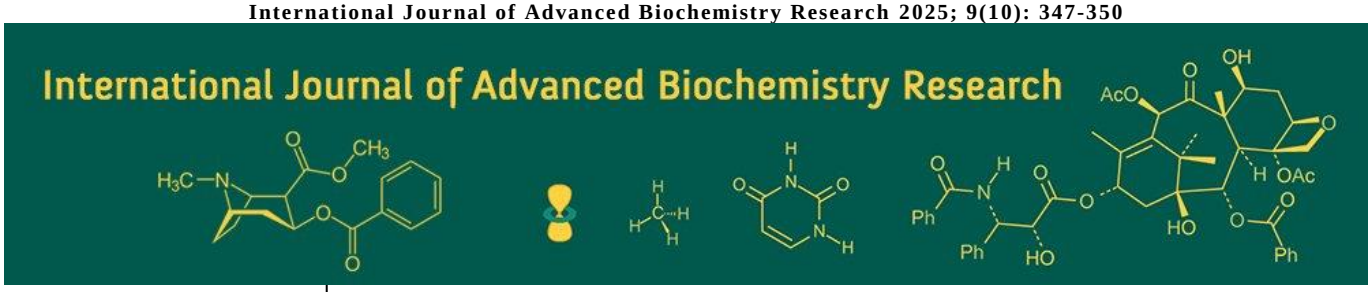

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Physico-chemical and economic evaluation of lassi fortified with Calcutta betel vine (*Piper betel*) leaves extract

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Abstract
The present investigation entitled "Preparation of Lassi Blended with Calcutta Betel Vine (*Piper betel*) Leaves Extract" was conducted in the Section of Animal Husbandry and Dairy Science, Nagpur. The study aimed to determine the optimum level of betel vine leaves extract in lassi preparation, with specific objectives of sensory evaluation, assessment of physico-chemical properties, and estimation of production cost. Five treatments were formulated, including a control (T_1) and lassi prepared with varying levels of betel vine leaves extract, i.e., 9% (T_2), 12% (T_3), 15% (T_4), and 18% (T_5).The sensory evaluation revealed that lassi with 15% betel vine leaves extract (T_4) recorded the highest scores for flavour (8.40), colour and appearance (8.20), body and texture (8.40), and overall acceptability (8.60). In contrast, the lowest scores.

Keywords: Lassi, betel vine leaves, physico-chemical properties, cost of production

1. Introduction
India is the leading country in milk production worldwide. In 2020, India produced 194.8 million tonnes of milk, accounting for 40.41% of global milk production (Anonymous, 2021) [1]. A substantial portion of surplus milk is processed into various dairy products such as dahi, lassi, chakka, shrikhand, khoa, paneer, butter, ghee, kulfi, and ice cream. Milk is recognized as an ideal food due to its rich nutritional profile, being a valuable source of proteins, bone-forming minerals, essential vitamins, lactose, and milk fat, along with essential fatty acids.

Piper betel L. (synonym: *Piper betel* Blanco), belonging to the family Piperaceae, is a perennial creeping plant native to Malaysia and widely distributed across tropical Asia and East Africa. It is cultivated extensively in India, Bangladesh, Sri Lanka, Thailand, and Malaysia, serving as a major cash crop and earning the title "green gold of India." Nearly 20 million people depend on betel vine cultivation, processing, and trade for their livelihood (Biswas *et al.*, 2022) [4].

Lassi is considered a probiotic beverage owing to the presence of *Lactobacillus* spp., which aid in digestion and improve gut health. It serves as an excellent source of calcium, potassium, magnesium, proteins, and vitamins that support bone health, immunity, and overall metabolic activity (Saha *et al.*, 2021) [11]. Regular consumption has also been associated with reduction of body fat, particularly abdominal fat, due to its lactic acid and vitamin D content.

Fermented milk products occupy a significant share in the Indian dairy sector. Nearly 10% of India's total milk production is processed into lassi, making it one of the most popular ready-to-serve traditional fermented beverages (Shaik *et al.*, 2017) [12].

2. Materials and Methods
2.1 Raw materials
Cow milk was procured from the local market of Nagpur for lassi preparation. Fresh betel vine leaves were purchased from local suppliers. Analytical-grade chemicals were used for compositional analysis.

2.2 Preparation of lassi
Lassi was prepared from cow milk by incorporating different levels of betel vine leaves extract distillate. The treatment combinations consisted of T_1 (control, 100% lassi without extract), T_2 (91% lassi with 9% extract), T_3 (88% lassi with 12% extract), T_4 (85% lassi with 15% extract), and T_5 (82% lassi with 18% extract). In all treatments, water and sugar were added at the rate of 10% each to curd before preparation.

2.3 Analytical Methods
The prepared lassi samples were analyzed for fat, protein, total solids, moisture, ash, SNF, and acidity as per standard methods.

2.4 Cost analysis
The cost of production was calculated considering prevailing market prices of milk, betel vine leaves, sugar, fuel, electricity, and labor. The cost per kilogram of lassi was computed for each treatment.

3. Results and Discussion
3.1 Fat content

Table 1: Fat content of lassi prepared by different levels of betel vine leaves (percent).

Treatments	Replications					Mean
	R-1	R-2	R-3	R-4	R-5	
T_1	2.98	3.02	3.00	2.99	2.86	2.97
T_2	2.82	2.86	2.97	2.85	2.73	2.84
T_3	2.75	2.78	2.84	2.74	2.64	2.75
T_4	2.69	2.63	2.77	2.62	2.55	2.65
T_5	2.56	2.47	2.64	2.51	2.42	2.52
S.E ± 0.049 C.D. 5 %0.012 Result Sig.						

The fat content of lassi decreased progressively with increasing levels of betel vine leaves extract, ranging from 2.97% in T_1 (control) to 2.52% in T_5 (18% extract). The highest fat was observed in T_1, while the lowest was recorded in T_5. These findings are in agreement with Dhumal (2018) [7], who reported a reduction in fat content of lassi with increasing levels of pudina extract.

3.2 Protein content
The protein content of lassi decreased with increasing levels of betel vine leaves extract, ranging from 3.47% in T_1 (control) to 2.74% in T_5 (18% extract). The highest protein was observed in plain lassi, while the lowest was in T_5. Similar trends were reported by Bawangade *et al.* (2020), who found a reduction in protein content of lassi with increasing levels of strawberry pulp.

Table 2: Protein content of lassi prepared by different levels of betel vine leaves (percent)

Treatments	Replications					Mean
	R-1	R-2	R-3	R-4	R-5	
T_1	3.50	3.46	3.48	3.52	3.43	3.47
T_4	3.42	3.43	3.38	3.41	3.35	3.39
T_3	3.10	3.13	3.07	3.09	3.29	3.13
T_2	2.98	3.02	2.97	2.96	2.93	2.97
T_5	2.76	2.74	2.78	2.70	2.72	2.74
S.E ± 0.002 C.D. 5% 0.064 Result Sig.						

3.3 Total solids and moisture
The total solids content of lassi increased with higher levels of betel vine leaves extract, ranging from 20.48% in T_1 (control) to 21.59% in T_5 (18% extract). The highest total solids were observed in T_5, while the lowest were in T_1. Similar findings were reported by Chawla (2017) [5], who noted an increase in total solids of vitamin A fortified lassi prepared with natural sources like mango and beetroot powder**.**

Table 3: Total solids content of lassi prepared by different levels of betel vine leaves (percent)

Treatments	Replications					Mean
	R-1	R-2	R-3	R-4	R-5	
T_1	20.78	20.84	20.32	20.24	20.23	20.48
T_2	20.58	21.69	21.42	21.64	21.57	21.38
T_3	21.12	21.47	21.65	21.84	21.76	21.56
T_4	21.00	21.25	21.87	21.94	21.87	21.58
T_5	21.45	21.53	21.54	21.78	21.65	21.59
S.E ± 0.153 C.D. 5% 1.605 Result Sig.						

The moisture content of lassi increased with higher levels of betel vine leaves extract, ranging from 82.19% in T_1 (control) to 86.40% in T_5 (18% extract). The lowest value was observed in T_1, while the highest was in T_5. These findings indicate that incorporation of betel vine leaves extract enhances moisture content. In contrast, Kedaree *et al.* (2021) [8] reported a decrease in moisture content of lassi with increasing levels of kiwi pulp.

Table 4: Moisture content of lassi prepared by different levels of betel vine leaves (percent)

Treatments	Replications					Mean
	R-1	R-2	R-3	R-4	R-5	
T_1	82.15	82.15	82.20	82.22	82.25	82.19
T_2	83.20	83.22	83.24	83.26	83.28	83.24
T_3	84.25	84.27	84.30	84.35	84.37	84.30
T_4	85.30	85.33	85.35	85.37	85.40	85.35
T_5	86.35	86.37	86.40	86.44	86.48	86.40
S.E ± 0.019 C.D. 5% 0.057 Result Sig.						

3.4 Ash content
The ash content of lassi increased with higher levels of betel vine leaves extract, ranging from 0.54% in T_1 (control) to 0.75% in T_5 (18% extract). The lowest value was recorded in T_1, while the highest was in T_5. These results suggest that incorporation of betel vine leaves extract enhances the mineral content of lassi, which is consistent with findings by Pardhi *et al.* (2014) [10], who observed a similar increase in ash content with higher levels of finger millet flour in lassi.

Table 5: Ash content of lassi prepared by different levels of betel vine leaves (percent)

Treatments	Replications					Mean
	R-1	R-2	R-3	R-4	R-5	
T_1	0.58	0.53	0.56	0.54	0.53	0.54
T_2	0.62	0.56	0.61	0.58	0.56	0.58
T_3	0.64	0.60	0.62	0.60	0.62	0.61
T_4	0.69	0.70	0.73	0.78	0.70	0.72
T_5	0.72	0.73	0.75	0.79	0.78	0.75
S.E 0.012 CD 5% 0.036 Result Sig.						

3.5 Solids-not-fat (SNF)

The solid-not-fat (SNF) content of lassi increased with higher levels of betel vine leaves extract, ranging from 17.51% in T_1 (control) to 19.08% in T_5 (18% extract), indicating that incorporation of betel vine leaves extract enhances the SNF content of lassi.

Table 6: SNF content of lassi prepared by different levels of betel vine leaves (percent)

Treatments	Replications					Mean
	R-1	R-2	R-3	R-4	R-5	
T_1	17.8	17.82	17.32	17.25	17.37	17.51
T_2	17.7	18.83	18.45	18.79	18.84	18.52
T_3	18.3	18.69	18.81	19.1	19.12	18.80
T_4	18.3	18.62	19.1	19.32	19.32	18.93
T_5	18.95	19.06	18.9	19.27	19.23	19.08
S.E 0.162 CD 5% 0.474 Result Sig.						

3.6 Acidity

Table 7: Acidity content of lassi prepared by different levels of betel vine leaves (percent)

Treatments	Replications					Mean
	R-1	R-2	R-3	R-4	R-5	
T_1	0.69	0.67	0.70	0.69	0.67	0.68
T_2	0.71	0.69	0.71	0.70	0.69	0.70
T_3	0.73	0.71	0.72	0.73	0.70	0.71
T_4	0.75	0.74	0.75	0.74	0.74	0.74
T_5	0.78	0.77	0.76	0.76	0.75	0.76
S.E ± 0.004 C.D. 5% 0.014 Result Sig.						

The titratable acidity of lassi increased with increasing levels of betel vine leaves extract, ranging from 0.68% in T_1 (control) to 0.76% in T_5 (18% extract). The lowest acidity was observed in the control, while the highest was in T_5, indicating that incorporation of betel vine leaves extract slightly elevates the acidity of lassi. Consistent with Bagal *et al.* (2016) [2], who observed that lassi fortified with increasing concentrations of papaya pulp showed a progressive rise in acidity from 0.69% in T_1 to 1.18% in T_4.

3.7 Cost structure

Table 8: Cost of production for 1 Kg Betel vine leaves extract lassi prepared under various treatments

Particulars	Treatment									
	T_1		T_2		T_3		T_4		T_5	
	Qty. (g)	Amt. (Rs.)	Qty. (g)	Amt. (Rs.)	Qty. (g)	Amt. (Rs.)	Qty. (g)	Amt. (Rs.)	Qty. (g)	Amt. (Rs.)
(A) Quantity of standardized milk required (g) @ Rs.50/lit.	1000	50	910	45.5	880	44	850	42.5	820	41
(B) Quantity of betel vine leaves extract used by weight @ Rs 70/kg	0	0	0.90	6.3	0.120	8.4	0.150	10.5	0.180	12.6
(C) Sugar @ 10% used in (g) @ Rs. 40/kg	100	4	100	4	100	4	100	4	100	4
(D) Starter culture (g) @ Rs. 5/100 gm	10	0.50	10	0.50	10	0.50	10	0.50	10	0.50
(E) Cost of lassi Total = (A+B+C+D+E)	1110	54.5	1110	56.3	1110	56.9	1110	57.5	1110	58.1
(F) Miscellaneous cost (Gasused, Electricity, Labour etc.)	-	15	-	15	-	15	-	15	-	15
Total cost of production (E+F)	1110	69.5	1110	71.3	1110	71.9	1110	72.5	1110	73.1
Total cost of production Rs./Lit	1000	62.6	1000	64.2	1000	64.7	1000	65.3	1000	65.8

The cost of production of lassi increased slightly with higher levels of betel vine leaves extract. The production cost per litre was 62.6, 64.2, 64.7, 65.3, and 65.8 Rs. for T_1 (control), T_2 (9% extract), T_3 (12% extract), T_4 (15% extract), and T_5 (18% extract), respectively. The increase in cost is attributed to the added expense of betel vine leaves, while other production costs such as milk, sugar, culture, and labor were constant. Similar trends have been reported in previous studies, where fortification with papaya pulp, lemongrass, carrot, sorghum, or coconut milk led to a slight increase in production costs (Bagal *et al.*, 2016; Kumar and Das, 2015; David, 2015) [2, 9, 6].

4. Conclusion

The study concludes that lassi prepared from cow milk maintains its desirable nutritional profile and sensory quality when fortified with betel vine leaves extract up to 15%. The chemical composition reveals improved mineral and solid content, while production cost remains economically sustainable. These findings support the commercial development of herbal lassi as a value-added dairy product.

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