

Evaluation of sensory, physico-chemical and microbiological changes in herbal lassi during refrigerated storage

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Abstract

The present study evaluated the storage stability of control lassi as well as lassi fortified with lemongrass distillate and concentrated lemongrass extract (CLE) at $4\pm 1^\circ\text{C}$ for 21 days. During storage, the sensory attributes (flavour, texture, appearance, acidity, and overall acceptability) significantly declined in all samples. CLE-enriched lassi showed the highest total phenolic content and antioxidant activity (ABTS, DPPH), followed by lemongrass distillate and control lassi, although these values decreased during storage. The pH declined in all samples, with a rapid decrease in control lassi. Lemongrass added lassi remained acceptable for up to 21 days, while control lassi was acceptable up to 18 days.

Keywords: Lemongrass, lassi, herbal, antioxidant, shelf-life, sensory

Introduction

Reactive oxygen species (ROS), which include free radicals like superoxide anion radical (O_2^-), hydroxyl radical (OH \cdot), and singlet oxygen, produce the oxidation products from biological reactions or external substances in the body and diet [1, 2]. Both free radicals and active oxygen species, like the oxygen molecule, exhibit contradictory behaviours. They are crucial for the synthesis of physiologically active and necessary chemicals and are significant mediators in signal transduction. They are also known to be toxic and contribute to a number of illnesses [3].

There is growing evidence that ROS are involved in a number of typical *in-vivo* regulation mechanisms. By oxidising membrane lipids, cellular proteins, DNA, and enzymes, an excess of free radicals can overwhelm defence enzymes like superoxide dismutase, catalase, and peroxidase and cause deadly cellular effects (apoptosis) by stopping cellular respiration. Furthermore, oxidative stress has been identified as a major contributor to certain age-specific illnesses. Lipid peroxides and low molecular weight molecules generated in the last stages of the oxidative process are the factors responsible for these disorders. For instance, numerous investigations have revealed elevated oxidative damage to every major class of biomolecules in Alzheimer's patients' brains [4, 5]. Atherosclerosis, diabetes, and rheumatoid arthritis are other pathological disorders linked to evidence of severe damage caused by free radicals [4, 6, 7]. Moreover, oxidative DNA damage is most likely the cause of cancer.

In the upcoming years, India is expected to produce more than 200 million tonnes of milk annually. Approximately 55% of the nation's milk production is used to make different dairy products. Fermented milk products are thought to make up around 7% of the total amount of milk produced. In order to prevent milk solids from spoiling, fermented milk products were created all over the world and have endured for generations in underdeveloped nations. The production scale varied from home-based to large-scale, involving the utilisation of specific starter cultures, automated procedures, and contemporary machinery. Products made from fermented milk are well-liked due to their unique flavour, refreshing taste, and enhanced

digestibility, among other organoleptic qualities. It is easy to modify the content of fermented milk products to satisfy different nutritional needs. Due to their numerous nutritional and medicinal qualities, Indian fermented milk products have been shown to have dietetic relevance [3, 8].

Lassi is a well-known traditional Indian fermented milk product that is regularly consumed in practically every household in our nation. It is made by fermenting milk with lactic acid bacteria and is regarded as a functional food because of its established nutritional benefits as well as its therapeutic and health-promoting qualities. According to empirical data, value-added goods with extra health advantages are progressively making up the average Indian's food basket [8, 9].

Lemongrass (*Cymbopogon citratus*) is a kind of grass of the Gramineae family. It is a tall, clumped perennial grass that can reach a height of one metre. The leaf blade can reach a maximum length of 50 cm and a maximum width of 1.5 cm. It is linear and tapered at both ends. This tropical grass is indigenous to Sri Lanka and western India. It produces fragrant oil that is used in medicine, fragrance, and flavouring. It has been utilised for centuries in South America and India and is said to have a variety of therapeutic properties. Although there are many species of lemongrass, just a few are suggested for use in food and medicine [3].

The leaves and shoots of the lemongrass plant are used to make lemongrass extract, which is utilised in a variety of culinary items, such as frozen goods and drinks. According to reports, lemongrass extract has a number of health advantages. Only the essential oil extracted from fresh or dried lemongrass leaves are utilised. Because of its strong lemon flavour, lemongrass is frequently utilised as an essential ingredient in Asian cuisines. Additionally, it is said to be a beloved component of Thai food and recipes [3].

In India, lemongrass herbal tea is used as both an immunostimulant and a sedative. Typically, lemongrass was only recognised for its fragrant qualities. But it also has several health advantages, making it a priceless herb. According to reports, lemongrass extract has antioxidant, antibacterial, and antifungal qualities, detoxifies the liver, pancreas, kidney, bladder, and digestive tract, and

strengthens the immune system. Lemongrass flavour pairs nicely with acidic items, just way citrus flavours do. Thus, the suggested research study will try to create herbal lassi with increased antioxidant activity by using lemongrass.

Materials and Methods

Milk: Fresh, chilled, raw cow milk of Kankrej breed was collected from the Livestock Research Station (LRS), SDAU, Sardarkrushinagar.

Lemongrass: Lemongrass (*Cymbopogon citratus*) grown in the Centre for Agro-Forestry, Forage Crops and Green Belt, SDAU was used for the study. Fresh green matured leaves of medium size were selected and cut from the plant.

Lactic cultures: Freeze dried DVS culture (Lyofast MS 059 ET) consisting of specifically selected blend of lactic acid bacteria used for preparing the fermented milk products was obtained from Sacco System, Italy.

Skim milk powder: Spray dried skim milk powder (SMP) was procured from Banas dairy, Palanpur, Gujarat and was used for standardization of solid not fat (SNF) level.

Sugar: Crystalline sugar procured from the local market was used as the sweetening material in the preparation of fermented product.

Method for preparation of lemongrass incorporated herbal lassi

The herbal lassi was prepared by adding different levels i.e. T1 (0.0%, control), T2 (1.0%), T3 (1.5%), T4 (2.0%) and T5 (2.5%) of concentrated lemongrass extract (CLE) possessing highest antioxidant activity. Optimization of level of addition of CLE was carried out through sensory evaluation using 9 points Hedonic scale by a panel of 7 semi-trained judges. The sensory attributes like flavour, body and texture, colour and appearance, product acidity and overall acceptability were used for sensory evaluation of lassi. The scores were ascertained for each factor and expressed numerically. Finally, based on the sensory acceptability of the product, addition of CLE (2.0%) was considered as the best level for incorporation into lassi [3].

The control lassi as well as lassi prepared with addition of CLE (2.0%), adjudged as best optimized product on the basis of sensory evaluation were packed in polypropylene cups with lid and stored at refrigeration temperature (4±1°C). The samples were drawn after every 3 days till its acceptable sensory attributes and analyzed for change in their total phenol content and antioxidant activity (ABTS and DPPH assay). The samples were also analyzed for changes in sensory attributes, pH and microbial load.

Analysis of control and optimized lassi

During storage study, the control and optimized lassi samples were analyzed for sensory attributes viz. flavour, body and texture, colour and appearance, product acidity and overall acceptability. The pH was determined using digital bench top pH meter [10]. The samples were also analyzed for TPC [11] and antioxidant potential by ABTS assay [12, 13], and DPPH assay [14]. Analysis of yeast and mould counts and the coliform counts of the samples were ascertained as suggested by [15].

Statistical analysis

A completely randomized design (CRD) with 3 repetitions was used for data analysis. The data are presented as means±standard error of mean (SEM). Analysis of variance (ANOVA) was used to determine the main effects of treatments [16, 17].

Results and Discussions

Changes in sensory attributes

The control lassi as well as lassi prepared with addition of CLE (2.0%) samples were stored at refrigeration temperature (4±1°C) were monitored for changes in various sensory attributes viz. flavour, body and texture, colour and appearance, product acidity and overall acceptability after every 3 days till its acceptable sensory attributes up to the period of 21 days and the results are illustrated in Table 1.

A key sensory factor in determining the acceptability of lassi is flavour. The results showed a substantial (P<0.05) decline in the flavour of both the control and lemongrass incorporated lassi over the storage period; however, the decline was more noticeable in the control sample as compared to CLE added lassi (Table 1). Even at low temperatures, fermentation continues to alter the flavour compounds [18]. In addition, lassi should be smooth-textured and should have a good body. Regardless of the control or experimental sample, it was found that the body and texture scores significantly (P<0.05) declined during storage. The loose body observed during the progress of storage period may be the cause of decline in scores [19]. During storage, there was a noticeable difference between colour and appearance of the control and CLE added lassi and the scores of samples decreased significantly (P<0.05) till the end of storage period. Similarly, the sensory scores for product acidity of control and CLE lassi were significantly (P<0.05) decreased throughout the storage period. The declining trend might be caused by an increase in acidity, which could be linked to the creation of organic acids as a result of ongoing fermentation during storage [20]. Unlike other sensory characteristics, overall acceptability scores of all samples significantly (P<0.05) declined over the storage period; however, the control sample's decline was more rapid than that of the CLE lassi samples.

Table 1: Effect of refrigerated storage on sensory attributes of lassi

Storage Days	Control lassi				
	Flavour	Body and Texture	Colour and Appearance	Product Acidity	Overall Acceptability
0	8.07±0.09 ^{eA}	8.30±0.11 ^{eA}	7.82±0.14 ^{fA}	7.86±0.13 ^{fA}	7.96±0.16 ^{fA}
3	8.01±0.12 ^{eA}	8.14±0.14 ^{deA}	7.73±0.12 ^{fA}	7.61±0.08 ^{fA}	7.74±0.14 ^{fA}
6	7.86±0.13 ^{deA}	7.94±0.07 ^{cdA}	7.58±0.09 ^{efA}	7.49±0.11 ^{efA}	7.41±0.15 ^{eA}
9	7.51±0.08 ^{cdA}	7.76±0.11 ^{cA}	7.23±0.16 ^{dA}	7.18±0.09 ^{dA}	7.04±0.11 ^{dA}
12	7.30±0.10 ^{cA}	7.41±0.08 ^{bA}	6.88±0.15 ^{cA}	6.74±0.13 ^{cA}	6.68±0.07 ^{cA}
15	6.53±0.16 ^{bA}	7.12±0.13 ^{abA}	6.45±0.13 ^{bA}	6.42±0.10 ^{bA}	6.36±0.11 ^{bA}

18	5.15±0.09 ^{aA}	6.84±0.11 ^{aA}	5.69±0.15 ^{aA}	6.10±0.12 ^{aA}	5.83±0.13 ^{aA}
21	---	---	---	---	---
Optimized lassi					
Storage Days	Flavour	Body and Texture	Colour and Appearance	Product Acidity	Overall Acceptability
0	8.58±0.16 ^{eB}	8.28±0.08 ^{fB}	8.23±0.11 ^{eB}	8.34±0.15 ^{eB}	8.49±0.10 ^{fB}
3	8.53±0.12 ^{eB}	8.16±0.14 ^{efB}	8.19±0.13 ^{eB}	8.26±0.11 ^{eB}	8.33±0.14 ^{fB}
6	8.45±0.10 ^{deB}	7.87±0.07 ^{deB}	7.95±0.08 ^{deB}	8.13±0.09 ^{deB}	8.26±0.09 ^{efB}
9	8.21±0.12 ^{dB}	7.69±0.11 ^{cdB}	7.73±0.14 ^{cdB}	7.84±0.13 ^{dB}	8.01±0.12 ^{deB}
12	7.86±0.15 ^{cB}	7.44±0.08 ^{cB}	7.65±0.09 ^{bcdB}	7.51±0.12 ^{cB}	7.81±0.08 ^{cdB}
15	7.78±0.09 ^{cB}	7.05±0.13 ^{bB}	7.51±0.07 ^{bcB}	7.29±0.09 ^{cB}	7.64±0.16 ^{bcB}
18	7.46±0.13 ^{bB}	6.86±0.11 ^{abB}	7.39±0.10 ^{bB}	6.95±0.13 ^{bB}	7.35±0.12 ^{bB}
21	7.11±0.08 ^a	6.72±0.15 ^a	7.04±0.13 ^a	6.51±0.11 ^a	7.03±0.11 ^a
Means with different superscripts in each column (a, b, c, d, e, f) and (A, B) differ significantly (P < 0.05) from each other. Data are presented as means ± SEM (n = 18).					

Changes in total phenolic content (TPC) and antioxidant capacity (ABTS & DPPH)

The changes in TPC and antioxidant capacity (ABTS, DPPH assay) of control as well as CLE incorporated lassi were determined after every 3 days up to the period of 21 days and the results are shown in Table 2. The results delineated significant (P<0.05) decrease in TPC (μM GAE/100 g) of control and CLE lassi from 27.45±0.03 and 50.28±0.04, of fresh product to 13.26±0.02 and 34.57±0.04 of 21st day stored product, respectively. Similarly, the antioxidant capacity (μM TE/100 g) of control and CLE lassi measured by ABTS assay was significantly (P<0.05) decreased from 9.67±0.02, 19.46±0.03 at 0 day to

3.08±0.03, 11.53±0.02 at 21st day, respectively, whereas DPPH values were observed to decrease significantly (P<0.05) from 13.93±0.03, 33.53±0.05 at 0 day to 7.26±0.03, 23.61±0.05 at 21st day, respectively. Although, the TPC and antioxidant capacity of CLE incorporated lassi was decreased during the storage period, but according to reports, even minute levels of phenolic compounds found in fruits and medicinal plants may have positive impacts on human health, including antioxidant, antibacterial, anti-inflammatory, anticarcinogenic action and are also associated with a lower mortality risk due to cardiovascular diseases [21, 22].

Table 2: Effect of refrigerated storage on TPC and antioxidant capacity (ABTS, DPPH) of CLE incorporated herbal lassi

Storage period (days)	Total phenolic content (μM GAE*/100 g)		ABTS - Antioxidant capacity (μM TE#/100 g)		DPPH - Antioxidant capacity (μM TE#/100 g)	
	Control	CLE incorporated herbal lassi	Control	CLE incorporated herbal lassi	Control	CLE incorporated herbal lassi
0	27.45 ± 0.03 ^{gA}	50.28 ± 0.04 ^{fB}	9.67 ± 0.02 ^{fA}	19.46 ± 0.03 ^{eB}	13.93 ± 0.03 ^{fA}	33.53 ± 0.05 ^{eB}
3	26.63 ± 0.02 ^{fgA}	49.91 ± 0.03 ^{fB}	9.15 ± 0.04 ^{fA}	19.21 ± 0.06 ^{eB}	13.65 ± 0.04 ^{fA}	33.36 ± 0.04 ^{eB}
6	25.78 ± 0.03 ^{fA}	49.36 ± 0.04 ^{efB}	8.09 ± 0.02 ^{eA}	18.77 ± 0.04 ^{eB}	12.48 ± 0.02 ^{eA}	32.91 ± 0.06 ^{eB}
9	23.71 ± 0.02 ^{eA}	48.42 ± 0.05 ^{eB}	7.72 ± 0.03 ^{eA}	17.51 ± 0.02 ^{dB}	12.15 ± 0.05 ^{deA}	32.64 ± 0.04 ^{deB}
12	20.39 ± 0.04 ^{dA}	45.67 ± 0.02 ^{dB}	6.63 ± 0.03 ^{dA}	16.86 ± 0.05 ^{dB}	11.34 ± 0.03 ^{dA}	31.72 ± 0.03 ^{dB}
15	17.56 ± 0.03 ^{cA}	41.13 ± 0.05 ^{cB}	5.38 ± 0.05 ^{cA}	15.64 ± 0.02 ^{cB}	10.17 ± 0.04 ^{cA}	28.53 ± 0.04 ^{cB}
18	15.11 ± 0.02 ^{bA}	37.84 ± 0.06 ^{bB}	4.24 ± 0.02 ^{bA}	13.75 ± 0.04 ^{bB}	8.87 ± 0.03 ^{bA}	25.88 ± 0.05 ^{bB}
21	13.26 ± 0.02 ^{aA}	34.57 ± 0.04 ^{aB}	3.08 ± 0.03 ^{aA}	11.53 ± 0.02 ^{aB}	7.26 ± 0.03 ^{aA}	23.61 ± 0.05 ^{aB}
Means with different superscripts in each column (a, b, c, d, e, f, g) and in row (A, B) differ significantly (LSD test, P < 0.05) from each other. Data are presented as means ± SE (n = 3). * - GAE- gallic acid equivalent, # - TE- trolox equivalent						

Changes in pH

The control lassi as well as lassi prepared with addition of CLE (2.0%) samples stored at refrigeration temperature (4±1°C) were analyzed for changes in pH after every 3 days till its acceptable sensory attributes and the results are illustrated table 3. The results depicted decreasing trend in the pH values of all samples during the entire period of

storage study, however rapid decrease was observed in the control lassi as compared to CLE lassi. Phattayakorn and Wanchaitanawong (2009) [23] reported that the gram-positive bacteria are susceptible to antimicrobial activity which may be related to the slower rate of pH decrease of developed products, that could have been caused by phenolic compound's inhibitory effect on the starter cultures.

Table 3: Effect of refrigerated storage on pH of CLE incorporated herbal lassi

Storage Days	pH	
	Control lassi	CLE incorporated herbal lassi
0	4.65 ± 0.01 ^{gA}	4.71 ± 0.01 ^{hB}
3	4.57±0.03 ^{fA}	4.63±0.02 ^{gB}
6	4.48±0.01 ^{eA}	4.52±0.01 ^{fB}
9	4.35±0.04 ^{dA}	4.42±0.04 ^{eB}
12	4.21±0.02 ^{cA}	4.33±0.04 ^{dB}
15	4.06±0.01 ^{bA}	4.24±0.01 ^{cB}
18	3.88±0.04 ^{aA}	4.12±0.02 ^{bB}
21	---	4.01±0.01 ^a
Means with different superscripts in each column (a, b, c, d, e, f, g, h) and in row (A, B) were significantly different (P<0.05) from each data. Data are presented as mean ± SE (n=3).		

Microbiological analysis of control and CLE incorporated herbal lassi

The microbiological analysis (LAB, coliforms and yeast and moulds) of control as well as CLE incorporated herbal lassi samples stored at refrigeration temperature ($4\pm 1^\circ\text{C}$) was performed after every 3 days till their acceptable attributes. The effect of storage on LAB and yeast and mould counts of

control and CLE lassi are given in table 4. The results of microbiological analysis revealed that the coliform counts (cfu/g) were absent in both control as well as CLE incorporated herbal lassi samples during the entire period of storage study at refrigeration temperature. Coliform could not grow in fermented dairy products because of their high acidity and low pH [24, 25].

Table 4: Effect of refrigerated storage on LAB and yeast and mould counts of control and CLE incorporated herbal lassi

Storage period (days)	Control lassi (log cfu/g)		CLE incorporated herbal lassi (log cfu/g)	
	LAB	Yeast and Mould	LAB	Yeast and Mould
0	8.16 ^a ±0.17	Nil	8.21 ^a ±0.14	Nil
3	8.49 ^a ±0.21	Nil	8.41 ^a ±0.18	Nil
6	7.81 ^b ±0.24	0.78 ^d ±0.05	8.26 ^a ±0.14	0.17 ^d ±0.01
9	7.53 ^b ±0.16	0.89 ^d ±0.11	8.09 ^a ±0.14	0.25 ^d ±0.03
12	7.36 ^b ±0.13	1.25 ^c ±0.10	7.87 ^{ab} ±0.24	0.31 ^d ±0.05
15	7.28 ^{cb} ±0.18	1.43 ^b ±0.07	7.46 ^b ±0.21	0.57 ^c ±0.12
18	7.02 ^{cb} ±0.19	1.81 ^a ±0.13	7.32 ^b ±0.20	1.02 ^b ±0.05
21	6.89 ^{cb} ±0.15	1.98 ^a ±0.09	7.04 ^{cb} ±0.15	1.51 ^a ±0.11
General Mean	7.56±0.14	1.02±0.08	7.82±0.11	0.48±0.10
SE	0.28	0.03	0.29	0.041
CD (0.05)	0.54	0.19	0.54	0.22
CV%	7.00	18.69	7.27	20.26

Means with different superscripts in each column (a, b, c, d) differ significantly (LSD test, P < 0.05) from each other. Data are presented as means ± SE (n = 3).

Conclusion

The present study concludes that lassi prepared with addition of CLE (2.0%) has 21 days shelf life, when stored at refrigeration temperature ($4\pm 1^\circ\text{C}$). Storage has led to decline in sensory quality as well as physico-chemical parameters. During storage study, the average scores for flavour, body and texture, colour and appearance, product acidity and overall acceptability of all samples were significantly decreased. Similarly, the decrease in pH, TPC and antioxidant capacity (ABTS, DPPH) was also recorded.

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References

- Phaniendra A, Jestadi DB, Periyasamy L. Free radicals: properties, sources, targets, and their implication in various diseases. *Indian J. Clin. Biochem*,2015;30(1):11-26.
- Chaudhary P, Janmeda P, Docea AO, Yeskaliyeva B, Abdull Razis AF, Modu B, *et al.* Oxidative stress, free radicals and antioxidants: potential crosstalk in the pathophysiology of human diseases. *Frontiers in Chemistry*,2023;11:1158198.
- Shendurse AM, Patel AC, Gopikrishna G, Gawai KM, Prajapati RJ. Studies on preparation of antioxidant enriched herbal lassi incorporated with lemongrass (*Cymbopogon citratus*) extract. *Int. J. Ag. Env. Biotech.*,2024;17(02):131-137.
- Halliwell B. Role of free radicals in the neurodegenerative diseases: therapeutic implications for antioxidant treatment. *Drugs & Aging*,2001;18(9):685-716.
- Liu RH. Potential synergy of phytochemicals in cancer prevention: mechanism of action. *J. of Nutrition*,2004;134(12 S):3479S-3485S.
- Halliwell B, Whiteman M. Measuring reactive species and oxidative damage *in vivo* and in cell culture: how should you do it and what do the results mean? *British J. of Pharmacology*,2004;142(2):231-255.
- Hoelzl C, Bichler J, Ferk F, Simic T, Nersesyan A, Elbling L, *et al.* Methods for the detection of antioxidants which prevent age related diseases: a critical review with particular emphasis on human intervention studies. *J. of Physiology and Pharmacology*,2005;56(Suppl 2):49-64.
- Sarkara S. Innovations in Indian fermented milk products- a review. *Food Biotechnology*,2008;22(1):78-97.
- Singh D, Singh J. Shrikhand: a delicious and healthful traditional Indian fermented dairy dessert. *Trends in Biosciences*,2014;7:153-155.
- BIS. SP: 18 (Part XI – Dairy Products). *BIS Handbook of Food Analysis*. Bureau of Indian Standards, Manak Bhavan, New Delhi, 1981.
- Kahkonan MP, Hopia AI, Vuorela HJ, Rauha JP, Pihkaja K, Kujala TS, *et al.* Antioxidant activity of plant extracts containing phenolic compounds. *J. Agri. Food Chem*,1999;47:3954-3962.
- Re R, Pellegrini N, Proteggente A, Pannala A, Yang M, Rice-Evans C. Antioxidant activity applying an improved ABTS radical cation decolorization assay. *Free Radical Bio. Med.*,1999;26(9-10):1231-1237.

13. Guo Y, Jauregi P. Protective effect of β -lactoglobulin against heat induced loss of antioxidant activity of resveratrol. *Food Chem*,2018;266:101-109.
14. Brand-Williams W, Cuvelier ME, Berset C. Use of a free radical method to evaluate antioxidant activity. *LWT-Food Sci. Technol*,1995;28(1):25-30.
15. Houghtby GA, Maturin LJ, Koenig EK. Microbiological count methods. In: *Standard Methods for the Analysis of Dairy Products*. 16th edition. R. T. Marshall, ed. American Public Health Association, Washington, DC,1992:213-246.
16. Snedecor GW, Cochran WG. *Statistical methods* (8th eds.). Iowa State University Press, USA, 1994, 524.
17. Gacula MC, Singh J, Bi J, Altan S. *Statistical methods in food and consumer research*. Academic Press, Inc. (London) Ltd., UK,2009:62-95, 105-113.
18. Sutariya H, Rao JK. Utilization of lemongrass distillate in the preparation of yoghurt. *Indian J. Dairy Sci*,2015;68(6):525-533.
19. Mahajan D, Bhat ZF, Kumar S. Pomegranate (*Punica granatum*) rind extract as a novel preservative in cheese. *Food Bioscience*,2015;12:47-53.
20. Tamime AY, Robinson RK. *Yoghurt Science and Technology*, 2nd edition. Woodhead Publishing Ltd., Cambridge, UK, 1999, 606.
21. Sun W, Shahrajabian MH. Therapeutic potential of phenolic compounds in medicinal plants-natural health products for human health. *Molecules*,2023;28(4):1845.
22. Ahmad Z, Rauf A, Orhan IE, Mubarak MS, Akram Z, Islam MR, *et al*. Antioxidant potential of polyphenolic compounds, sources, extraction, purification and characterization techniques: a focused review. *Food Sci. Nutrition*,2025;13(12):e71259.
23. Phattayakorn K, Wanchaitanawong P. Antimicrobial activity of Thai herb extracts against coconut milk spoilage microorganisms. *Kasetsart J. Nat. Sci.*,2009;43(4):752-759.
24. Kumar P, Das A, Upadhyay S, David J, Thakur SN. Changes in physico-chemical, microbial and organoleptic attributes of shrikhand fortified with litchi pulp and lactulose during storage at refrigerated temperature. *J. Pharmacogn. Phytochem*,2019;8(5):169-173.
25. Pathrikar AD, Patange DD, Mote GV, Udachan IS, Lokhande SM. Process development for goat milk shrikhand added with kiwi fruit. *Journal of Postharvest Technology*,2021;9(2):89-100.