***Review Article***

**Functional Properties and Challenges in Production of Goat Milk-Fruit Pulp Based Composite Sweets**

**ABSTRACT**

Goat milk, known for its superior digestibility, bioactive composition and low allergenicity, is a promising source for the development of functional dairy sweets. However, its distinct flavor and textural limitations often reduce consumer acceptance. Integrating fruit pulps, such as mango, papaya and berries, enhances the nutritional, sensory and functional properties of goat milk-based sweets, offering improved flavor, color, antioxidant capacity and shelf stability. This review explores the nutritional composition and functional attributes of goat milk and tropical fruit pulps, examines traditional and novel sweet goat milk formulations and evaluates processing considerations, sensory enhancements and microbial stability. Challenges related to cost, standardization and consumer perception are discussed along with opportunities for diversification through underutilized fruits and indigenous goat breeds. Advanced food technologies, such as microencapsulation and freeze drying, offer solutions for extending the shelf life and preserving bioactivity. Overall, this review highlights the potential of goat milk–fruit pulp sweets as innovative, health-promoting functional foods with promising commercial applications.

**Keywords**: *Goat milk, Nutritional composition, Fruit pulps, Sweets.*

1. **INTRODUCTION**

Traditional dairy sweets hold a significant place in Indian culture, serving as symbols of celebration, prosperity and social unity (Kapoor, 2021). These sweets, including khoa-based products, *Kulfi*, *Rasogulla* and *Shrikhand* are not only culinary delights, but also represent cultural heritage and social traditions. They are often prepared and consumed during festivals, weddings and other important occasions, thereby reinforcing social bonds and cultural identity.

Goat milk offers unique nutritional benefits compared to cow milk, making it an attractive alternative for dairy product development. It is composed of smaller fat globules, lower αs1-casein content and higher concentrations of medium-chain triglycerides, vitamins, minerals and bioactive compounds (Tafes, 2020;Lad *et al*., 2017). These characteristics contribute to enhanced digestibility and various health benefits including antioxidant, anti-inflammatory and cardioprotective effects. These properties make goat milk particularly advantageous for individuals who are lactose intolerant or allergic to cow milk protein. Goat milk contains lactic acid bacteria (LAB) and offers numerous health benefits through its fermented products (Bokadia *et al*., 2024). These products are rich in probiotics, which support digestive health and boost the immune system (Meena *et al*., 2017, 2023). Fermentation enhances the bioavailability of nutrients and reduces lactose content, making it more digestible for lactose-intolerant individuals (Joshi *et al*., 2025). Fermented goat milk products also possess antimicrobial properties, which may help prevent gastrointestinal infections. In addition, they contain bioactive peptides that can lower blood pressure and exhibit anti-inflammatory effects. The unique fatty acid profile of goat milk, combined with the beneficial effects of fermentation, contributes to improved overall health and well-being (Meena *et al.*, 2025). However, goat milk faces challenges in consumer acceptance owing to its characteristic flavor and poor gelation properties. These sensory limitations can affect the overall appeal of goat milk-based products, potentially hindering their widespread adoption in the market.

To address these challenges and to enhance the nutritional and sensory profiles of goat milk-based sweets, researchers have explored the incorporation of fruit pulp. Fruits contribute to natural flavors, colors and bioactive compounds, offering a promising solution for improving product quality and consumer acceptance. The integration of fruit pulps, such as apple, sapota, papaya and kiwi, has shown significant potential in mitigating the sensory limitations of goat milk (Sahu *et al*., 2021; Sahu *et al*., 2025; Yadav *et al*., 2018). The incorporation of fruit pulp into goat milk-based sweets has been shown to significantly improve the overall sensory and functional attributes. The addition of fruit pulp not only enhances the sweetness and flavor profile - effectively masking the characteristic "goaty" taste often perceived as undesirable by consumers - but also contributes to improved color and visual appeal, making the products more attractive. Furthermore, the inclusion of fruit pulp modifies the texture and mouthfeel, resulting in a more desirable consistency and contributing to an increase in antioxidant activity, thereby potentially offering additional health benefits. Importantly, fruit pulp addition also enhances the shelf stability of these sweets, extending their usability and marketability. However, the extent of these improvements is influenced by several critical factors, including the type and concentration of fruit pulp used, the specific processing techniques applied during preparation, and the conditions under which the products are stored. These parameters determine the final quality, functionality, and consumer acceptance of goat-milk-based composite sweets.

The integration of fruit pulp with goat milk in traditional dairy sweets represents a promising approach for developing innovative, nutritious and appealing products. This combination leverages the health benefits of goat milk while addressing its sensory limitations, potentially expanding the market for goat milk-based products and offering healthier alternatives to traditional dairy sweets. This review explores the cultural and nutritional roles of traditional dairy sweets, evaluates the functional potential and sensory challenges of goat milk and highlights how fruit pulp integration can enhance product quality and consumer acceptance based on contemporary research.

1. **COMPOSITION AND NUTRITIONAL PROFILE**
   1. **Nutritional Composition of Goat Milk**

Goat milk is a nutritionally rich dairy alternative that contains approximately protein, fat, lactose, ash, and energy comparable to cow’s milk, but with smaller fat globules and reduced lactose content, enhancing nutrient digestibility and absorption (Rai *et al.*, 2022). It is notably high in medium-chain triglycerides such as caproic, caprylic and capric acids, which support faster digestion and energy metabolism compared to long-chain fatty acids found in bovine milk (Getanesh *et al*., 2016; Assan, 2014)). Additionally, goat milk provides superior levels of essential micronutrients, including calcium, phosphorus, potassium, magnesium, selenium, zinc and vitamins, while containing lower levels of allergenic αs1-casein, leading to softer curd formation and improved gastrointestinal tolerance (Singh *et al*., 2022; Singh *et al*., 2021; Meena *et al*., 2014). Comparative evaluations have shown that goat milk proteins and fats are more efficiently digested and absorbed than those in cow or buffalo milk, contributing to better nitrogen retention and making it suitable for infant formulas and therapeutic nutrition (Kapadiya *et al*., 2016; Yangilar, 2013; Jandyal *et al*., 2024; Park *et al*., 2007; Jandal, 1996).

* 1. **Nutritional Comparison of Goat Milk with Cow Milk**

**Table 1: Basic constituents of goat and cow milk (Lima *et al*., 2018).**

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No** | **Constituents** | **Goat milk** | **Cow milk** |
| 1. | Total solids (%) | 12.2 | 12.3 |
| 2. | Lactose (%) | 4.6 | 4.7 |
| 3. | Water (%) | 87.5 | 87.7 |
| 4. | Fat (%) | 4.0 – 4.5 | 3.8 |
| 5. | Protein (%) | 3.2 | 3.3 |
| 6. | Ash (%) | 0.8 | 0.7 |
| 7. | Energy (Kcal/100g) | 70 | 69 |

**Table 2: Average fatty acid composition (g/100 g) of goat and cow milk (Turkmen, 2017).**

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No** | **Fatty acid composition** | **Goat milk** | **Cow milk** |
| 1. | Butyric acid | 0.13 | 0.11 |
| 2. | Caproic acid | 0.09 | 0.06 |
| 3. | Caprylic acid | 0.10 | 0.04 |
| 4. | Capric acid | 0.26 | 0.08 |
| 5. | Lauric acid | 0.12 | 0.09 |
| 6. | Myristic acid | 0.32 | 0.34 |
| 7. | Palmitic acid | 0.91 | 0.88 |
| 8. | Stearic acid | 0.44 | 0.40 |
| 9. | Palmitoleic acid | 0.08 | 0.08 |
| 10. | Vaccenic acid | 0.98 | 0.84 |
| 11. | Linoleic acid | 0.11 | 0.08 |
| 12. | α-Linolenic acid | 0.04 | 0.05 |

**Table 3: Protein profile (g/L) of goat and cow milk (Roy *et al*., 2020).**

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No** | **Protein fractions** | **Goat milk** | **Cow milk** |
| 1. | Total casein | 23.3 – 46.3 | 24.6 - 28 |
| 2. | Total whey protein | 3.7 – 7.0 | 5.5 – 7.0 |
| 3. | Casein to whey protein ratio | 78:22 | 82:18 |
|  | **Major caseins** |  |  |
| 4. | αs1 - casein | 0 – 13.0 | 8.0 – 10.7 |
| 5. | α s2- casein | 2.3 – 11.6 | 2.8 – 3.4 |
| 6. | β -casein | 0 – 29.6 | 8.6 – 9.3 |
| 7. | k-casein | 2.8 – 13.4 | 2.3 – 3.3 |
|  | **Major whey protein** |  |  |
| 8. | β -lactoglobulin | 1.5 – 5.0 | 3.2 – 3.3 |
| 9. | α- lactalbumin | 0.7 – 2.3 | 1.2 – 1.3 |

**Table 4: Average minerals content of goat and cow milk (Kumar *et al*., 2016).**

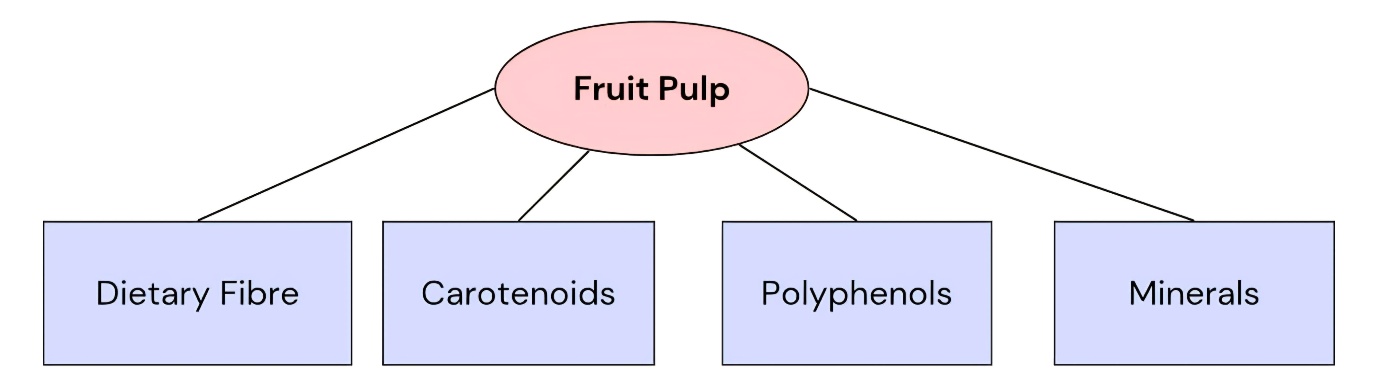
|  |  |  |  |
| --- | --- | --- | --- |
| **S. No** | **Mineral (mg/100 g)** | **Goat milk** | **Cow milk** |
| 1. | Potassium | 181 | 152 |
| 2. | Chloride | 150 | 100 |
| 3. | Calcium | 134 | 122 |
| 4. | Phosphorus | 121 | 119 |
| 5. | Sodium | 41 | 58 |
| 6. | Sulphur | 28 | 32 |
| 7. | Magnesium | 16 | 12 |
| 8. | Selenium | 1.33 | 0.96 |
| 9. | Zinc | 0.56 | 0.53 |
| 10. | Iron | 0.07 | 0.08 |
| 11. | Iodine | 0.022 | 0.021 |

**Table 5: Average vitamin contents of goat and cow milk (Lad *et al*., 2017).**

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No** | **Vitamin (per 100g)** | **Goat milk** | **Cow milk** |
| 1. | Vit.- A (IU) | 185 | 126 |
| 2. | Vit.- D (IU) | 2.3 | 2.0 |
| 3. | Vit.- B1 (mg) | 0.068 | 0.045 |
| 4. | Vit.- B2 (mg) | 0.21 | 0.16 |
| 5. | Vit.- B3 (mg) | 0.27 | 0.08 |
| 6. | Vit.- B5 (mg) | 0.31 | 0.32 |
| 7. | Vit.- B6 (mg) | 0.046 | 0.042 |
| 8. | Vit.- B8 (µg) | 1.5 | 2.0 |
| 9. | Vit.- B9 (µg) | 1.0 | 5.0 |
| 10. | Vit.- B12 (µg) | 0.065 | 0.357 |
| 11. | Vit.- C (mg) | 1.29 | 0.94 |

**2.3 Functional Components of Fruit Pulps**

Fruit pulp from tropical fruits such as mango, banana, papaya and bael are rich in phytochemicals and antioxidants, making them valuable functional ingredients when combined with goat milk (Islam *et al*., 2021). Mango pulp is especially notable for its high content of carotenoids (β-carotene, lutein), polyphenols (quercetin, mangiferin, gallic and caffeic acids) and ascorbic acid, contributing to strong antioxidant and anti-inflammatory properties *(*Nigam *et al*., 2009; Lebaka *et al*., 2021). Papaya pulp offers provitamins A and C, essential minerals, fibre and papain (an enzymatic protease) that aids digestion and imparts anti-inflammatory benefits (Abbasi *et al*., 2016; Pandey *et al*., 2014; Rocha *et al*., 2024; Sarkar *et al*., 2021). Banana and mixed berry pulps further enrich the formulation with flavonoids, phenolic acids, vitamins and dietary fiber, enhancing nutritional value and antioxidant capacity. When incorporated into goat milk-based sweets, these fruit pulps improve sensory appeal by enhancing sweetness, color and texture, while also boosting nutrient bioavailability and delivering synergistic health benefits such as improved digestion, oxidative stress reduction and potential cardiometabolic support (Yang *et al*., 2023)



**Fig:1 Functional components of fruit pulp.**

(Islam *et al*., 2021; Yang *et al*., 2023)

**2.4 Nutritional Enhancements in Composite Sweets**

Incorporating fruit pulps into goat milk–based sweets significantly enhance their nutritional profile by increasing levels of protein, vitamins, minerals, antioxidants and dietary fibre. Formulations such as goat milk *Shrikhand* enriched with apple, papaya and kiwi pulp have demonstrated notable increases in ash content, water activity and brix value, alongside reduced fat and moderate changes in protein contributing to improved nutrient density and energy balance (Sahu *et al*., 2021; Yadav *et al.*, 2018). These blends also exhibit increased antioxidant activity due to elevated concentrations of polyphenols, flavonoids, vitamin-C and carotenoids from the fruit pulps, offering synergistic health effects such as enhanced oxidative defense and cardiometabolic protection (Araujo *et al*., 2022). Additionally, fruit-derived dietary fibre improves textural qualities and sweetness while supporting digestive health, resulting in a functionally enriched and sensorially attractive dairy product (Kedaree *et al*., 2021)

**3. TRADITIONAL AND NOVEL GOAT MILK-BASED SWEETS**

**3.1 Overview of Traditional Goat Milk Sweets**

Traditional goat milk sweets such as *Peda, Burfi, Kalakand* and *Kheer* hold significant regional importance across India, reflecting diverse culinary practices and cultural heritage. Goat milk *Peda*, prepared by heating khoa with sugar and flavorings like cardamom or saffron, is widely produced in regions such as Gujarat and Karnataka, where variants like *Thabdi* and *Dharwad* *Peda* are distinguished by specific heat desiccation techniques and flavor profiles (Pandey *et al*., 2024; Modha *et al*., 2015). *Burfi* and *Kalakand* are made by cooking goat milk solids to achieve distinct textures *Burfi* being firm and *Kalakand* moist and granular often with the use of citric acid or paneer to enhance structure (Singh *et al*., 2020). *Kheer*, on the other hand, involves slow simmering of goat milk with rice or vermicelli, followed by sweetening and garnishing, with regional variations influencing consistency and additional ingredients (Jandyal *et al.*, 2024; Meena *et al.*, 2025). These traditional sweets exemplify the cultural and technological adaptability of goat milk in Indian confectionery, tailored through localized processing methods to align with regional tastes and traditions (Nayik *et al*., 2021; Gomes *et al*., 2018; Biernacka *et al*., 2022; Atallah, 2015).

**3.2 Development of fruit-infused variants**

The development of fruit-infused goat milk products employs advanced blending and formulation optimization to enhance both sensory appeal and nutritional quality. Fruit pulps such as apple, strawberry, papaya, guava, cupuassu, sapota and red pumpkin are incorporated at concentrations, using homogenization or mixing techniques to ensure uniform distribution and maintain desirable physicochemical properties such as pH, viscosity and color. Formulation trials, supported by mixture design and sensory evaluation, identify optimal pulp levels for example, goat milk *Shrikhand* with apple pulp showed high acceptability (Sahu *et al*., 2021), while strawberry pulp offered a well-balanced flavor and texture. Goat milk *Basundi* with red pumpkin pulp improved protein content, total solids, sensory attributes and cost-efficiency (Parmeshwar *et al*., 2019). In functional beverages, probiotic goat milk drinks with jambo pulp (Araujo *et al.*, 2022), beal (*Aegle marmelos*) pulp (Siriwardhana *et al.*, 2024), mangosteen rind (*Garcinia mangostana Lin*) (Wibawanti *et al*., 2018), achieved enhanced antioxidant, phenolic and anthocyanin levels without compromising taste. Fermented goat milk with fruit pulp demonstrated improved curd strength and reduced coagulation time (Ismail *et al*., 2016) (Velyamov *et al.*, 2023), while cupuassu pulp (Costa *et al*., 2016), banana pulp (David, 2015), mangaba fruit (*Hancornia speciosa gomes*) (Santos *et al*., 2017), date puree (Yacoub *et al*., 2024), sweet orange pulp (*Citrus sinensis-L*) (Desfi *et al*., 2024) and date palm (Munoz-Tebar *et al*., 2024)in goat yogurt enhanced viscosity, color and consumer preference. Beyond beverages, innovative products include shrikhand and *Lassi* with sapota pulp and betel leaf (Yadav *et al.,* 2018; Yadav and Prasad, 2025), banana pulp and papaya pulp (Maske *et al*., 2022) and apple fruit pulp (Sahu *et al*., 2021). These advancements, driven by blending technologies and sensory-based optimization, highlight goat milk’s versatility in creating health-promoting, flavourful and market-ready fruit-infused dairy sweets.

**Table 6: Development of goat milk sweets blended with fruit pulp**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S. No** | **Sweets** | **Added Pulp** | **Key findings** | **References** |
| 1. | *Shrikhand* | Apple pulp | *Shrikhand* with apple pulp showed superior texture, sensory acceptability and overall quality, making it the best formulation. | (Sahu *et al*., 2021) |
| 2. | *Shrikhandwadi* | Banana and papaya pulp | *Shrikhandwadi* prepared from goat milk chakka, fruit pulps and ashwagandha showed increased total solids, carbohydrates and ash with reduced protein, fat, moisture, acidity and energy. | (Maske *et al*., 2022) |
| 3. | *Lassi* | Sapota pulp | *Lassi* with sapota pulp showed highest sensory acceptability with improved antioxidants and microbial quality. | (Yadav and Prasad, 2025) |
| 4. | Yogurt | Banana pulp | Goat milk yogurt with banana pulp showed the best overall sensory acceptability. | (David, 2015) |
| Sweet orange pulp | Sweet orange addition reduced goaty odor, improved taste, increased lactic acid and moisture, but decreased protein, with stable pH. | (Desfi *et al*., 2024) |
| Cupuassu  pulp | Incorporating cupuassu pulp improved the sensory, physicochemical, and antioxidant properties of goat milk yogurt enhancing consumer acceptance. | (Costa *et al*., 2016) |
| 5. | *Basundi* | Red pumpkin pulp | Addition of red pumpkin pulp to goat milk *Basundi* reduced moisture, fat and sucrose while increasing protein, ash, carbohydrates and total solids significantly. | (Parmeshwar *et al*., 2019) |

|  |  |
| --- | --- |
| **Goat Milk**  Filtration (using muslin cloth)  Fat Standardization  Heat Treatment (85**°**C for 30 min)  Cooling (37 ± 2**°**C)  Starter Culture Inoculation (NCDC-159 @ 2.5% by v/v of milk)  Dahi Formation  Whey Drainage (Hanging for 16-18 hr)  Chakka Preparation  Addition of Sugar (30% of total weight)  Mixing with **Apple Pulp**  **Shrikhand**  Filling in Polypropylene Cups  Refrigerated Storage (4 ± 2**°**C)  **Fig 2: Flow Diagram for Apple Pulp Based Shrikhand (Sahu *et al*., 2021).** | **Goat Milk**  Pasteurization (63**°**C for 30 min)  Standardization (4% fat 8.5% SNF)  Cooling (30 ± 2**°**C)  Inoculation (29**°**C for 15 hr)  Curd  25% Sugar+ 2% Ashwagandha Powder in Chakka (by weight of chakka)  Whey Drainage (Hanging for 16-18 hr)  **Banana & Papaya Pulp** Added (as per treatments)  Desiccating (70**°**C for 10-12 min)  Spreading in thick mass and Cooling (13**°**C)  Storage (room temperature)  **Shrikhandwadi**  **Fig 3: Flow Diagram for Banana and Papaya Pulp Based Shrikhandwadi (Maske *et al*., 2022)** |

**4. PROCESSING AND TECHNOLOGICAL CONSIDERATIONS**

**4.1 Pre-Treatment and Processing of Fruit Pulps**

The integration of fruit pulps into goat milk-based sweets requires meticulous pre-treatment and processing to ensure product safety, quality and compatibility with the dairy products (Silva and Abud, 2017). Pulp extraction involves selecting ripe fruits, followed by washing, peeling, deseeding and mechanical pulping (Bag *et al*., 2011). Fruits like mango, papaya and guava are frequently used for their sensory compatibility and functional benefits (Desouky, 2018; Wairimu *et al*., 2022). Post-extraction, pasteurization at 85–90°C for 5 to 10 minutes is essential to eliminate pathogens and inactivate spoilage enzymes such as polyphenol oxidase, thereby enhancing microbiological safety and extending shelf life (Akhtar *et al*., 2010; Syafitri *et* *al*., 2024).

Storage under refrigeration is standard for short-term preservation, while aseptic packaging or frozen storage ensures long-term stability and prevents oxidation and microbial growth (Haase *et al.*, 2023; Silva *et al*., 2015). To minimize enzymatic browning and microbial spoilage, additives like ascorbic acid and citric acid are incorporated, alongside strict hygiene protocols and sterile equipment use especially important for sensitive products like *Peda* and *Shrikhand* (Sahu *et al.*, 2021 Sirajuddin *et al.*, 2024). These pre-treatment measures support the stability and sensory integrity of fruit pulps while ensuring these are compatible with goat milk’s lipid-rich and oxidation-prone composition.

**4.2 Processing Challenges with Goat Milk**

Formulating value-added goat milk sweets blended with fruit pulp presents several processing challenges. Goat milk high content of short and medium-chain fatty acids increases its susceptibility to oxidation during heat treatments, potentially leading to off flavors and nutrient degradation (Park *et* *al*., 2007). Additionally, its characteristic "goaty" aroma linked to caproic, caprylic and capric acids can deter consumers, necessitating effective flavor masking strategies. While fruit pulps help mask these flavors, these introduce complexity in balancing sensory attributes (Haenlein, 2004). Textural consistency is another concern, as goat milk's smaller fat globules and lower αs1-casein levels result in a softer curd and thinner texture, impacting the structural integrity of sweets like *Peda* and *Burfi* (Ambrosoli *et al*., 1988). Moreover, the acidic nature of many fruit pulps can interact with milk proteins, causing coagulation or phase separation if pH and thermal conditions are not carefully controlled. To address these challenges, processing optimization is essential, including controlled heating, incorporation of natural flavor enhancers, and the use of stabilizers compatible with both dairy and fruit systems. Advanced techniques such as homogenization and emulsification are also employed to enhance product stability and improve consumer acceptability.

**4.3 Effect of Processing on Nutritional and Sensory Properties**

The processing of goat milk blended with fruit pulp plays a essential role in determining the nutritional and sensory quality of the final product. Retention of bioactive compounds such as polyphenols, flavonoids, vitamin-C and overall antioxidant capacity is critical during thermal treatments like pasteurization or concentration. Controlled pasteurization has been shown to preserve these nutrients effectively while ensuring microbial safety, particularly in formulations incorporating fruit pulps such as mango, papaya and berries (Feng *et al*., 2018; Desouky, 2018). However, excessive heat or prolonged exposure can lead to the degradation of heat-sensitive compounds, diminishing the functional value of the product.

Sensory attributes, including flavor, texture and shelf life are also influenced by processing conditions. Fruit pulp addition enhances sweetness, aroma and overall acceptability, helping to cover the characteristic "goaty" flavor and improving consumer acceptance (Santis *et al*., 2019). Interactions between fruit fibres and milk proteins can modify the texture, often yielding a softer, more cohesive consistency in sweets like *Burfi* and *Peda*. While appropriate thermal processing and packaging can extend shelf life, the inclusion of fruit increases the risk of microbial spoilage if not adequately preserved (Aneja *et al*., 2014). Therefore, precise optimization of processing parameters is essential to balance nutritional retention and sensory appeal in goat milk-based composite sweets.

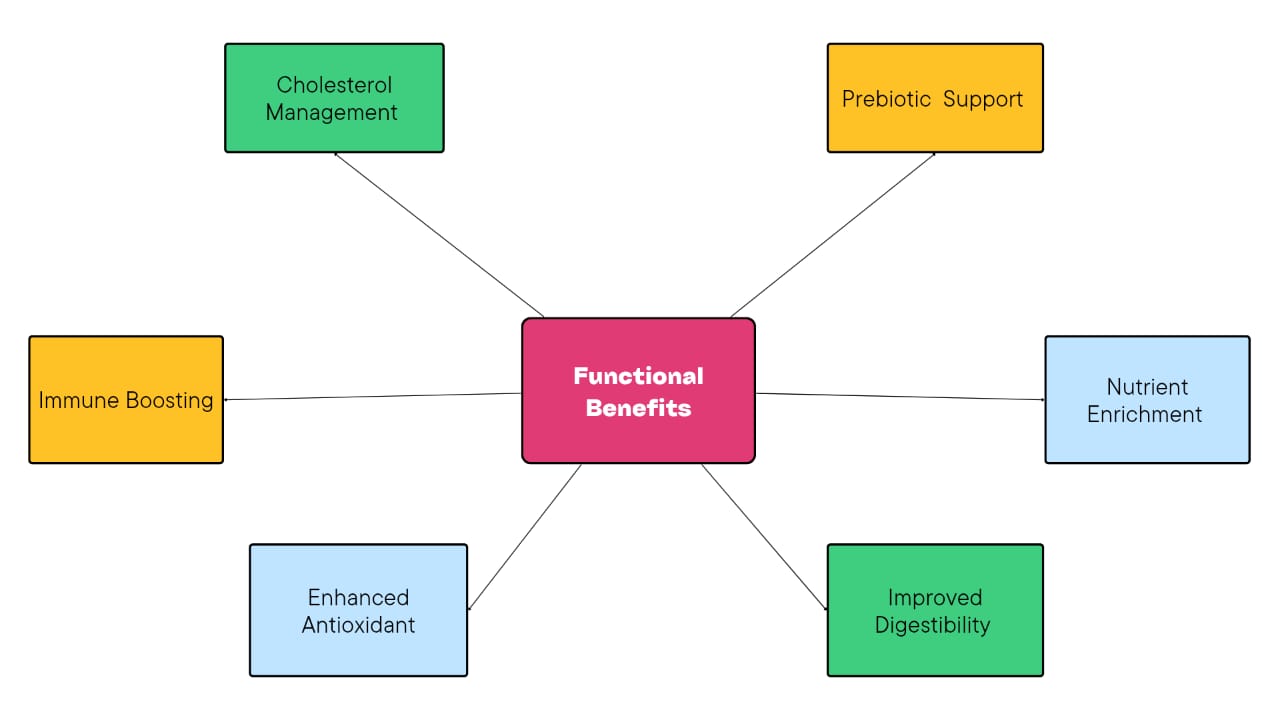
**5. SENSORY AND FUNCTIONAL EVALUATION**

**5.1 Sensory Attributes**

Sensory attributes are critical to the consumer acceptance and marketability of goat milk-based sweets blended with fruit pulp. The incorporation of fruit pulp significantly enhances flavor, color and texture, improving overall acceptability. Fruity aromas and natural sweetness from pulps such as mango, pineapple, papaya and berries effectively mask the strong "goaty" flavor of goat milk, creating a more balanced and appealing taste profile (Ranadheera *et al*., 2012). Color improvements, driven by natural pigments like carotenoids in mango and anthocyanins in berries, contribute to enhanced visual appeal an important factor influencing consumer choices (Spence, 2015). Additionally, fruit-derived fibres and pectins interact with milk proteins to improve textural characteristics, yielding smoother and more cohesive sweets such as *Burfi*, *Peda* and *Sandesh*. Consumer studies have shown that moderate levels of fruit pulp enhance sensory scores, particularly in flavor and overall acceptability (Harker *et al*., 2009; Costa *et al.*, 2016). The perceived novelty and health benefits of fruit pulp-based goat milk sweets further increase their appeal, especially among health-conscious consumers. However, consistent sensory quality depends on the careful optimization of pulp concentration, processing conditions and ingredient interactions.

**5.2 Functional Benefits**

Goat milk-based sweets blended with fruit pulp offer significant functional benefits due to the synergistic effects of their bioactive components (Nayik *et al*., 2021). Goat milk is a source of medium-chain fatty acids, bioavailable calcium and bioactive peptides, which contribute to cholesterol-lowering and improved metabolic health (Bokadia et al., 2024). When combined with fruit pulps rich in polyphenols, flavonoids and dietary fibres such as those from berries, mango and papaya the resulting products demonstrate enhanced antioxidant activity and oxidative stress reduction (Nardini & Garaguso, 2020; Singh & Immanuel, 2014). The dietary fibers and oligosaccharides from fruit also enhance the prebiotic potential of these sweets by supporting beneficial gut microbiota, thereby promoting digestive health and immune modulation (Jubair *et al*., 2025). This is complemented by goat milk’s high digestibility and suitability for lactose-sensitive individuals. Additionally, these blends may aid in glycemic control, as the balance of natural fruit sugars with milk proteins and fibers can moderate postprandial glucose responses, making them suitable for individuals managing glycemic load (Lumaga *et al*., 2012; Shkembi & Huppertz, 2023). Collectively, these attributes support the positioning of goat milk fruit pulp sweets as both indulgent and health promoting functional foods.



**Fig 4: Functional benefits of goat milk sweets blended with fruit pulp.**

(Nayik *et al*., 2021; Nayik *et al*., 2021; Jubair *et al*., 2025)

**6. MICROBIAL AND SHELF-LIFE STUDIES**

The microbiological stability and shelf-life of goat milk-based sweets blended with fruit pulp are essential for ensuring product safety and quality. Goat milk nutrient-rich composition creates a favourable environment for microbial growth, which can be intensified by the addition of fruit pulps rich in natural sugars and enzymes (Kumar *et al*., 2019). Studies have shown that sweets like *Burfi* or *Peda* blended with mango or papaya pulp are susceptible to increased microbial load over time, particularly under ambient storage. Therefore, regular monitoring of microbial indicators such as total plate count, yeast & mold, and coliforms is necessary (Elkot *et al*., 2023; Ismail *et al.*, 2016). Proper pasteurization of both milk and fruit pulp, along with hygienic handling and packaging, is critical to reducing microbial risks. Shelf-life studies indicate that refrigerated storage at 4 ± 1°C can maintain acceptable sensory and microbiological quality (Agnihotri and Pal, 1996; Pal *et al*., 2017). The use of natural preservatives such as ascorbic acid, citric acid and fruit-derived phenolics (e.g., from guava or pineapple) further enhances microbial stability (Dhanalakshmi *et al*., 2022; Bano *et al*., 2023; Debnath *et al*., 2024).

Innovative packaging techniques, including vacuum sealing and biodegradable films infused with essential oils, contribute to extended shelf life by minimizing oxidation, moisture loss and microbial contamination (Borah *et* *al*., 2024; Sharma *et al*., 2021). Thus, a comprehensive approach combining good manufacturing practices, natural preservatives and advanced packaging is vital for ensuring the microbiological safety and shelf life of goat milk-based fruit pulp sweets.

**7. CHALLENGES AND LIMITATIONS**

The development of goat milk-based sweets blended with fruit pulp faces several challenges that impact scalability, product consistency and consumer acceptance. A major limitation is the seasonal availability of tropical fruits such as mango, papaya and pineapple, which restricts year-round production and complicates standardization. While preservation methods like freezing or concentration can extend pulp availability, they may alter sensory and nutritional attributes. Cost is another critical barrier. Goat milk is more expensive than cow milk due to lower yields and limited supply, and when combined with the cost of premium fruit pulps and advanced processing technologies, overall production expenses rise significantly. Additionally, maintaining hygienic processing, cold chain logistics and quality assurance further increases operational costs, particularly for small-scale producers. Consumer acceptance poses further challenges, as the characteristic flavor of goat milk can be off-putting to some. Effective formulation strategies are needed to balance or mask this flavor using fruit pulp without compromising product quality. Moreover, limited consumer awareness about the health benefits of goat milk and fruit-based dairy products restricts market growth. Targeted educational initiatives, clear labeling and health-focused marketing are essential to improve consumer perception and expand market reach.

**8. FUTURE PROSPECTS AND RESEARCH DIRECTIONS**

The development of goat milk-based sweets blended with fruit pulp offers significant potential for innovation and commercialization within the functional food sector. Utilizing regionally available, underutilized fruits such as bael, jamun and karonda all rich in antioxidants, vitamins and phytochemicals can enhance both nutritional value and product diversity. Additionally, sourcing milk from indigenous goat breeds, known for their climate resilience and unique nutritional profiles, can contribute to authenticity and functional appeal. Advanced processing technologies such as microencapsulation, freeze-drying and high-pressure processing offer effective means to preserve sensitive bioactive, improve shelf life and enhance nutrient delivery. Microencapsulation protects probiotics and bioactive compounds improving their stability and bioavailability, while freeze-drying retains the nutritional and sensory attributes of both milk and fruit components. These innovations support the positioning of goat milk-fruit pulp sweets in the therapeutic and health-oriented food markets. The combined functional benefits such as antioxidative potential, metabolic regulation and gut health promotion underscore their relevance in health-promoting diets. Future research should emphasize clinical validation, standardization of processing methods, and optimization of formulation to enable large-scale production and regulatory approval.

**9. CONCLUSION**

This review explores the potential of goat milk-fruit pulp composite sweets as functional foods. Goat milk offers superior digestibility, bioactive composition and low allergenicity, while fruit pulps like mango, papaya and berries enhance nutritional, sensory, and functional properties. Traditional and novel formulations are examined, along with processing considerations, sensory enhancements and microbial stability. Challenges related to cost, standardization and consumer perception are discussed and opportunities for diversification through underutilized fruits and advanced technologies are highlighted. With targeted research, standardization and consumer education, these composite products have strong potential for up scaling and commercialization, particularly within the modern health-conscious consumers and functional food markets.

**ETHICAL CONSIDERATIONS**

This article does not include any studies involving human or animal subjects.

**DATA AVAILABILITY**

All datasets generated or analyzed during this study are included in the manuscript.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declares that no generative AI technologies such as large language models (ChatGPT, manuscript).

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