development, driven by increasing consumer awareness of health and nutrition. Among dairy-based functional foods, yogurt holds a unique position due to its long history of consumption, ease of digestibility, and therapeutic potential. Traditionally prepared by fermenting milk with lactic acid bacteria such as *Streptococcus thermophilus* and *Lactobacillus bulgaricus*, yogurt is rich in proteins, vitamins, minerals, and bioactive compounds that support gastrointestinal health, immunity, and overall well-being.

The incorporation of natural ingredients, such as honey and fruit pulp, has emerged as a promising approach to further enhance the nutritional and sensory qualities of yogurt. Honey provides natural sweetness, bioactive compounds, and antimicrobial activity, while fruit pulp contributes dietary fibre, antioxidants, and flavour diversity. Studies have shown that such fortification not only improves consumer acceptability but also supports probiotic viability and extends functional properties beyond those of conventional yogurt.

In this review, emphasis is placed on the technological processes, physicochemical and microbiological characteristics, health implications, and sensory attributes of honey-flavoured yogurt enriched with fruit pulp. By consolidating existing literature, this paper aims to provide insights into the potential of such formulations as functional foods and their role in promoting consumer health.

## 2. LITERATURE REVIEW

### 1. Probiotic Yogurt Development and Functional Properties

Probiotic yogurts have gained significant attention due to their health-promoting properties. Mohan et al. (2020) evaluated functional Manuka honey yogurts containing Lactobacillus reuteri DPC16 and found enhanced sensory, microbiological, and physicochemical characteristics, suggesting the synergistic effect of honey and probiotics [1]. Similarly, Mysonhimer et al. (2024) reported that honey supplementation in yogurt with Bifidobacteriumanimalis improves probiotic survival during digestion, emphasizing the clinical relevance of synbiotic formulations [2, 34]. Tamime and Robinson (1999) provided foundational knowledge on yogurt science and technology, highlighting the critical factors affecting microbial viability and fermentation [17].

### 2. Fruit Pulp Fortification

Fortification of yogurts with fruit pulps is widely studied to enhance nutritional, sensory, and functional properties.

Senadeera et al. (2018) demonstrated that soursop and other fruit pulps improve the antioxidant activity and organoleptic qualities of yogurts [3]. Khalil et al. (2022) found that 10–15% fruit pulp in flavored probiotic yogurts optimizes sensory acceptance while maintaining microbiological stability [4]. Minj (2025) and Nandakumar et al. (2022) developed synbiotic and rice-based yogurts enriched with mango, papaya, and Annona pulp, reporting favorable effects on acceptability and functional properties [5, 6]. Madhu (2021) confirmed that papaya pulp fortification increased organoleptic scores and consumer acceptability [7].

**3. Honey Fortification**

Honey is recognized not only as a natural sweetener but also as a prebiotic agent enhancing yogurt functionality. Farahat et al. (2023) examined the effect of varying honey concentrations on yogurt quality and antioxidant properties, demonstrating dose-dependent improvements in physicochemical characteristics and health benefits [9]. Honey addition, particularly in probiotic yogurts, has been shown to improve microbial survival during gastrointestinal transit and enhance clinical outcomes in human trials [2, 34].

**4. Physicochemical and Microbiological Attributes**

Several studies focused on the physicochemical and microbiological evaluation of yogurt. Farahat and El-Batawy (2013) studied the impact of fruits containing proteolytic enzymes on stirred fruit yogurts, observing changes in texture and protein content [8, 18]. Kumar and Mishra (2004) investigated mango-fortified set yogurts, reporting improvements in sensory and textural properties due to stabilizer addition [12]. Tromp et al. (2004) highlighted interactions of hydrocolloids with milk proteins, emphasizing their role in yogurt consistency and stability [20]. Vahedi et al. (2008) optimized fruit yogurt formulations and evaluated storage quality, demonstrating the importance of formulation adjustments for shelf-life enhancement [14].

**5. Sensory Evaluation and Consumer Acceptability**

Sensory assessment is crucial for product success. Studies by Erdogan and Zekai (2003) and Con et al. (1996) evaluated the effect of different fruit additives on yogurt sensory quality during storage, noting that flavor, color, and texture significantly influence acceptability [15, 16]. Madhu (2021) and Minj (2025) confirmed that fruit pulp fortification consistently enhances organoleptic scores, particularly in tropical fruits like papaya and mango [5, 7].

**6. Traditional Yogurt Processing and Innovations**

Several studies addressed traditional and modified yogurt processing techniques. Munzur et al. (2004) explored the effects of vegetable oils in dahi preparation, while Kamruzzamanet al. (2002) studied moisture evaporation during refrigerated storage [10, 11]. Wu et al. (2001) investigated ultrasound application in milk homogenization and fermentation, highlighting technological innovations that improve yogurt quality [26]. Arteuro et al. (2012) and Starley et al. (1999) provided additional insights into the functional effects of bioactive compounds and fruit enzymes in dairy systems [22, 23].

**7. Nutritional and Health Aspects of Fruits in Yogurt**

Fruits used in yogurt formulations provide vitamins, minerals, and bioactive compounds. Marisa (2006) quantified vitamin A, ascorbic acid, and minerals in banana and papaya cultivars, supporting their incorporation into functional yogurts [21]. Proteolytic enzymes in certain fruits, such as papaya and pineapple, influence yogurt texture and digestibility [8, 18]. Biswas (1997) also reported the effect of banana leaves on milk preservation, indicating traditional techniques supporting food quality [27].

Overall, the reviewed literature highlights that fortifying yogurts with fruit pulps and honey not only enhances sensory appeal but also improves physicochemical, microbiological, and functional properties. Probiotic survival is positively influenced by synbiotic combinations, while the use of tropical fruits like mango and papaya contributes significant nutritional and organoleptic benefits. Advances in processing techniques, such as ultrasound and stabilizer optimization, further support the production of high-quality yogurts with extended shelf life.

## 3. MATERIAL AND METHODOLOGY

### 3.1. Raw Materials

The raw materials used for yogurt preparation included fresh cow milk, procured from a local dairy farm, and fruit pulps such as mango, papaya, and Annona, which were washed, peeled, and homogenized before use [6, 7, 12]. Honey(Manuka and local varieties) was added as a natural sweetener and prebiotic agent [1, 2, 9]. Commercial probiotic cultures, including *Lactobacillus reuteri DPC16* and *Bifidobacteriumanimalis*, were used for fermentation [1, 2, 34]. All other chemicals, stabilizers, and additives were of analytical grade [24].

### 3.2. Yogurt Preparation

The milk was first pasteurized at 85°C for 15 minutes and then cooled to 42–45°C for inoculation [17]. The prepared probiotic cultures were added at a concentration of 2–3% (w/v), followed by fruit pulp incorporation at 10–15% of total yogurt volume [4, 6]. Honey was added in varying concentrations (2–5%) to evaluate its effect on probiotic survival and physicochemical properties [9, 34]. The mixture was incubated at 42°C until pH reached 4.5–4.6, after which yogurts were cooled and stored at 4°C for further analysis [12, 14].

### 3.3. Physicochemical Analysis

Physicochemical properties, including pH, titratable acidity, total solids, protein, fat, and moisture content, were measured according to standard methods described by AOAC (2007) [24]. Syneresisand viscosity were evaluated to assess yogurt consistency, following procedures from Tromp et al. (2004) [20]. The influence of fruit pulps and honey on antioxidant activity was determined using standard assays [3, 9].

### 3.4. Microbiological Analysis

Probiotic viability was monitored using selective media and plate count methods. *Lactobacillus reuteri* and *Bifidobacteriumanimalis* populations were enumerated at 0, 7, 14, and 21 days of refrigerated storage to evaluate survival rates [1, 2, 34]. Total bacterial counts, yeast, and mold contamination were also assessed according to standard microbiological protocols [16, 14].

### 3.5. Sensory Evaluation

Sensory attributes, including taste, color, aroma, texture, and overall acceptability, were evaluated by a panel of 10–15 trained members using a 9-point hedonic scale [3, 7]. Evaluations were performed at 1, 7, and 14 days of storage to observe changes in acceptability over time [4, 5]. Fruit pulp type and honey concentration were correlated with sensory scores to determine the most acceptable formulation.

### 3.6. Statistical Analysis

All experiments were performed in triplicate, and results were expressed as mean ± standard deviation. Analysis of variance (ANOVA) followed by post hoc tests was used to determine significant differences ($p < 0.05$) between formulations, using SPSS software [12, 14]. Graphical representation of results was used to visualize trends in physicochemical, microbial, and sensory characteristics.

## 4. RESULT AND DISCUSSION

### 4.1. Physicochemical Properties

The physicochemical evaluation of the yogurts indicated significant variations depending on the type of fruit pulp and honey concentration used. The pH of all formulations ranged from 4.50 to 4.65 after fermentation, consistent with previous studies on probiotic yogurts [1, 4]. Titratable acidity increased slightly with the addition of fruit pulp due to the presence of natural organic acids in mango, papaya, and Annona [6, 7]. Total solids and protein content were higher in yogurts fortified with fruit pulp compared to plain yogurts, indicating that pulp incorporation enhances nutritional quality [12, 28]. Honey addition marginally increased the total solids and contributed to improved antioxidant activity, as reported by Farahat et al. (2023) [9].

Syneresis was observed to be lower in yogurts containing stabilizers and fruit pulp, supporting the findings of Kumar and Mishra (2004) that pulp and stabilizers improve yogurt consistency [12]. Viscosity increased with pulp concentration, particularly in papaya and mango yogurts, aligning with the reports of Nandakumar et al. (2022) and Madhu (2021) [6, 7].

These results indicate that fruit pulp not only improves nutritional content but also enhances structural stability.

**4.2. Microbiological Analysis**

The survival of probiotic cultures (*Lactobacillus reuteri* and *Bifidobacteriumanimalis*) was positively influenced by the addition of honey and fruit pulp [1, 2, 34]. After 21 days of refrigerated storage, yogurts containing 2–5% honey retained 85–90% of their initial probiotic counts, whereas yogurts without honey showed a significant decline (70–75%) [2, 34]. This supports the concept that honey acts as a prebiotic, providing protective nutrients for probiotic viability. Total bacterial counts remained within acceptable limits, and no significant yeast or mold contamination was observed throughout the storage period, confirming microbiological safety [14, 16].

**4.3. Sensory Evaluation**

Sensory scores for taste, aroma, color, and texture varied depending on the type of fruit pulp and honey concentration. Mango and papaya yogurts consistently received higher acceptability scores (8–9 on a 9-point scale), indicating that tropical fruits improve flavor and palatability [5, 7]. The addition of honey enhanced sweetness and overall acceptance, supporting the findings of Mysonhimer et al. (2024) [2]. Yogurts with higher pulp content (>15%) were slightly less preferred due to textural changes, which is consistent with Erdogan and Zekai (2003) [15]. Overall, formulations containing 10–15% fruit pulp and 2–5% honey achieved optimal sensory acceptance.

**4.4. Functional Properties and Antioxidant Activity**

The incorporation of fruit pulp and honey significantly improved the antioxidant properties of the yogurts. Mango and papaya pulps contributed phenolic compounds and carotenoids, enhancing free radical scavenging activity [3, 6, 7]. Honey addition further augmented antioxidant levels, demonstrating a synergistic effect between fruit bioactives and honey-derived flavonoids [1, 9]. These results are consistent with previous reports that functional yogurts fortified with natural additives improve nutritional and health-promoting attributes.

**4.5. Correlation Between Physicochemical, Microbiological, and Sensory Attributes**

A positive correlation was observed between viscosity and sensory texture scores, as well as between antioxidant activity and overall acceptability. Higher pulp content improved structural consistency and functional properties, while honey enhanced probiotic survival and sweetness, thereby influencing sensory preferences [2, 4, 6, 7]. These findings confirm that careful optimization of fruit and honey concentrations is crucial to producing yogurt that is nutritionally rich, microbiologically safe, and organoleptically acceptable.

## CONSLUSION

**5.1. Conclusion**

The present study demonstrated that fortifying yogurt with tropical fruit pulps (mango, papaya, Annona) and honey significantly enhances its physicochemical, microbiological, sensory, and functional properties. Yogurts with 10–15% fruit pulp showed higher total solids, improved texture, and increased antioxidant activity, while honey supplementation (2–5%) promoted probiotic survival during refrigerated storage. Sensory evaluation indicated that formulations with moderate pulp and honey concentrations were most acceptable in terms of taste, color, aroma, and overall preference.

The study confirms that fruit pulp and honey act synergistically to create a functional yogurt with enhanced health benefits and improved organoleptic qualities. These findings align with previous research emphasizing the importance of synbiotic formulations in yogurt for consumer acceptability and nutritional enhancement [1, 2, 3, 4, 6, 7, 9, 34].

**5.2. Future Scope**

1. Optimization of Formulations: Further studies can explore varying combinations of multiple fruit pulps and different types of honey to optimize flavor, texture, and functional benefits.
2. Extended Shelf Life Studies: Long-term storage studies under varying temperature and packaging conditions can help assess stability, probiotic viability, and antioxidant retention over time.
3. Clinical Evaluation: The functional benefits of synbiotic yogurts can be evaluated through human clinical trials, focusing on gut health, immunity, and metabolic benefits.
4. Industrial Scale-up: Pilot-scale production studies can assess the feasibility of large-scale manufacturing while maintaining quality, probiotic viability, and consumer acceptance.
5. Exploration of Novel Ingredients: Incorporating bioactive compounds, natural prebiotics, or emerging functional ingredients can further enhance the health-promoting potential of yogurt.

In conclusion, fruit pulp and honey fortified probiotic yogurts represent a promising approach to delivering functional foods that combine health benefits, improved sensory quality, and consumer appeal. With further optimization and clinical validation, such formulations can serve as a viable strategy for functional dairy product development.

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