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Shelf life and cost of production of lassi blended with dragon fruit

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ABSTRACT

The present study was undertaken to evaluate the shelf life and cost of production of lassi blended with dragon fruit (*Selenicereus undatus*) pulp at levels of 0% (T_0 , control), 2% (T_1), 4% (T_2) and 6% (T_3). Shelf-life assessment was conducted under refrigerated storage at $7 \pm 2^\circ\text{C}$ over 9 days at 3-day intervals, based on sensory parameters including colour and appearance, flavour, taste, body and texture, and overall acceptability. Sensory scores declined progressively with advancing storage in all treatments. Overall acceptability scores on the 0th day were 7.50, 8.50, 8.00 and 7.50 for T_0 , T_1 , T_2 and T_3 , respectively, declining to 6.00, 6.00, 5.50 and 4.50 on the 9th day. Based on sensory evaluation, dragon fruit pulp blended lassi was acceptable up to the 6th day of refrigerated storage. Cost of production per 1000 ml increased with increasing pulp level: Rs. 112.07 (T_0), Rs. 114.88 (T_1), Rs. 116.22 (T_2) and Rs. 118.29 (T_3). Treatment T_2 (4% pulp), selected as the optimum on the basis of sensory acceptability, had a cost of Rs. 116.22 per 1000 ml, representing a reasonable value addition for a functional fermented dairy beverage.

Keywords: Lassi, Dragon fruit, *Selenicereus undatus*, Shelf life, Refrigerated storage, Cost of production, Functional dairy beverage

1. Introduction

Lassi is one of India's most widely consumed traditional fermented dairy beverages, prepared by blending curd (*dahi*) with water, sugar and flavouring agents. It is valued for its probiotic properties, refreshing taste and nutritional contribution to the diet. The growing consumer preference for value-added and functional dairy beverages has created significant market potential for novel formulations of lassi incorporating health-promoting ingredients (Tamime *et al.*, 2007; Aneja *et al.*, 2002) [2, 1].

However, the commercial viability of any new dairy product formulation depends critically on two practical considerations: its shelf life under practical storage conditions, and its economic cost of production. Shelf life determines the product's marketability, distribution scope and consumer safety assurance, while the cost of production determines the pricing strategy and economic feasibility of large-scale manufacturing (Jay *et al.*, 2005; Pawar *et al.*, 2010) [3, 4].

Dragon fruit (*Selenicereus undatus*) is an exotic tropical fruit rich in betalain pigments, polyphenolic compounds, ascorbic acid, dietary fibre and essential minerals. The natural antimicrobial and antioxidant compounds present in dragon fruit pulp may potentially contribute to improved microbiological stability and oxidative resistance of the fortified lassi during refrigerated storage (Pavithra *et al.*, 2023; Hafiz *et al.*, 2025) [6, 5]. Studies on storage quality of dragon fruit blended dairy products have shown that properly fortified products can maintain acceptable sensory and microbiological quality under refrigeration for several days (Jayasinghe *et al.*, 2015; Khairnar *et al.*, 2025) [7, 8].

Although the sensory and physico-chemical properties of dragon fruit blended lassi have been characterized, limited quantitative information is available on its shelf life under refrigerated storage conditions and on the economic cost implications of dragon fruit pulp incorporation at different levels. Therefore, the present investigation was undertaken to evaluate the storage stability and cost of production of dragon fruit pulp blended lassi at four pulp incorporation levels, to determine the practical shelf life and economic feasibility of the optimum formulation.

2. Materials and Methods

2.1 Preparation of lassi

Fresh cow milk (3.5% fat, 8.5% SNF) procured from Natural Milk Pvt. Ltd., Latur was pasteurized at $80-85^\circ\text{C}$ for 15 minutes, cooled to 37°C and inoculated with standard dahi culture NCDC-167 at 2% (w/w). Inoculated milk was incubated at 30°C for 12 hours to obtain set curd. The coagulum was broken and blended with 20% chilled water and 15% sugar (w/w). Dragon fruit (*Selenicereus undatus*) pulp was incor

porated at four levels: T₀ (0%, control), T₁ (2%), T₂ (4%) and T₃ (6%) on a weight-by-weight basis. The prepared *lassi* was packed in pre-sterilized glass bottles and stored at 7 ± 2 °C.

2.2 Shelf-life evaluation

The shelf life of dragon fruit pulp blended *lassi* was assessed under refrigerated storage at 7 ± 2 °C by sensory evaluation on the 0th, 3rd, 6th and 9th days of storage. Sensory evaluation was performed by a semi-trained panel of five judges using a 9-point Hedonic scale. The sensory parameters assessed were colour and appearance, flavour, taste, body and texture, and overall acceptability. The product was considered acceptable as long as the overall acceptability score remained above 6.0 on the 9-point scale.

2.3 Cost of production

The cost of production per 1000 ml of dragon fruit pulp blended *lassi* was estimated based on the prevailing market prices of raw materials during 2025–26. The cost components considered included dahi (Rs. 110/kg), dragon fruit pulp (Rs. 250/kg), sugar (Rs. 42/kg), labour charges (Rs. 15 per batch), fuel charges (Rs. 10 per batch), miscellaneous charges (Rs. 5 per batch) and starter culture (Rs. 5 per batch). Each batch yielded 1350 ml of *lassi*, and the cost per 1000 ml was calculated accordingly.

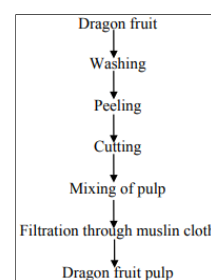
2.4 Statistical design

The experiment was conducted in a Completely Randomized Design (CRD) with four replications per treatment. Statistical analysis of sensory data was performed following Panse and Sukhatme (1985), and 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 pre-sterilized glass bottles and stored at 7 ± 2 °C. Shelf-life assessment was conducted by sensory evaluation at 3-day intervals (0th, 3rd, 6th and 9th day) by a semi-trained panel of five judges on a 9-point Hedonic scale. The product was considered acceptable as long as the overall acceptability score remained at or above 6.0. The cost of production per 1000 ml was estimated based on prevailing market prices of raw materials during 2025–26, including the cost of dahi, dragon fruit pulp, sugar, starter culture, labour, fuel and miscellaneous charges; each batch yielded 1350 ml of *lassi* and the cost per 1000 ml was calculated accordingly.

Preparation of dragon fruit pulp



Flow diagram. No.1.1. Flow chart for preparation of dragon fruit pulp

Treatment combinations

For preparation of *lassi* by using dragon fruit (*Selenicereus undatus*) pulp, by adding sugar 15 per cent by weight of *lassi* and dragon fruit pulp as per the treatment combinations was finalized on weight basis as follows:

T₀ - 100 parts of curd

T₁ - 98 parts of curd + 02 parts of dragon fruit pulp

T₂ - 96 parts of curd + 04 parts of dragon fruit pulp

T₃ - 94 parts of curd + 06 parts of dragon fruit pulp

Preparation of dragon fruit (*Selenicereus undatus*) pulp blended *lassi*

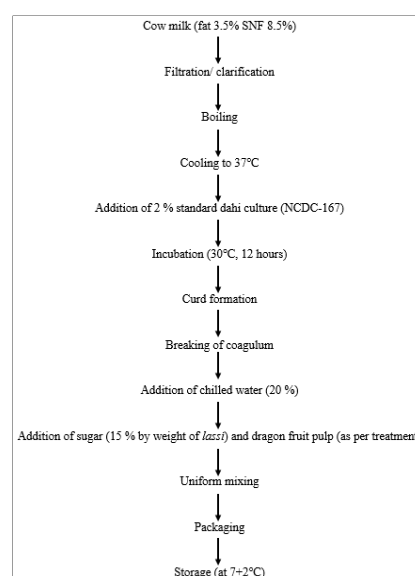


Figure 1.2. Flow chart for preparation of dragon fruit pulp blended *lassi*

3. Results and Discussion

3.1 Shelf-life evaluation

The shelf life of dragon fruit pulp blended *lassi* was assessed at 3-day intervals during refrigerated storage at 7 ± 2 °C. All sensory scores declined with advancing storage period. The complete sensory scores for all treatments across the storage period are presented in Table 1.

Table 1. Shelf life of *lassi* blended with dragon fruit pulp under refrigerated storage (7 ± 2 °C)

Sensory Parameter / Treatment	0th Day	3rd Day	6th Day	9th Day
Colour and Appearance				
T ₀ (Control)	8.00	8.00	7.50	6.00
T ₁ (2% pulp)	8.50	8.00	7.50	6.00
T ₂ (4% pulp)	9.00	8.50	7.50	5.00
T ₃ (6% pulp)	7.50	7.00	6.50	6.00

(continued on next page)

Sensory Parameter / Treatment	0th Day	3rd Day	6th Day	9th Day
Flavour				
T ₀ (Control)	8.50	7.00	6.50	5.00
T ₁ (2% pulp)	7.50	8.00	7.50	6.50
T ₂ (4% pulp)	8.50	7.00	6.50	5.50
T ₃ (6% pulp)	7.50	6.50	5.00	5.50
Taste				
T ₀ (Control)	7.00	7.00	6.50	6.50
T ₁ (2% pulp)	8.00	7.00	7.50	5.00
T ₂ (4% pulp)	8.50	8.50	6.50	6.00
T ₃ (6% pulp)	8.50	7.50	6.00	5.50
Body and Texture				
T ₀ (Control)	7.00	7.50	6.00	5.50
T ₁ (2% pulp)	8.00	7.00	6.50	6.00
T ₂ (4% pulp)	8.50	7.50	6.00	5.00
T ₃ (6% pulp)	8.50	8.50	6.50	4.50
Overall Acceptability				
T ₀ (Control)	7.50	7.50	6.00	6.00
T ₁ (2% pulp)	8.50	7.00	6.00	6.00
T ₂ (4% pulp)	8.00	7.50	6.50	5.50
T ₃ (6% pulp)	7.50	7.00	5.50	4.50

3.1.1 Colour and appearance during storage

Colour and appearance scores were highest on the 0th day for all treatments, with T₂ (4% pulp) recording the highest initial score of 9.00, followed by T₁ (8.50), T₀ (8.00) and T₃ (7.50). The higher initial score in T₂ reflects the attractive natural pink colour imparted by the betalain pigments of dragon fruit pulp. Scores declined progressively during storage across all treatments. By the 6th day, scores ranged from 6.50 (T₃) to 7.50 (T₀, T₁, T₂), remaining within the acceptable range (above 6.0). On the 9th day, scores declined further to 5.00 (T₂), 6.00 (T₀, T₁, T₃), indicating reduced visual appeal due to progressive colour degradation and oxidative pigment changes. The gradual fading of betalain pigments in dragon fruit during storage, particularly under refrigeration, has been documented by Stintzing *et al.* (2007) [9]. Similar colour score decline during storage of fruit-fortified fermented dairy products was reported by Jayasinghe *et al.* (2015) [7] and Suresh *et al.* (2022) [10].

3.1.2 Flavour during storage

Initial flavour scores on the 0th day were 8.50 for T₀ and T₂, and 7.50 for T₁ and T₃. The pleasant lactic acid fermentation aroma complemented by the mild fruity notes of dragon fruit contributed to favourable initial flavour ratings. Flavour scores declined during storage due to progressive proteolytic and lipolytic activities of residual lactic acid bacteria, producing off-flavours, and due to progressive oxidation of volatile aromatic compounds from the fruit pulp. By the 6th day, flavour scores ranged from 5.00 (T₃) to 7.50 (T₁), with T₁ retaining better flavour acceptability. On the 9th day, scores fell to 5.00–6.50, indicating reduced flavour quality. These results are consistent with findings by Sharma *et al.* (2016) [11] and Krishna *et al.* (2019) [12], who reported progressive flavour score decline in fermented dairy beverages during refrigerated storage.

3.1.3 Taste during storage

Initial taste scores on the 0th day were high for T₂ and T₃ (8.50 each), followed by T₁ (8.00) and T₀ (7.00), reflecting the pleasant sweet-sour balance of the fruit-fortified formulations. During storage, taste scores declined in all treatments due to progressive lactic acid accumulation by residual starter culture activity, increasing perceived sourness and reducing palatability. By the 6th day, scores ranged from 6.00 (T₃) to 7.50 (T₁), remaining within acceptable limits. On the 9th day, scores fell to 5.00–6.50 for all treatments, indicating borderline acceptability. The progressive increase in acidity during cold storage

of fermented dairy products is a well-established phenomenon that adversely affects taste acceptability (Jadhav *et al.*, 2014; Mohanpriya *et al.*, 2019) [13, 14].

3.1.4 Body and texture during storage

Body and texture scores were high on the 0th day for T₂ and T₃ (8.50 each) and T₁ (8.00), while T₀ recorded 7.00. The fibrous components of dragon fruit pulp contributed to the improved initial body and texture of fruit-fortified formulations. During storage, body and texture scores declined, primarily due to progressive casein proteolysis by residual lactic acid bacteria and whey syneresis, resulting in phase separation and thinning of the beverage. By the 6th day, scores ranged from 6.00 (T₀, T₂) to 6.50 (T₁, T₃). The pronounced decline in T₃ body and texture to 4.50 on the 9th day indicates greater susceptibility to textural deterioration at higher pulp levels, possibly due to the higher moisture content promoting microbial growth and protein degradation.

3.1.5 Overall acceptability during storage

Overall acceptability scores on the 0th day were 8.50, 8.00, 7.50 and 7.50 for T₁, T₂, T₀ and T₃, respectively. T₁ (2% pulp) showed the highest initial overall acceptability, followed by T₂, T₀ and T₃. During the 3rd day of storage, scores declined slightly to 7.00 (T₁, T₃), 7.

50 (T₀, T₂), remaining within the acceptable range. By the 6th day, scores ranged from 5.50 (T₃) to 6.50 (T₂), with T₀ and T₁ recording 6.00. The 9th day scores were 6.00 (T₀, T₁), 5.50 (T₂) and 4.50 (T₃), clearly indicating that sensory quality declined below acceptable levels for most treatments by the 9th day.

Based on the overall acceptability criterion (score ≥ 6.0), dragon fruit pulp blended *lassi* remained acceptable up to the 6th day of refrigerated storage at 7 ± 2 °C for T₀, T₁ and T₂, while T₃ (6% pulp) showed acceptability falling below 6.0 on the 9th day, suggesting a shelf life of 6 days under the tested storage conditions. These observations agree with Khairnar *et al.* (2025) [8], who reported acceptable shelf life up to 6 days for dragon fruit blended *lassi* at 5 ± 1 °C. Pawar *et al.* (2010) [4] and Sharma *et al.* (2016) [11] also reported acceptable shelf life of 6 to 21 days for fruit or additive-fortified *lassi* under refrigerated conditions depending on formulation and preservative use. The progressive decline in sensory quality is a consequence of (i) ongoing lactic acid fermentation increasing acidity and sourness, (ii) lipolytic and proteolytic activity by residual starter bacteria producing off-flavours, (iii) oxidative degradation of betalain pigments reducing

colour appeal, and (iv) syneresis (whey separation) reducing consistency at higher pulp levels (Suresh *et al.*, 2022) [10].

3.2 Cost of production

The cost of production of dragon fruit pulp blended *lassi* per 1000 ml was calculated based on prevailing market rates in 2025–26 and is presented in Table 2. The total cost per 1000 ml increased progressively from Rs. 112.07 (T₀) to Rs. 114.88 (T₁), Rs. 116.22 (T₂) and Rs. 118.29 (T₃) with increasing dragon fruit pulp incorporation.

Table 2. Cost of production of *lassi* blended with dragon fruit pulp (per 1000 ml)

Sr. No.	Particulars	Rate (Rs. /kg)	(T ₀) Cost (Rs.)	(T ₁) Cost (Rs.)	(T ₂) Cost (Rs.)	(T ₃) Cost (Rs.)
1	Dahi (1000/980/960/940 g)	110	110.00	107.80	105.60	103.40
2	Dragon fruit pulp (0/20/40/60 g)	250	—	5.00	10.00	15.00
3	Sugar @ 15% (150 g)	42	6.30	6.30	6.30	6.30
4	Water (200 ml)	—	—	—	—	—
5	Labour charges	—	15.00	15.00	15.00	15.00
6	Fuel charges	—	10.00	10.00	10.00	10.00
7	Miscellaneous charges	—	5.00	5.00	5.00	5.00
8	Starter culture	—	5.00	5.00	5.00	5.00
9	Total cost (for 1350 ml)	—	151.30	155.10	156.90	159.70
10	Cost per 1000 ml	—	112.07	114.88	116.22	118.29

The cost of production increased with increasing dragon fruit pulp level primarily because the cost of dragon fruit pulp (Rs. 250/kg) is considerably higher than dahi on a per-gram basis, and the pulp directly replaces a portion of the lower-cost curd base. Specifically, the addition of 20 g, 40 g and 60 g of dragon fruit pulp at T₁, T₂ and T₃ respectively contributed Rs. 5.00, Rs. 10.00 and Rs. 15.00 to the ingredient cost of each treatment.

The optimum treatment T₂ (4% dragon fruit pulp) had a cost of Rs. 116.22 per 1000 ml, which is Rs. 4.15 more than the control (T₀: Rs. 112.07). This marginal increase in cost of Rs. 4.15 per litre for T₂ corresponds to a cost increment of approximately 3.7% over the control, which is a modest price premium for the considerably enhanced nutritional value, attractive natural pink colour, improved sensory acceptability and functional health benefits conferred by dragon fruit pulp incorporation.

The economic feasibility of the T₂ formulation is supported by increasing consumer willingness to pay premium prices for naturally fortified, clean-label functional dairy beverages. Comparative cost analysis of fruit-fortified *lassi* formulations in published literature indicates that the cost increments observed in the present study fall within the range reported for other fruit-fortified *lassi* variants, including kiwi *lassi* (Kedaree *et al.*, 2021) [15], strawberry *lassi* (Kahandal *et al.*, 2020) [16] and banana *lassi* (Khunte *et al.*, 2022) [17].

3.3 Integration of shelf-life and economic observations

Considering both shelf life and cost of production simultaneously, T₂ (4% dragon fruit pulp) emerges as the most balanced and economically viable formulation. It demonstrated acceptable sensory quality up to the 6th day of refrigerated storage at 7 ± 2 °C, had the highest initial overall acceptability (8.00 on 0th day in shelf-life assessment), and had a reasonable production cost of Rs. 116.22 per 1000 ml. While T₁ (2% pulp) showed the highest initial overall acceptability (8.50), T₂ offered a superior balance of colour improvement, taste acceptability, shelf life and cost efficiency. T₃ (6% pulp) showed faster sensory quality decline and the highest production cost, rendering it economically less attractive despite its superior colour score.

A shelf life of 6 days under refrigerated conditions at 7 ± 2 °C is consistent with the commercial shelf life of similar fermented dairy beverages available in the market, where *lassi* products typically carry a shelf life of 5 to 10 days under refrigeration depending on formulation and packaging (Krishna *et al.*, 2019; Sharma *et al.*, 2016) [12, 11]. The

shelf life could potentially be extended by employing aseptic packaging, adding natural preservatives such as nisin, or using modified atmosphere packaging, which are commonly used in commercial dairy product formulation (Pawar *et al.*, 2010; Kumar, 2014) [4].

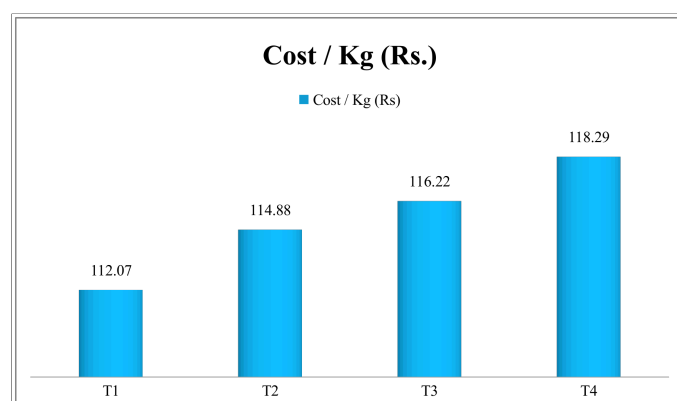


Figure. Graphical presentation of cost of production *lassi* blended with dragon fruit pulp

4. Conclusion

The present study demonstrated that dragon fruit (*Selenicereus undatus*) pulp blended *lassi* exhibited acceptable sensory quality under refrigerated storage (7 ± 2 °C) up to the 6th day across all treatments (T₀ to T₂), while T₃ (6% pulp) showed a marked decline in sensory scores on the 9th day. Colour and appearance, flavour, taste, body and texture and overall acceptability all declined progressively during storage. The decline in sensory quality during storage is attributed to progressive lactic acid accumulation, lipolytic and proteolytic activity, betalain pigment oxidation and whey syneresis.

Cost of production per 1000 ml increased with increasing pulp level from Rs. 112.07 (T₀) to Rs. 118.29 (T₃). T₂ (4% dragon fruit pulp), identified as the optimum formulation on the basis of sensory acceptability, had a production cost of Rs. 116.22 per 1000 ml, representing a modest 3.7% cost increment over the control. Considering the combined criteria of shelf life (6 days), sensory acceptability and economic viability, T₂ (4% dragon fruit pulp) is the most suitable and commercially viable formulation for the preparation of functional dragon fruit blended *lassi*. The product can be recommended for both household preparation and small-scale dairy enterprise production.

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