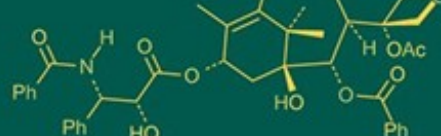
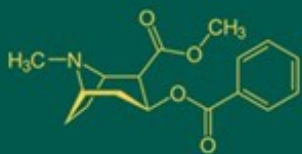


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Studies on optimization and sensory evaluation of lassi blended with dragon fruit (*Selenicereus Undatus*) pulp

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ABSTRACT

The present investigation was undertaken to optimize the level of dragon fruit (*Selenicereus undatus*) pulp in lassi and to evaluate its sensory and physico-chemical properties. Fresh cow milk (3.5% fat, 8.5% SNF) was used to prepare lassi blended with dragon fruit pulp at four levels: T_0 (control, 0%), T_1 (2%), T_2 (4%) and T_3 (6%) on weight basis, with constant 15% sugar and 20% water addition. Sensory evaluation was performed by a semi-trained panel using a 9-point Hedonic scale. Colour and appearance scores improved significantly ($p < 0.05$) with increasing pulp level, ranging from 6.80 (T_0) to 8.71 (T_3). Flavour scores ranged from 7.78 to 8.43 (non-significant). Taste scores were significantly different, with T_2 recording the highest score (8.58). Overall acceptability was significantly influenced, with T_2 (4% pulp) recording the highest mean score of 8.58. Physico-chemical analysis revealed that titratable acidity increased from 0.82% (T_0) to 0.91% (T_3), while pH decreased from 4.56 to 4.29. Fat and protein decreased progressively, whereas moisture and ash increased with increasing pulp level. T_2 (4% dragon fruit pulp) was identified as the optimum level based on overall sensory acceptability and physico-chemical characteristics.

Keywords: Lassi, Dragon fruit, *Selenicereus undatus*, Sensory evaluation, Physico-chemical properties, Fermented dairy beverage

1. Introduction

Milk and milk-based products have long been recognized as essential components of human nutrition due to their balanced composition and high biological value. In recent years, consumer demand has shifted toward functional foods that offer additional health benefits beyond basic nutrition. Fermented dairy beverages such as lassi provide an excellent medium for incorporating natural ingredients like fruit pulps to enhance their nutritional and sensory properties (Tamime *et al.*, 2007) [1].

Lassi is a traditional fermented milk beverage widely consumed across India and South Asia. It is prepared by blending curd (*dahi*) with water, sugar and optional flavouring agents. The beverage is valued for its probiotic properties, pleasant taste, cooling character and therapeutic attributes (Aneja *et al.*, 2002; Panesar, 2011) [2, 3]. The growing popularity of fruit-flavoured lassi varieties has opened new avenues for the development of functional dairy beverages with enhanced nutritional and sensory profiles (Patel *et al.*, 2013) [4].

Dragon fruit (*Selenicereus undatus*), belonging to the family Cactaceae, is an exotic tropical fruit gaining widespread popularity due to its striking pink appearance and high therapeutic value. It is rich in natural betalain pigments, polyphenolic compounds, flavonoids, ascorbic acid, soluble dietary fibre and essential minerals including calcium, phosphorus and iron (Zainoldin *et al.*, 2012; Siregar *et al.*, 2023) [6, 5]. Its antioxidant, anti-diabetic, hypocholesterolemic and immune-enhancing properties make it a suitable functional ingredient for dairy product fortification (Pavithra *et al.*, 2023; Hafiz *et al.*, 2025) [8, 7].

The incorporation of dragon fruit pulp into lassi serves a dual objective: it imparts a natural attractive pink hue eliminating the need for synthetic colorants, while simultaneously enriching the beverage with bioactive functional compounds. Limited research has been conducted on dragon fruit blended lassi; therefore, the present study was undertaken to optimize the level of dragon fruit pulp incorporation and evaluate the resulting sensory and physico-chemical characteristics.

2. Materials and Methods**2.1 Collection of raw materials**

Fresh cow milk (3.5% fat, 8.5% SNF) was procured from Natural Milk Pvt. Ltd., Latur. Fresh pink dragon fruit (*Selenicereus undatus*) was purchased from the local market in Latur city. Standard freeze-dried dahi culture (NCDC-167) containing *Lactococcus lactis* and *Streptococcus thermophilus* was used for fermentation at 2% inoculation rate.

2.2 Preparation of dragon fruit pulp

Fresh dragon fruit was washed, peeled and cut into small slices. The pulp was extracted by pressing through a clean muslin cloth, removing seeds to obtain clear pulp, which was stored under refrigeration until use.

2.3 Preparation of lassi

Cow milk was pasteurized at 80–85 °C for 15 minutes, cooled to 37 °C and inoculated with active dahi culture (NCDC-167) at 2% on weight basis. Inoculated milk was incubated at 30 °C for 12 hours until set curd was obtained. The coagulum was broken and blended with 20% chilled water and 15% sugar (w/w). Dragon fruit pulp was incorporated as per experimental treatments. The prepared lassi was packed in sanitized glass bottles and stored at 7 ± 2 °C.

2.4 Treatment combinations

Four experimental treatments were formulated on a weight-by-weight basis as follows:

T₀: 100 parts curd (Control, 0% dragon fruit pulp)

T₁: 98 parts curd + 2 parts dragon fruit pulp

T₂: 96 parts curd + 4 parts dragon fruit pulp

T₃: 94 parts curd + 6 parts dragon fruit pulp

2.5 Sensory evaluation

Sensory evaluation was performed by a semi-trained panel of judges using a 9-point Hedonic scale (9 = Like extremely; 1 = Dislike extremely) as per the Quartermaster Food and Container Institute, USA. Evaluated parameters included colour and appearance, flavour, taste, body and texture, and overall acceptability.

2.6 Physico-chemical analysis

Titrate acidity was determined by IS: 1479 (1960) Part-I. pH was measured using a digital pH meter (EUTECH Instruments, Model 335). Fat content was determined by Gerber's method (IS: 1224, Part II, 1977). Protein was estimated using the Lowry method (Lowry *et al.*, 1951) [9]. Moisture and total solids were determined by IS: SP (Part XI) 1981. Ash content was estimated by ignition in a muffle furnace at 550 °C as per IS: SP (Part XI) 1981.

2.7 Statistical analysis

All experimental data were statistically analysed using a Completely Randomized Design (CRD) with four replications per treatment, following the method of Panse *et al.* (1985) [10]. Significance of treatment differences was evaluated using Critical Difference (CD) at 5% level of probability.

Procedure

The fresh dragon fruit purchased from the local market was washed thoroughly and stored in the refrigerator. It was then peeled and cut into small slices. The slices were churned and pressed through a clean muslin cloth, collecting the pulp in a beaker and separating the seeds. The extracted pulp was stored under refrigeration until further use. For preparation of lassi blended with dragon fruit pulp, the cow milk was heated at 80–85 °C for 15 minutes and cooled to 37 °C. After cooling, standard dahi culture NCDC-167 @ 2 per cent (w/w) was added to the milk, which was then incubated at 30 °C for 12 hours to obtain set curd. The coagulum was broken and chilled water (20%) was added. Dragon fruit pulp was blended into the lassi as per the respective treatment combinations (T₀: 0%, T₁: 2%, T₂: 4%, T₃: 6% on weight basis) and churned using an electric churner. Sugar (15% by weight of lassi) was mixed uniformly. The prepared lassi was packed in sanitized glass bottles and stored at 7 ± 2 °C for further sensory and physico-chemical analysis.

3. Results and Discussion

3.1 Chemical composition of raw materials

The cow milk used in the study contained 3.50% fat, 8.50% SNF, 3.30% protein, 4.70% lactose, 87.80% moisture and 12.20% total solids, confirming compliance with FSSAI standards for standardized whole cow milk. The dragon fruit pulp contained 87.10 g moisture, 1.10 g protein, 0.57 g fat, 11.20 g carbohydrates, 2.80 g dietary fibre, 20.50 mg vitamin C, 8.50 mg calcium, 22.50 mg phosphorus and 1.90 mg iron per 100 g. These values are consistent with those reported by Sonawane (2017) and Siregar *et al.* (2023) [5].

3.2 Sensory evaluation

3.2.1 Colour and appearance

The mean colour and appearance scores for T₀, T₁, T₂ and T₃ were 6.80, 7.50, 8.49 and 8.71, respectively (Table 1). The treatment effect was statistically significant ($F_{\text{cal}} = 29.1198 > F_{\text{table}} = 3.4903$; CD at 5% = 0.5079). All four treatments differed significantly from one another (superscripts a, b, c, d). The progressive increase in scores with pulp level reflects the visually attractive pink-red colour imparted by the natural betalain pigments of dragon fruit pulp, which dispersed uniformly in the aqueous phase of lassi without precipitation. These findings agree with Kedaree *et al.* (2021) [11], Jayasinghe *et al.* (2015) [12] and Aiswarya *et al.* (2025) [13], who reported significant improvement in colour scores with increasing fruit pulp incorporation in fermented dairy products.

Means with different superscripts differ significantly ($p < 0.05$)

Table 1. Colour and appearance score of lassi blended with dragon fruit pulp

Treatment	R1	R2	R3	R4	Mean
T ₀	6.40	6.55	7.05	7.20	6.80a
T ₁	7.10	7.25	7.75	7.90	7.50b
T ₂	8.20	8.70	8.45	8.60	8.49c
T ₃	8.30	8.85	8.70	9.00	8.71d

$S.E._m \pm 0.1648$ C.D. at 5% = 0.5079

3.2.2 Flavour

The mean flavour scores for T₀, T₁, T₂ and T₃ were 7.78, 8.23, 8.43 and 8.37, respectively (Table 2). T₂ recorded the highest numerical score (8.43), followed by T₃, T₁ and T₀. ANOVA indicated a non-significant treatment effect ($F_{\text{cal}} = 2.2401 < F_{\text{table}} = 3.4903$), and all treatments were statistically at par (superscript 'a'). The mild fruity aromatic notes of dragon fruit pulp complemented the lactic acid flavour profile generated by the starter culture, providing a pleasant refreshing taste. These observations are in agreement with Khairnar *et al.* (2025) [14] and Jayasinghe *et al.* (2015) [12].

3.2.3 Taste

Taste scores for T₀, T₁, T₂ and T₃ were 7.50, 7.77, 8.58 and 8.49, respectively (Table 3). T₂ (4% pulp) registered the highest mean score (8.58), followed by T₃ (8.49), T₁ (7.77) and T₀ (7.50). ANOVA showed a significant treatment effect ($F_{\text{cal}} = 10.8517 > F_{\text{table}} = 3.4903$; CD at 5% = 0.4964), with T₀ and T₁ statistically at par and T₂ and T₃ at par and superior to T₀ and T₁. The slight decline in taste at 6% pulp may be related to higher acidity at elevated pulp levels. These results are consistent with Dhumal *et al.* (2018) [15], who observed a similar pattern of taste improvement up to an optimum level followed by a decline.

Table 2. Flavour score of lassi blended with dragon fruit pulp

Treatment	R1	R2	R3	R4	Mean
T ₀	8.01	8.05	7.05	8.01	7.78a
T ₁	8.01	8.40	8.01	8.50	8.23a
T ₂	8.05	8.50	8.30	8.85	8.43a
T ₃	8.25	9.00	8.20	8.01	8.37a

S.E._m ± 0.1948 C.D. at 5% = 0.6004NS = Non-Significant ($p > 0.05$)**Table 3.** Taste score of lassi blended with dragon fruit pulp

Treatment	R1	R2	R3	R4	Mean
T ₀	7.50	7.00	7.50	8.00	7.50a
T ₁	8.02	7.50	8.10	7.45	7.77a
T ₂	8.60	8.50	8.70	8.50	8.58b
T ₃	8.10	8.40	8.50	8.95	8.49b

S.E._m ± 0.1611 C.D. at 5% = 0.4964Means with different superscripts differ significantly ($p < 0.05$)

3.2.4 Body and texture

Body and texture scores were 7.65, 8.50, 8.15 and 8.00 for T₀, T₁, T₂ and T₃, respectively (Table 4). T₁ (2% pulp) recorded the highest numerical score (8.50), followed by T₂ (8.15), T₃ (8.00) and T₀ (7.65). ANOVA showed a significant treatment effect ($F_{cal} = 8.1506 > F_{table} = 3.4903$). The improvement in body and texture is attributed to the hydrocolloidal dietary fibre (soluble pectin and mucilage) in dragon fruit pulp, which interacts with casein micelles forming a hydrated matrix that increases water retention and reduces syneresis. Similar observations were made by Mule *et al.* (2018) [16] and Jadhav (2016).

Means with different superscripts differ significantly ($p < 0.05$)

3.2.5 Overall acceptability

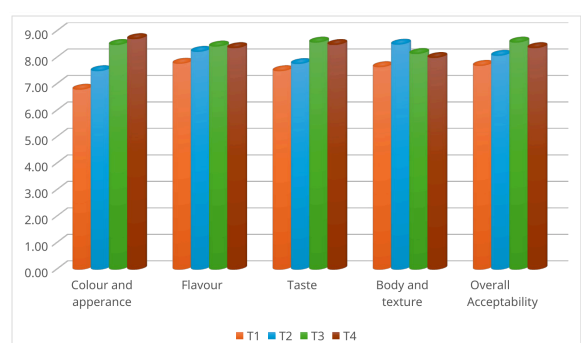
Overall acceptability scores ranged from 7.70 (T₀) to 8.58 (T₂). The mean scores for T₀, T₁, T₂ and T₃ were 7.70, 8.08, 8.58 and 8.37, respectively (Table 5). ANOVA revealed a significant treatment effect ($F_{cal} = 4.64909 > F_{table} = 3.4903$; CD at 5% = 0.5446). T₂ (4% dragon fruit pulp) recorded the highest numerical overall acceptability score, indicating a favourable balance among colour, flavour, taste and textural attributes at this pulp level. These results agree closely with Jayasinghe *et al.* (2015) [12], Khairnar *et al.* (2025) [14] and Aiswarya *et al.* (2025) [13].

Means with different superscripts differ significantly ($p < 0.05$)**Table 4.** Body and texture score of lassi blended with dragon fruit pulp

Treatment	R1	R2	R3	R4	Mean
T ₀	7.70	7.00	7.30	7.60	7.65a
T ₁	8.10	7.50	8.50	7.90	8.50a
T ₂	8.60	8.00	8.50	8.50	8.15ab
T ₃	8.50	8.50	8.00	8.85	8.00ab

S.E._m ± 0.1712 C.D. at 5% = 0.5275**Table 5.** Overall acceptability score of lassi blended with dragon fruit pulp

Treatment	R1	R2	R3	R4	Mean
T ₀	7.07	7.89	7.90	7.93	7.70a
T ₁	8.00	8.16	8.09	8.08	8.08a
T ₂	8.95	8.20	8.26	8.90	8.58ab
T ₃	8.60	7.95	8.80	8.12	8.37a

S.E._m ± 0.1768 C.D. at 5% = 0.5446

Graphical presentation of sensory quality of lassi blended dragon fruit pulp

3.3 Physico-chemical properties

3.3.1 Titratable acidity

Titrateable acidity increased progressively from 0.82% (T₀) to 0.84% (T₁), 0.89% (T₂) and 0.91% (T₃) (Table 6). The treatment effect was significant ($F_{cal} = 33.0526 > F_{table} = 3.4903$; CD at 5% = 0.0237), with T₂ and T₃ statistically at par. The increase in acidity is attributed to the organic acids naturally present in dragon fruit pulp. These findings are consistent with Upadhyay *et al.* (2017) [17] and Siregar *et al.* (2023) [5].

Means with different superscripts differ significantly ($p < 0.05$)

Table 6. Titratable acidity (%) of lassi blended with dragon fruit pulp

Treatment	R1	R2	R3	R4	Mean
T ₀	0.80	0.81	0.83	0.82	0.82a
T ₁	0.81	0.85	0.87	0.84	0.84b
T ₂	0.89	0.88	0.89	0.90	0.89c
T ₃	0.92	0.91	0.90	0.92	0.91c
<i>S.E._m ± 0.0077 C.D. at 5% = 0.0237</i>					

3.3.2 pH

pH values declined progressively from 4.56 (T₀) to 4.43 (T₁), 4.37 (T₂) and 4.29 (T₃) (Table 7). The treatment effect was significant ($F_{\text{cal}} = 35.5044 > F_{\text{table}} = 3.4903$), with T₁ and T₂ statistically at par. The decrease in pH corresponds with the progressive increase in

titratable acidity upon dragon fruit pulp incorporation. A lower product pH enhances microbiological safety by suppressing pathogenic microorganisms, thereby extending storage stability. Similar results were reported by Ghule *et al.* (2015) [18], Hafiz *et al.* (2025) [7] and Dhumal *et al.* (2018) [15].

Table 7. pH of lassi blended with dragon fruit pulp

Treatment	R1	R2	R3	R4	Mean
T ₀	4.55	4.52	4.60	4.55	4.56a
T ₁	4.38	4.42	4.47	4.43	4.43b
T ₂	4.32	4.36	4.38	4.41	4.37b
T ₃	4.30	4.34	4.27	4.24	4.29c
<i>S.E._m ± 0.0189 C.D. at 5% = 0.0582</i>					

Means with different superscripts differ significantly ($p < 0.05$)

3.3.3 Fat content

Fat content decreased progressively from 2.55% (T₀) to 2.51% (T₁), 2.47% (T₂) and 2.44% (T₃) (Table 8). The treatment effect was significant ($F_{\text{cal}} = 14.0571 > F_{\text{table}} = 3.4903$; CD at 5% = 0.0372). The ob-

served reduction is attributed to the comparatively low fat content (0.57 g/100 g) of dragon fruit pulp and the dilution effect of increasing pulp levels. Comparable results were reported by Dhumal *et al.* (2018) [15] and Kahandal *et al.* (2020) [19].

Table 8. Fat content (%) of lassi blended with dragon fruit pulp

Treatment	R1	R2	R3	R4	Mean
T ₀	2.54	2.55	2.53	2.56	2.55a
T ₁	2.50	2.51	2.52	2.49	2.51b
T ₂	2.49	2.45	2.46	2.48	2.47bc
T ₃	2.41	2.47	2.48	2.40	2.44c
<i>S.E._m ± 0.0121 C.D. at 5% = 0.0372</i>					

Means with different superscripts differ significantly ($p < 0.05$)

3.3.4 Protein content

Protein content decreased progressively from 3.13% (T₀) to 2.95% (T₁), 2.81% (T₂) and 2.71% (T₃) (Table 9). ANOVA indicated a highly significant treatment effect ($F_{\text{cal}} = 94.019 > F_{\text{table}} = 3.4903$;

CD at 5% = 0.0576), with all four treatments differing significantly from one another. The reduction is associated with the comparatively low protein content (1.10 g/100 g) of dragon fruit pulp compared to the cow milk base (3.30%). Comparable findings were reported by Kahandal *et al.* (2020) [19].

Table 9. Protein content (%) of lassi blended with dragon fruit pulp

Treatment	R1	R2	R3	R4	Mean
T ₀	3.11	3.12	3.14	3.15	3.13a
T ₁	2.96	2.97	2.96	2.90	2.95b
T ₂	2.80	2.79	2.81	2.83	2.81c
T ₃	2.70	2.65	2.70	2.80	2.71d
<i>S.E._m ± 0.0187 C.D. at 5% = 0.0576</i>					

Means with different superscripts differ significantly ($p < 0.05$)

3.3.5 Moisture content

Moisture content increased from 87.21% (T₀) to 88.59% (T₁), 89.50% (T₂) and 89.65% (T₃) (Table 10). The treatment effect was significant ($F_{\text{cal}} = 12.7484 > F_{\text{table}} = 3.4903$; CD at 5% = 0.9664),

with T₁, T₂ and T₃ statistically at par while T₀ differed significantly. The increase is consistent with the high moisture content of fresh dragon fruit pulp (87.10 g/100 g). Comparable results were reported by Dhumal *et al.* (2018) [15].

Table 10. Moisture content (%) of lassi blended with dragon fruit pulp

Treatment	R1	R2	R3	R4	Mean
T ₀	87.10	87.30	86.20	88.25	87.21a
T ₁	88.05	89.14	88.15	89.01	88.59b
T ₂	89.70	90.10	89.12	89.08	89.50b
T ₃	89.10	89.25	90.10	90.15	89.65b
S.E. _m ± 0.3136 C.D. at 5% = 0.9664					

Means with different superscripts differ significantly ($p < 0.05$)

3.3.6 Total solids

Total solids decreased from 12.79% (T₀) to 11.41% (T₁), 10.50% (T₂) and 10.35% (T₃) (Table 11). The treatment effect was significant ($F_{cal} = 12.7484 > F_{table} = 3.4903$), with T₁, T₂ and T₃ statistically at

par while T₀ differed significantly. The decrease in total solids corresponds with the increase in moisture content, attributable to the high moisture content and comparatively lower total solids of fresh dragon fruit pulp. These findings are comparable with Mule *et al.* (2018) [16] and Bagal *et al.* (2016) [20].

Table 11. Total solids content (%) of lassi blended with dragon fruit pulp

Treatment	R1	R2	R3	R4	Mean
T ₀	12.90	12.70	13.80	11.75	12.79a
T ₁	11.95	10.86	11.85	10.99	11.41b
T ₂	10.30	9.90	10.88	10.92	10.50b
T ₃	10.90	10.75	9.90	9.85	10.35b
S.E. _m ± 0.3136 C.D. at 5% = 0.9664					

Means with different superscripts differ significantly ($p < 0.05$)

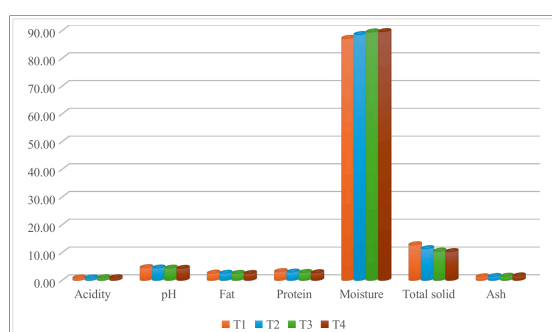
3.3.7 Ash content

Ash content increased numerically from 1.25% (T₀) to 1.36% (T₁), 1.44% (T₂) and 1.58% (T₃) with ANOVA showing a significant treatment effect ($F_{cal} = 51.127 > F_{table} = 3.4903$). The increase in ash is

attributed to the mineral contribution of dragon fruit pulp (calcium, phosphorus, iron), which supplemented the intrinsic mineral profile of the cow milk base, thereby increasing overall mineral residue upon ignition. This mineral enrichment represents a nutritional advantage of dragon fruit pulp incorporation into lassi.

Table 4.25. Ash content of lassi blended with dragon fruit pulp

Treatment	R1	R2	R3	R4	Mean
T ₀	1.30	1.25	1.20	1.25	1.25a
T ₁	1.40	1.32	1.35	1.35	1.36a
T ₂	1.50	1.40	1.45	1.40	1.44a
T ₃	1.60	1.55	1.60	1.55	1.58a
S.E. _m ± 0.0191 C.D. at 5% = 0.0591					



4. Conclusion

The present study demonstrated that dragon fruit (*Selenicereus undatus*) pulp can be successfully incorporated into lassi at levels of 2–6% without adversely affecting product quality. Colour and appearance improved significantly with increasing pulp level, with T₃ (6% pulp) recording the highest score (8.71). Flavour scores improved numerically but non-significantly. Taste and overall acceptability were significantly influenced, with T₂ (4% pulp) recording the highest scores of 8.58 in both parameters. Physico-chemical analysis revealed progressive increases in acidity and ash, and decreases in fat, protein and total solids with increasing pulp incorporation. On the basis of highest overall acceptability (8.58) and favourable physico-chemical charac-

teristics, T₂ (4% dragon fruit pulp) was identified as the optimum formulation. The study demonstrates the feasibility of developing a naturally coloured, nutritionally enriched and sensory-acceptable functional fermented dairy beverage by incorporating 4% dragon fruit pulp into lassi.

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