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Optimization and Quality Evaluation of Dragon Fruit (*Hylocereus undatus*) Blended Lassi: Sensory, Nutritional, and Shelf-Life Assessment

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Abstract

The study aimed to develop an optimized formulation of dragon fruit (*Hylocereus undatus*) blended lassi by assessing the effects of different levels of dragon fruit pulp and sugar on sensory characteristics, nutritional composition, and shelf life. Lassi was prepared using various forms of dragon fruit (pulp, juice, shredded and powder), with the pulp form showing superior acceptability. The optimal formulation (10% dragon fruit pulp and 20% sugar) received the highest sensory ratings for colour (8.1 ± 0.02), consistency (8.0 ± 0.02), flavour (8.2 ± 0.02), mouth feel (8.1 ± 0.02), and overall acceptability (8.1 ± 0.01). The optimized lassi contained 1.9% fat, 4.3% reducing sugars, 9.1% non-reducing sugars, and viscosity of 27.4 cp. Microbial evaluation revealed acceptable limits up to 6 days at 5 ± 1 °C. The findings suggest that dragon fruit pulp can effectively enhance the sensory and nutritional profile of lassi while maintaining consumer appeal and functional value.

Keywords: Dragon fruit, lassi, sensory evaluation, dragon fruit pulp, sugar levels, dairy product, nutritional composition

Introduction

Lassi, a traditional Indian fermented milk beverage, has gained global recognition for its refreshing taste, nutritional richness, and probiotic properties. Typically prepared by blending curd with water, sugar, and sometimes fruits or Flavouring agents, lassi offers both sensory satisfaction and health benefits (Patidar & Prajapati, 1998; Maji *et al.*, 2018) ^[1, 9]. Incorporating functional fruits into dairy matrices has become a recent trend to improve Flavour, nutrition, and consumer appeal (Akhtar *et al.*, 2021; Kaur *et al.*, 2019) ^[2, 6].

Dragon fruit (*Hylocereus undatus*), a tropical cactus fruit native to Central and South America, is now widely cultivated in Asia, including India. The fruit is rich in vitamins (notably C and E), minerals, polyphenols, and betalain pigments, which contribute to its antioxidant and anti-inflammatory potential (Lourith & Kanlayavattanukul, 2013; Purwati *et al.*, 2018) ^[8, 14]. Its vivid pink colour and subtle sweetness make it an attractive natural additive for dairy-based products such as yogurts and smoothies.

The functional incorporation of dragon fruit in lassi not only enhances its sensory quality but may also improve its bioactive and nutritional value (Hamidah *et al.*, 2017) ^[5]. However, the optimization of pulp and sugar concentration is crucial to maintain an ideal balance between taste, texture, and stability. Hence, this study was conducted to optimize the formulation of dragon fruit-blended lassi by evaluating the impact of varying pulp and sugar levels on its sensory, physico-chemical, and microbiological properties during refrigerated storage.

Material and Method

Preparation of Dragon Fruit Lassi

The process was standardized using the modified method of George *et al.* (2010) ^[18]:

1. **Milk Standardization and Heat Treatment:** Fresh cow milk (4% fat) was heated to 90°C for 15 min to denature whey proteins and enhance consistency. It was then cooled to 37°C.
2. **Inoculation and Fermentation:** A 2% starter culture containing *Streptococcus lactis* subsp. *lactis* was added and incubated at 37°C for 10 hours to obtain dahi.

3. **Lassi Preparation:** Dragon fruit pulp (5-5%), sugar (10–25%), and 10% water were blended into the curd using a hand blender until uniform.
4. **Packaging and Storage:** The product was filled into low-density polyethylene (LDPE) pouches and stored at $5 \pm 1^\circ\text{C}$ for further analysis.

Sensory Evaluation

A semi-trained panel of 10 judges evaluated samples using the 9-point hedonic scale (colour, consistency, Flavour, Mouth feel, and overall acceptability) as per BIS (IS: 6273 Part II, 1971).

Microbiological Quality

Standard Plate Count (SPC), Yeast and Mold Count (YMC), and Coliform Count (CC) were determined using standard methods (Marth, 2009; Robinson, 2005) [19, 20]. Results were expressed as CFU/mL.

Physico-Chemical Analysis

Parameters such as fat, protein, reducing and non-reducing sugars, ash, pH, acidity, and viscosity were determined following AOAC (2019) procedures.

Statistical Analysis

Data were analyzed using Completely Randomized Design (CRD) and Factorial CRD as per Snedecor and Cochran (1967) [11]. Significance was tested at $p < 0.05$.

Result and Discussion

Effect of Dragon Fruit Form

Among pulp, juice, shredded, and powder forms, lassi prepared with pulp (F1) achieved significantly higher scores in all sensory attributes ($p < 0.05$). The superior results are attributed to the even dispersion and natural pectin content in pulp, which improves consistency and colour retention.

Similar observations were reported for kiwi-blended lassi and by Washimbe *et al.* (2020) [13] for muskmelon-based lassi.

Effect of Dragon Fruit Pulp Level

Lassi with 10% pulp (L2) obtained the highest mean sensory scores for colour (7.70 ± 0.04), consistency (7.80 ± 0.04), and Flavour (7.74 ± 0.08). Higher pulp levels (20–25%) decreased acceptability due to excessive thickness and astringency, consistent with findings by Dudhate *et al.* (2021) [4] in pear-enriched lassi.

Effect of Sugar Level

Sugar improved sweetness and balance. Optimal sensory quality was achieved with 20% sugar (S4), which significantly enhanced Flavour, colour, and overall acceptability ($p < 0.05$). Over-sweetening (25%) caused a cloying taste, reducing preference (Prakash *et al.*, 2020) [10].

Combined Effect of Pulp and Sugar

The interaction effect between dragon fruit pulp and sugar was statistically non-significant, suggesting independent influence. The formulation T1S2 (10% pulp, 20% sugar) scored highest across all sensory parameters. Similar optimization trends were observed in fortified yogurt studies (Rohani *et al.*, 2015; Akhtar *et al.*, 2021) [12, 2].

Results and Discussion

Effect of Form of Dragon Fruit on Sensory Attributes of Lassi: Different forms of dragon fruit — pulp (F1), juice (F2), shredded (F3), and powder (F4) — were tested for sensory quality. Results (Table 1) revealed that lassi made with pulp (F1) achieved the highest scores in colour, consistency, Flavour, Mouth feel, and overall acceptability. The natural colour pigments (betacyanins) and pectin in dragon fruit pulp contributed to better texture and stability (Lourith & Kanlayavattanukul, 2013) [8].

Table 1: Effect of form of dragon fruit on sensory attributes of lassi (Mean $\pm$ SE, n = 3)

Form of Dragon Fruit	Colour & Appearance	Consistency	Flavour	Mouth feel	Overall Acceptability
F1 (Pulp)	$7.83 \pm 0.04a$	$7.80 \pm 0.04a$	$7.58 \pm 0.04a$	$7.70 \pm 0.04a$	$7.73 \pm 0.02a$
F2 (Juice)	$7.50 \pm 0.06b$	$7.60 \pm 0.13a$	$7.40 \pm 0.04a$	$7.55 \pm 0.15b$	$7.45 \pm 0.02b$
F3 (Shredded)	$7.25 \pm 0.02c$	$7.60 \pm 0.07a$	$6.90 \pm 0.04b$	$7.60 \pm 0.07ab$	$7.37 \pm 0.17b$
F4 (Powder)	$6.95 \pm 0.11d$	$6.90 \pm 0.04b$	$6.98 \pm 0.11b$	$6.91 \pm 0.04c$	$6.88 \pm 0.11c$

Means followed by different superscripts in a column differ significantly ($p < 0.05$).

Lassi prepared with dragon fruit pulp (F1) received the highest overall acceptability. This could be attributed to the uniform colour distribution, desirable viscosity, and the smooth Mouth feel imparted by pulp compared to other forms. These findings are consistent with those of who reported that fruit pulps improve body and texture in Flavoured lassi.

Effect of Level of Dragon Fruit Pulp on Sensory Attributes

The sensory quality of lassi improved with increasing pulp level up to 10% (L2), beyond which scores declined (Table 2). Higher pulp levels made the product excessively thick and slightly astringent, decreasing acceptability.

Table 2: Effect of dragon fruit pulp level on sensory attributes of lassi

Pulp Level (%)	Colour & Appearance	Consistency	Flavour	Mouth feel	Overall Acceptability
5 (L1)	7.23 ± 0.06^b	7.23 ± 0.06^b	7.00 ± 0.04^b	7.15 ± 0.06^b	7.10 ± 0.04^b
10 (L2)	7.70 ± 0.04^a	7.80 ± 0.04^a	7.74 ± 0.08^a	7.70 ± 0.04^a	7.74 ± 0.03^a
15 (L3)	7.45 ± 0.04^a	7.78 ± 0.02^a	7.65 ± 0.06^a	7.50 ± 0.04^a	7.66 ± 0.03^a
20 (L4)	7.28 ± 0.06^b	7.28 ± 0.06^b	7.20 ± 0.06^b	7.10 ± 0.04^b	7.15 ± 0.04^b
25 (L5)	6.83 ± 0.04^c	6.90 ± 0.04^c	6.93 ± 0.02^c	6.85 ± 0.02^c	6.86 ± 0.02^c

Means followed by different superscripts in a column differ significantly ($p < 0.05$).

A 10% pulp addition provided the most balanced sensory attributes. This aligns with Dudhate *et al.* (2021) ^[4], who found 10–12% fruit pulp to be optimal for fruit-enriched lassi. Excess pulp increases thickness and sedimentation, reducing consumer acceptance.

Table 3: Effect of sugar concentration on sensory attributes of lassi

Sugar Level (%)	Colour & Appearance	Consistency	Flavour	Mouth feel	Overall Acceptability
10 (S1)	6.83 ± 0.02 ^c	6.85 ± 0.04 ^c	7.00 ± 0.04 ^c	6.80 ± 0.04 ^c	6.83 ± 0.02 ^c
15 (S3)	7.75 ± 0.02 ^a	7.75 ± 0.02 ^a	7.75 ± 0.05 ^a	7.75 ± 0.02 ^a	7.72 ± 0.04 ^a
20 (S4)	8.03 ± 0.04 ^a	8.05 ± 0.06 ^a	8.03 ± 0.04 ^a	8.03 ± 0.04 ^a	7.90 ± 0.02 ^a
25 (S5)	7.60 ± 0.04 ^b	7.65 ± 0.02 ^b	7.43 ± 0.02 ^b	7.50 ± 0.02 ^b	7.43 ± 0.02 ^b

Means followed by different superscripts in a column differ significantly ($p < 0.05$).

Sugar enhances palatability and Mouth feel up to 20% concentration, beyond which the sweetness overshadows the natural fruit Flavour. Similar findings were noted by Prakash *et al.* (2020) ^[10] and Rohani *et al.* (2015) ^[12] in Flavoured yogurt studies.

Combined Effect of Dragon Fruit Pulp and Sugar

The combination of 10% pulp and 20% sugar (T1S2) resulted in the highest mean scores for sensory attributes, indicating synergistic enhancement. The interaction effect (pulp × sugar) was non-significant ($p > 0.05$), suggesting independent contributions of each factor.

Physico-Chemical Composition

The proximate composition of the optimized formulation (10% pulp and 20% sugar) showed moderate fat, adequate protein, and enhanced total solids due to fruit addition (Table 4).

Table 4: Physico-chemical attributes of optimized dragon fruit lassi

Parameter	Value (Mean ± SE)
Fat (%)	1.9±0.01
Protein (%)	2.6±0.02
Reducing Sugar (%)	4.3±0.02
Non-reducing Sugar (%)	9.1±0.02
Total Solids (%)	18.7±0.04
pH	4.42±0.01
Acidity (% LA)	0.90±0.02
Viscosity (cp)	27.4±0.02

The slight increase in reducing sugar and viscosity compared to control lassi is attributed to the sugar and pectin content of dragon fruit pulp. These results are consistent with Kaur *et al.* (2019) ^[6] and Washimbe *et al.* (2020) ^[13], who observed similar improvements in fruit-blended dairy beverages.

Microbial and Shelf-Life Evaluation

The microbial load (SPC, YMC, and CC) remained within acceptable limits up to 6 days of storage at 5 ± 1 °C, after which sensory quality declined due to yeast and mold growth. These findings corroborate Hossain *et al.* (2022), who observed 5–7 days of shelf stability for fruit yogurt under similar conditions. The optimal formulation of lassi using 10% dragon fruit pulp and 20% sugar provided the best sensory and nutritional balance with acceptable shelf stability. The natural antioxidants and colour compounds in dragon fruit enhance the product's visual and nutritional

Effect of Sugar Level on Sensory Attributes

The sugar level significantly influenced sweetness balance and overall perception (Table 3). Maximum sensory ratings were recorded for 20% sugar (S4), beyond which acceptability declined due to excessive sweetness.

appeal, positioning it as a value-added functional dairy beverage.

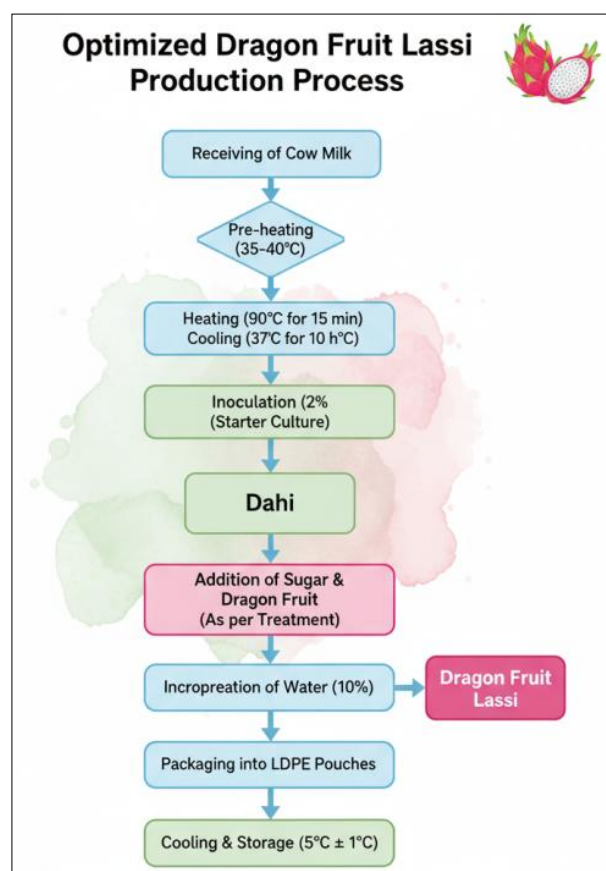


Fig 1: Optimized flow chart of preparation of lassi blended with dragon fruit

Conclusion

The study established that blending dragon fruit (*Hylocereus undatus*) pulp into lassi significantly enhances its sensory appeal and nutritional value. Among the tested formulations, lassi prepared with 10% dragon fruit pulp and 20% sugar exhibited the best sensory attributes for colour, consistency, Flavour, Mouth feel, and overall acceptability. The optimized product contained desirable physico-chemical properties and maintained good microbial quality for up to 6 days at 5 ± 1 °C. These findings confirm that dragon fruit pulp can serve as a valuable functional ingredient in dairy beverages, contributing to the development of a nutritious, visually appealing, and consumer-preferred value-added lassi.

Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this research paper. No financial, commercial, or personal relationships have influenced the outcomes or interpretations presented in this study.

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