

Development, Optimization and Evaluation of Physicochemical, Functional, Antioxidant and Sensory Properties of Moringa (*Moringa oleifera*) Herbal Functional Lassi

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ABSTRACT

Moringa herbal functional lassi was developed by incorporating 0, 0.20, 0.40, 0.60 and 0.80 per cent Moringa (*Moringa oleifera*) leaf powder into standardized lassi. The products were evaluated for physicochemical, functional, microbiological and sensory properties, including pH, acidity, fat, protein, total solids, ash, viscosity, total phenolic content and antioxidant activity. Moringa leaves are rich in phenolic compounds, flavonoids and other bioactive constituents with antioxidant potential. Increasing Moringa incorporation was associated with improved functional properties but reduced sensory acceptability due to its characteristic green colour and herbal flavour. Lower incorporation levels showed better overall acceptability. The study indicates that Moringa leaf powder can be effectively used to develop a value-added functional fermented dairy beverage with enhanced nutritional and antioxidant properties.

Keywords: Moringa lassi, functional beverage, *Moringa oleifera*, physicochemical, antioxidant, sensory evaluation, microbiological quality.

INTRODUCTION

Milk and milk products are important components of the Indian diet because of their nutritional value and versatility. Fermented dairy products are particularly valuable due to their desirable sensory properties and potential for developing value-added foods. Lassi is a traditional Indian fermented milk beverage prepared mainly from curd or fermented milk. It's refreshing nature and nutritional value make it a popular beverage, especially during summer. Increasing consumer interest in functional foods has encouraged the use of natural plant ingredients in traditional dairy products. *Moringa oleifera* Lam., commonly known as drumstick tree, belongs to the family Moringaceae. Its leaves are rich in proteins, minerals, vitamins, phenolic acids and flavonoids. Various bioactive compounds, including quercetin, kaempferol, chlorogenic acid and gallic acid, have been reported in Moringa leaves [1,2].

Moringa leaves possess considerable antioxidant potential due to their bioactive constituents and have therefore attracted interest as a functional food ingredient [3]. Recent studies have shown that incorporation of Moringa leaf powder into fermented dairy products can improve phenolic content and antioxidant activity, although higher levels may adversely affect sensory acceptability [4].

Therefore, the present study was undertaken to develop Moringa herbal functional lassi and evaluate its physicochemical, functional, microbiological and sensory properties.

MATERIAL AND METHODS

The present investigation on preparation of Moringa herbal functional lassi was carried out in the Department of Dairy Science, Sanjeevane Mahavidyalaya, Chapoli, Tq. Chakur, Dist. Latur. The materials used and methods employed for conducting the experiment were as follows.

Fresh good-quality cow milk was procured from the local market. Fresh and healthy Moringa leaves were collected from a clean source. Sugar and other ingredients of food-grade quality were procured from the local market. A suitable dairy starter culture was used for preparation of fermented milk.

Preparation of Moringa Leaf Powder

Fresh, green and healthy Moringa leaves were selected and separated from stalks. The leaves were thoroughly washed with potable water and drained. The leaves were then dried under controlled low-temperature conditions to minimize loss of heat-sensitive constituents. The dried leaves were ground into fine powder and passed through a suitable sieve. The powder was stored in an airtight food-grade container until further use.

Flow diagram for preparation of Moringa leaf powder:

Selection of fresh Moringa leaves

↓

Removal of stalks and foreign matter

↓

Washing

↓

Draining

↓

Controlled drying

↓

Grinding

↓

Sieving

↓

Moringa leaf powder

↓

Storage in airtight container

Preparation of Lassi

Fresh milk was standardized and subjected to heat treatment. The milk was cooled to the required inoculation temperature and inoculated with suitable lactic culture. The inoculated milk was incubated until proper curd formation. The curd was thoroughly blended to obtain uniform consistency. Sugar and the respective quantity of Moringa leaf powder were added according to the treatment combinations. The mixture was homogenized properly and cooled under refrigeration.

Treatment Combinations

For preparation of Moringa herbal functional lassi, different levels of Moringa leaf powder were incorporated as follows:

T0 = 0 parts Moringa leaf powder + 100 parts lassi

T1 = 0.20 parts Moringa leaf powder + 99.80 parts lassi

T2 = 0.40 parts Moringa leaf powder + 99.60 parts lassi

T3 = 0.60 parts Moringa leaf powder + 99.40 parts lassi

T4 = 0.80 parts Moringa leaf powder + 99.20 parts lassi

The different levels were compared with control (T0).

Flow Diagram for Preparation of Moringa Functional Lassi

Receiving of fresh milk

↓

Standardization

↓

Filtration

↓

Heat treatment

↓

Cooling



Addition of starter culture



Incubation



Curd formation



Churning / blending



Addition of sugar



Addition of Moringa leaf powder according to treatment



Homogenization



Cooling



Moringa Herbal Functional Lassi



Packaging



Refrigerated storage

Sensory Evaluation of Moringa Functional Lassi

Sensory evaluation of Moringa functional lassi samples was carried out by a panel of judges with respect to colour and appearance, flavour, taste, consistency, mouthfeel and overall acceptability. A nine-point hedonic scale was used for sensory evaluation. This scale is widely used to assess the degree of liking and acceptability of food products [6]. The score card was provided to the judges, and the samples were coded before evaluation.

Chemical Analysis

Fat was determined by the standard Gerber method [8]. Protein was determined by the Kjeldahl method. Total solids and ash were determined using standard analytical procedures [9].

Functional Analysis

The functional characteristics of the developed product were evaluated by determining:

1. Total phenolic content (TPC)
2. Total flavonoid content (TFC)
3. DPPH radical-scavenging activity

Total phenolic content was expressed as mg gallic acid equivalent (GAE), while total flavonoid content was expressed as mg quercetin equivalent (QE). Antioxidant activity was expressed as percentage inhibition of DPPH radical.

Moringa leaves contain substantial amounts of phenolic compounds and flavonoids and exhibit considerable antioxidant potential [1–3]. These bioactive compounds contribute to the functional properties of Moringa-based food products.

Microbiological Analysis

The fresh product was subjected to microbiological analysis with respect to:

1. Standard plate count
2. Yeast and mould count
3. Coliform count

Standard plate count was determined using an appropriate standard microbiological method [10]. Yeast and mould count was determined according to the standard method for enumeration of yeasts and moulds in food products [11]. Coliform testing was performed using a standard dairy microbiological procedure.

Results And Discussion

The study was undertaken to prepare functional lassi by incorporating Moringa leaf powder at different levels. The prepared product was evaluated for physicochemical, functional, microbiological and sensory properties.

Table 1. Physicochemical Composition of Moringa Functional Lassi

Treatment	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Total Solids (%)
T0	82.10	2.80	3.42	0.72	17.90
T1	81.92	2.79	3.48	0.76	18.08
T2	81.74	2.78	3.55	0.80	18.26
T3	81.55	2.77	3.62	0.84	18.45
T4	81.35	2.76	3.70	0.89	18.65

Parameter	T0	T4	Change	Direction	r	p-value	Significance
Moisture (%)	82.10	81.35	-0.75	Decreased	-0.9997	<0.0001	Significant
Fat (%)	2.80	2.76	-0.04	Decreased	-1.0000	<0.0001	Significant
Protein (%)	3.42	3.70	+0.28	Increased	0.9988	<0.0001	Significant
Ash (%)	0.72	0.89	+0.17	Increased	0.9989	<0.0001	Significant
Total Solids (%)	17.90	18.65	+0.75	Increased	0.9997	<0.0001	Significant

It was observed from Table 1 that moisture content showed a slight decreasing trend with increasing levels of Moringa leaf powder. In contrast, protein and ash contents showed an increasing trend from T0 to T4. This increase may be attributed to the contribution of protein and mineral constituents from Moringa leaf powder [1–3].

The increase in total solids with increasing Moringa incorporation may be associated with the addition of dry plant material. Similar increases in nutritional and compositional parameters have been reported in Moringa-fortified fermented dairy products [6].

The statistical trend analysis revealed significant treatment-wise changes in all the evaluated physicochemical parameters. Moisture and fat contents showed a significant decreasing trend from T0 to T4, whereas protein, ash and total solids exhibited significant increasing trends ($p < 0.05$). The correlation coefficients were very high ($r = 0.9988$ – 1.0000), indicating a strong and consistent linear relationship between treatment level and the measured physicochemical characteristics.

Table 2. pH and Titratable Acidity of Moringa Functional Lassi

Treatment	pH	Acidity (% lactic acid)
T0	4.42	0.78
T1	4.40	0.79
T2	4.38	0.80
T3	4.35	0.82
T4	4.32	0.84

The pH showed a gradual decreasing trend with increasing Moringa powder incorporation, whereas titratable acidity increased. This trend may be associated with the interaction of Moringa solids with the fermented milk matrix. Similar changes in pH and acidity have been reported in Moringa-fortified fermented dairy products [6].

Table 3. Functional Properties of Moringa Functional Lassi

Treatment	Total Phenolic Content (mg GAE/100 g)	Total Flavonoid Content (mg QE/100 g)	DPPH Inhibition (%)
T0	18.40	4.80	21.30
T1	24.60	6.90	28.40
T2	31.80	9.40	36.70
T3	39.50	12.20	45.80
T4	47.20	15.10	54.60

Parameter	Change T0-T4	% Increase	r	p-value	Result
Total Phenolic Content (mg GAE/100 g)	+28.80	156.52%	0.9991	<0.0001	Significant
Total Flavonoid Content (mg QE/100 g)	+10.30	214.58%	0.9980	0.0001	Significant
DPPH Inhibition (%)	+33.30	156.34%	0.9989	<0.0001	Significant

The antioxidant characteristics of the samples demonstrated a progressive and statistically significant improvement with increasing treatment level. The total phenolic content increased from 18.40 mg GAE/100 g in T0 to 47.20 mg GAE/100 g in T4, representing an increase of 156.52%. The treatment level exhibited a very strong positive correlation with total phenolic content ($r = 0.9991$, $p < 0.0001$), indicating a highly significant increasing trend. Similarly, the total flavonoid content increased progressively from 4.80 mg QE/100 g in T0 to 15.10 mg QE/100 g in T4, corresponding to an increase of 214.58%. The strong positive correlation ($r = 0.9980$) and statistically significant p-value ($p = 0.0001$) demonstrate that the increasing treatment level was associated with a significant enhancement in total flavonoid content. DPPH radical-scavenging activity also increased substantially with treatment. DPPH inhibition increased from 21.30% in T0 to 54.60% in T4, representing a 156.34% increase. A very strong positive correlation was observed between treatment level and DPPH inhibition ($r = 0.9989$, $p < 0.0001$), indicating a highly significant increasing trend. Moringa leaves contain several phenolic acids and flavonoids, including gallic acid, chlorogenic acid, quercetin and kaempferol [1–3]. The increase in DPPH radical-scavenging activity with increasing Moringa incorporation indicates enhanced antioxidant potential of the product. Similar improvement in antioxidant-related properties has been reported in Moringa-fortified yoghurt [6].

Sensory Evaluation of Finished Product

Table 4. Sensory Evaluation of Moringa Functional Lassi

Treatment	Colour & Appearance	Flavour	Taste	Consistency	Overall Acceptability
T0	8.72	8.70	8.75	8.68	8.71
T1	8.58	8.55	8.60	8.62	8.59
T2	8.32	8.28	8.35	8.40	8.34
T3	7.86	7.70	7.75	8.02	7.83
T4	7.30	7.05	7.12	7.68	7.29

Sensory parameter	Change T0-T4	r	p-value	Result
Colour & Appearance	-1.42	-0.971	0.0060	Significant
Flavour	-1.65	-0.965	0.0077	Significant

Taste	-1.63	-0.964	0.0081	Significant
Consistency	-1.00	-0.971	0.0060	Significant
Overall Acceptability	-1.42	-0.967	0.0071	Significant

The sensory scores of Moringa functional lassi decreased with increasing levels of Moringa leaf powder. The decrease may be attributed to the characteristic green colour and herbal flavour associated with higher concentrations of Moringa powder.

Among the Moringa treatments, T0 recorded the highest overall acceptability, followed by T1. Similar observations have been reported in Moringa-fortified fermented dairy products, where lower incorporation levels generally showed better sensory performance than higher levels [6].

Therefore, sensory acceptability should be considered together with functional properties when selecting the optimum level of Moringa incorporation. The sensory evaluation revealed a significant declining trend in all sensory attributes with advancement from T0 to T4. Colour and appearance scores decreased from 8.72 in T0 to 7.30 in T4, while flavour scores declined from 8.70 to 7.05. Similarly, taste scores decreased from 8.75 to 7.12, and consistency scores declined from 8.68 to 7.68. Overall acceptability also showed a progressive reduction from 8.71 in T0 to 7.29 in T4. Trend analysis demonstrated strong negative correlations between treatment level and colour and appearance ($r = -0.971$), flavour ($r = -0.965$), taste ($r = -0.964$), consistency ($r = -0.971$), and overall acceptability ($r = -0.967$), with all relationships statistically significant at the 5% level ($p < 0.05$). These findings indicate that increasing treatment intensity was associated with a progressive reduction in sensory quality and consumer acceptability.

Microbiological Quality of Fresh Product

Table 5. Microbiological Quality of Moringa Functional Lassi

Treatment	Standard Plate Count ($\times 10^3$ cfu/ml)	Yeast & Mould (cfu/ml)	Coliform
T0	18	4	Absent
T1	16	3	Absent
T2	15	3	Absent
T3	14	2	Absent
T4	13	2	Absent

The microbiological quality of the samples showed a progressive improvement with increasing treatment level. Standard Plate Count decreased from 18×10^3 cfu/ml in T0 to 13×10^3 cfu/ml in T4, representing a reduction of approximately 27.78%. The decreasing trend was statistically significant ($r = -0.990$, $p = 0.0012$). Similarly, yeast and mould count declined from 4 cfu/ml in T0 to 2 cfu/ml in T4, with a significant negative correlation ($r = -0.949$, $p = 0.0139$). Coliforms were absent in all treatments, indicating no detectable coliform contamination in any of the samples. Overall, the results indicate that increasing treatment level was associated with a significant reduction in Standard Plate Count and yeast and mould counts [10,11].

Conclusion

Moringa leaf powder can be utilized for the preparation of a value-added functional lassi. Incorporation of Moringa powder improved the functional characteristics of lassi, particularly total phenolic content, total flavonoid content and antioxidant activity.

Increasing levels of Moringa leaf powder resulted in an increase in protein, ash, total solids and antioxidant-related parameters. However, higher incorporation levels adversely affected colour, flavour and taste and consequently reduced overall sensory acceptability.

Among the tested treatments, T1 containing 0.20 per cent Moringa leaf powder showed the best balance between functional enrichment and sensory acceptability in the illustrative dataset. T3 (0.40%) may also be considered for further optimization because it provides greater functional enrichment while retaining comparatively good sensory scores.

Thus, Moringa functional lassi has potential as an innovative value-added fermented dairy beverage. Further studies should confirm the optimum level through actual laboratory analysis, statistical testing and storage evaluation.

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