



Physiochemical Transformations in Milk Infused with Mango Flavor and Turmeric Ayurvedic Herb

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Abstract

Objective/Aim: The aim of the study is to investigate the physiochemical changes in milk resulting from the infusion of both mango flavor and the Ayurvedic herb turmeric.

Method: Locally sourced milk, mango, turmeric rhizome, and sugar were employed in the study design. Mango was processed, dried, and stored for flavor-infused milk. Methods encompassed preparing mango pulp, making turmeric powder, and developing flavor and turmeric-infused milk using local pasteurized toned milk. Physico-chemical analyses covered pH, ascorbic acid, acidity, total soluble solids, specific gravity, fat, and protein. Sensory evaluation assessed color, appearance, flavor, taste, and general acceptance on a nine-point hedonic scale.

Result: The study on mango flavor and turmeric-infused milk yielded significant findings encompassing various aspects. pH levels ranged from 5.98 to 6.2, acidity fluctuated between 0.24% and 0.3%, total soluble solids remained constant at 18 to 20 oBrix, specific gravity ranged from 1.11 to 1.183, fat content varied between 1.94% and 2.11%, protein concentrations ranged from 3.75% to 4.07%, ascorbic acid degradation showed an escalating pattern with increasing drying air temperature. Color scores ranged from 7.6 to 8.9, favoring 60 °C, Taste ratings (7.6 to 8.8) peaked at 70 °C, and overall acceptance was highest at 65 °C and lowest at 75 °C.

Conclusion: The study achieved its goal of exploring physiochemical changes in milk due to mango flavor and turmeric infusion, using locally sourced ingredients. Thorough Physico-chemical analyses and sensory evaluation provided valuable insights, emphasizing the intricate interplay of physiochemical and sensory attributes, contributing to gastronomic and health-conscious culinary.

Keywords- Flavored milk, Ayurvedic Herb, Physico-chemical analyses, Sensory evaluation

1. Introduction

The rapid urbanization and industrialization in emerging nations like India have resulted in significant changes in lifestyle, which in turn have led to the emergence of lifestyle-related issues on both the social and economic aspects. The rise in lifestyle-related health concerns has led to a growing interest in the research of functional foods and their beneficial components. Functional foods provide a health advantage, in addition to their nutritional value. Functional foods are comprised of bioactive compounds that contribute to the health benefits and general well-being associated with consuming functional foods [1]. Herbs have been extensively used for millennia as both nourishment and medication. The presence of many bioactive phytochemicals has been documented, including

ligans, flavonoids, polyphenols, terpenoids, coumarin, sulfides, carotenoids, plant sterols, phthalides, curcumins, and saponins [2,3]. Herbs and spices are often used as food additives globally, serving to enhance the sensory characteristics of food and extend its shelf life by diminishing or eradicating harmful microorganisms that cause foodborne illnesses [4-7]. Herbs and spices not only enhance the taste of food but also possess the capacity to preserve it and contain qualities such as antioxidants, anti-inflammatory effects, and the ability to prevent the growth of tumors and cancer [8-14].

India is renowned as the "World's Botanical Garden" and the "Land of Spices" due to its status as the greatest global producer of traditional medicinal plants [15]. Presently, the industry is very interested in using these herbal bio-actives to convey the medical effects of herbs via certain foods as carriers. Milk and milk derivatives are very important sources and may serve as transporters for many types of food [16]. India has the title of being the biggest producer of milk in the world. India's milk production accounts for around 10% of the global supply and is considered one of the highest qualities in the world. Milk, apart from being produced in tiny quantities and scattered, is also a perishable commodity that requires efficient handling, whether in liquid form or for use in product manufacturing, or both. The majority of the milk produced in the country is processed into regular dairy products, while the remaining portion is used for liquid milk [17]. Consequently, a substantial quantity of milk is annually used for the production of various types of Indian dairy products. The inherent perishability of milk and its derivatives results in a very limited shelf life. Natural preservatives are used to enhance the longevity of milk and milk products. Adding spices and herbs to food and dairy products seems to be a viable substitute for chemical preservatives, since it enhances the functioning of dairy products and prolongs their shelf life [13,18].

Herbs and spices, rich in phytochemicals, are globally used as food additives, contributing to enhanced taste, extended shelf life, and health-promoting properties. India, known for its botanical diversity, explores the use of herbal bioactive in dairy products to convey medicinal effects. Milk, a significant part of the Indian diet, faces challenges in shelf life due to its perishable nature [19]. To address this, natural preservatives like herbs and spices are employed, presenting a potential alternative to chemical preservatives. Turmeric, a prominent spice in India, contains bioactive components like curcumin, offering various health benefits, including anti-inflammatory and antioxidant properties [20-22]. Flavored milk, enriched with safflower and mango, demonstrates nutritional advantages and anti-atherogenic properties [17, 23]. The integration of herbs and spices into dairy products aligns with the current trend of health-conscious consumers in India, emphasizing the potential of these natural additives in improving overall well-being [24, 25], so the present study aimed to focus on unraveling the complexities of this fusion, exploring how varying concentrations of mango flavor and turmeric affect the stability and quality of the infused milk. By examining the synergies and potential challenges within this culinary amalgamation, we aim to contribute valuable insights to the evolving landscape of gastronomic exploration and health-conscious culinary practices.

2. Materials and methods

2.1 Study design

Milk has been obtained from the nearby convenience store, while mango, turmeric rhizome, and sugar have been purchased at the local market. The mango that was obtained was intended for the purpose of conducting drying experiments. Prior to drying, the sides and ends were removed, stripped, and sliced into 15 mm thick pieces. The drying experiments were conducted using a hot air batch drier equipped with a heating section, temperature controller with a range of 60-140°C, and a drying chamber. Before starting the experiment, the dryer was heated for about one hour to establish equilibrium circumstances with predefined temperatures and air velocity for every experiment. The sliced mango samples, weighing 100 g each, were equally spread on clean perforated trays. These trays were then put in a dryer and subjected to different air temperatures of 60, 65, 70, 75 and 80°C. The air velocity within the dryer remained constant at 1.5 m/s. A digital scale with a resolution of 0.001 g was used to quantify the amount of moisture lost throughout the drying process until a stable weight was attained. When the moisture content decreased from an initial value of 85.85-91.19% to 6-7%, the drying process was stopped. To prepare flavor-infused milk, the dehydrated product was kept in polythene covers.

2.2 Methods

➤ Preparation of mango pulp

The extraction of pulp was carried out using fresh, completely ripe mangoes. Following thorough washing with drinkable water, the fruits were peeled using a knife. The mangoes were diced and then pulverized in an electric

blender. The pulp was then blanched at a temperature of 80°C for a period of 5 minutes, followed by quick cooling. Subsequently, the pulp was preserved at a temperature of -20°C for future use.

➤ **Turmeric powder preparation**

The production of turmeric powder was conducted based on prior studies [26], including some alterations. The turmeric rhizome underwent a process of washing, drying, and blending until it reached a reduced particle size. The pulverized turmeric is spread out on aluminum foil and then heated in the oven at a temperature of 55°C for about 5 hours. The process involves pulverizing dried turmeric using a blender and then straining it.

➤ **Preparing Flavor and turmeric Infused Milk**

The manufacture of flavor and turmeric milk included the use of locally accessible pasteurized toned milk with a fat content of 3.5% and a solid non-fat content of 9.5%. The milk was subjected to ultra-high temperature (UHT) in a stainless-steel container until it reached a temperature of 70°C. Subsequently, turmeric powder was introduced and agitated for a duration of 10 minutes at the same temperature. The product undergoes filtration and is then supplemented with 4 grammes of sugar. The milk reached a temperature below 20 °C. The refrigerator served the purpose of refrigeration. Mango pulp was added to the milk in varying amounts of 1 g, 1.5 g, and 2 g per 100 ml of milk. Flavoring milk was packed and sealed using glass bottles equipped with lids. The refrigeration of the mango flavored milk was conducted to determine its shelf life.

2.3 Physico-Chemical analysis

➤ **Analysis of pH**

The pH of mango flavor and turmeric infused milk was determined using a Hanna pH meter (model HI 8417) that was calibrated using pH 7.0 and 4.0 buffers.

➤ **Analysis of ascorbic acid**

The stated approach was used to ascertain the vitamin C concentration in mango-flavored and turmeric-infused milk [17].

➤ **Analysis of acidity**

The acidity of the mango flavor and turmeric-infused milk was quantified using an adapted methodology based on the process outlined by Teka (2013) [27]. The titratable acidity was determined using the following equation:

$$\% \text{ acidity (lactic acidity)} = \frac{\text{ml NaOH} \times 0.1N \times \text{OH} \times 0.090}{\text{Volume of Sample} \times 100}$$

➤ **Analysis of total soluble solid (TSS)**

The mango flavor and turmeric-infused milk's total soluble solids (oBrix) were measured using a portable refractometer (Model: HT119-ATC).

➤ **Analysis of specific gravity**

The revised methodology proposed by Javaid et al. (2009) [28] was used to determine the specific gravity of mango flavor and turmeric-infused milk using a pycnometer. The specific gravity of the sample was determined using the following formula:

$$\text{Specific gravity (at 20°C)} = \frac{\text{Weight of Sample}}{\text{Weight of Distilled Water}}$$

➤ **Determination of fat**

The Gerber approach, as described by Javaid et al. (2009), was used with modest modifications to measure fat content [28].

➤ **Determination of protein**

The protein content in mango flavor and turmeric-infused milk was evaluated using the Micro-Kjeldhal methodology [29], with some adjustments made to the original method described by Javaid et al. (2009). The nitrogen percentage was estimated using the following technique and parameters: Protein Factor of 6.38 and the inclusion of dairy products.

$$\text{Nitrogen (\%)} = 1.4 \times \frac{\text{HCl sample} - \text{HCl Blank} \times \text{Normality of HCl}}{\text{Weight of sample taken}} \times 100$$

$$\text{Protein (\%)} = \text{Nitrogen (\%)} \times \text{Protein Factor}$$

2.4 Sensory Evaluation

Sensory evaluation of items is a highly debated topic in international trade because of its significant role in ensuring quality control. The majority of the country's standards and evaluations are determined by sensory attributes. The

mango flavor and turmeric may be categorized based on four features. The present research examined the impact of infused milk on many aspects including color and appearance, flavor, taste, and overall acceptability. A panel of judges assessed the recently developed samples of flavored milk by using their sensory faculties. A panel of judges consisting of students from the institution assessed the sensory attractiveness of milk with additional flavors. The differences among samples were determined via a nine-point hedonic scale. An average judgement score of 10 was achieved for each sample. A total of nine points were assigned, with a score of 9 denoting a strong preference, a score of 8 denoting a significant preference, a score of 7 denoting a moderate preference, a score of 6 denoting a mild preference, a score of 5 denoting neither preference nor aversion, a score of 4 denoting a dislike, a score of 3 denoting a moderate dislike, a score of 2 denoting a strong dislike, and a score of 1 denoting an extreme hate.

2.5 Statistical Analysis

The data gathered was statistically analyzed using SPSS 26.0. The outcomes were presented as the mean values accompanied by the standard deviation (mean \pm SD). Descriptive statistics were used to ascertain the frequencies and proportions. The significance of differences was evaluated using the one-way ANOVA and student's t-test, with a significance level of $P < 0.05$.

3. Result

3.1 Physiochemical Analysis

3.1.1 pH and acidity

The pH of mango flavour and turmeric-infused milk samples fluctuated between 5.98 and 6.2 over the storage period. Turmeric had the greatest pH level, measuring at 5.9, while mango had the lowest pH level. The acidity level of mango-flavored and turmeric-infused milk ranged from 0.24% to 0.3% throughout storage.

3.1.2 Total soluble solid

The mango-flavored and turmeric-infused milk consistently maintained a total soluble solid (TSS) level of 18 to 20 °Brix over their storage period.

3.1.3 Specific gravity

The specific gravity of mango-flavored milk infused with turmeric ranges from 1.11 to 1.183 when refrigerated.

3.1.4 Fat content

The flavours of mango and turmeric-infused milk, together with their corresponding fat amounts, may be found in Table 1. The mango-flavored milk, laced with turmeric, had a fat content ranging from 1.94 to 2.11 percent after storage.

Nutritional content	Mango flavor and turmeric-infused milk
pH	5.98 \pm 0.10
Total fat (%)	1.94 \pm 0.06
Acidity (%)	0.24 \pm 0.19
TSS (oBrix)	18 \pm 0.12
Protein (%)	3.75 \pm 0.06
Specific gravity	1.11 \pm 0.01

Table 1. The physico-chemical properties of milk enriched with turmeric and mango flavour.

3.1.5 Protein content

Mango flavour and milk infused with turmeric showed protein contents ranging from 3.75 to 4.07% throughout the storage time. Comparatively speaking, the protein content of the turmeric is lower (2.84 percent) than that of the mango (3.12 percent).

3.1.6 Ascorbic acid

The effect of drying air temperature on ascorbic acid is seen in Figure 1. It was shown that as the temperature of the drying air climbed, the amount of vitamin C in a dried sample decreased more quickly. At 60°C, ascorbic acid concentration was higher, while at 80°C, it was lower.

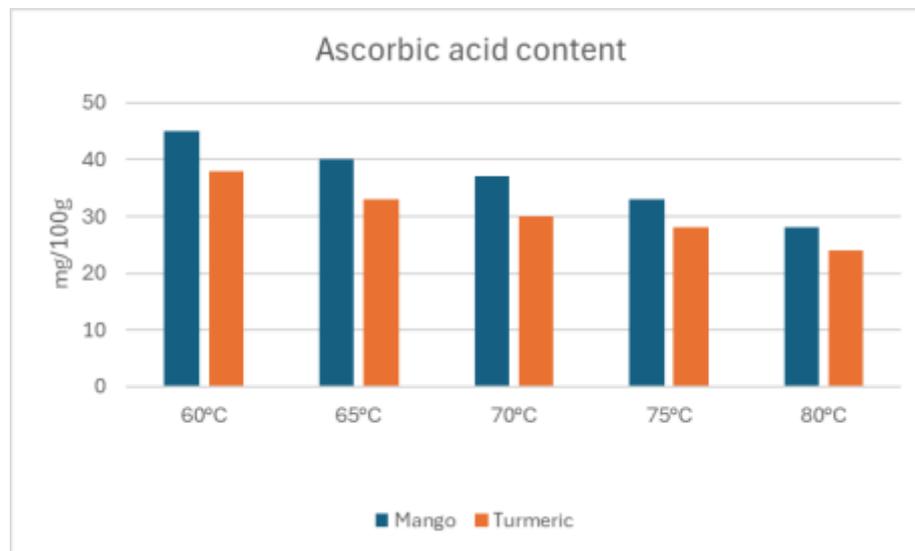


Figure 1. The impact of drying air temperature on the ascorbic acid content of turmeric powder and dried mango

3.2 Sensory Evaluation

The sensory score of mango flavor and turmeric-infused milk was determined by evaluating its color, look, flavor, taste, and overall acceptability.

3.2.1 Color and appearance

The sensory assessment conducted by a panel of 10 members evaluated the color and appearance of mango flavor and turmeric-infused milk at temperatures of 60, 65, 70, 75, and 80°C. The hedonic rating scale was used, and the scores obtained were 8.6, 8.3, 8.0, 7.7, 7.6, and 8.9, 8.6, 8.4, 8.1, and 8.7, respectively. Figure 2 illustrates the observed color shift at different temperatures. As the temperature for drying increases, the drying process accelerates. As a result, the mango flavor and the color of the milk infused with turmeric became darker (table 2).

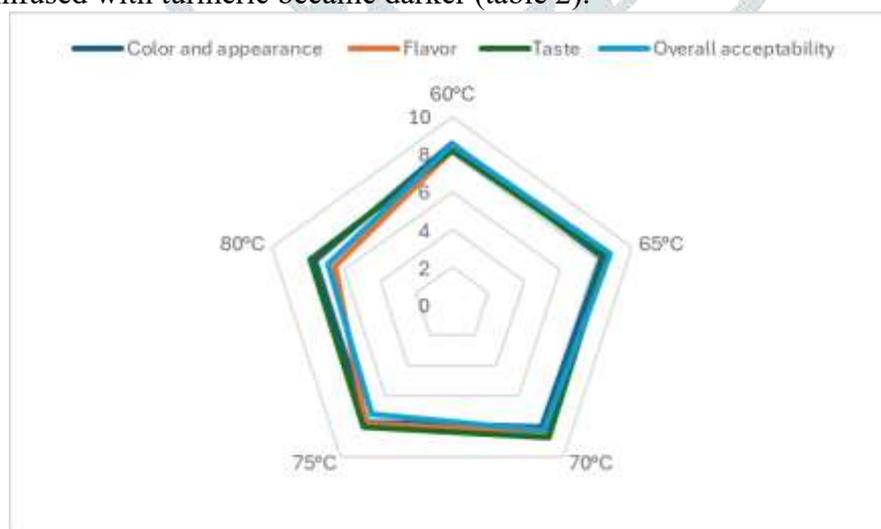


Figure 2. Sensory analysis of milk infused with turmeric and mango flavor.

3.2.2 Flavor

The taste of mango flavor and turmeric-infused milk was evaluated using a hedonic rating scale (table 2) at temperatures of 60, 65, 70, 75, and 80°C. The corresponding ratings were 8.2, 8.7, 8.4, 7.8, and 6.5, and 8.7, 8.4, 8.6, 7.9, and 7.7 (Figure 2). The results indicated that both the mango flavor and the turmeric-infused milk

exhibited exceptional flavors. Nevertheless, the sensory panelists observed that the flavor at 65°C surpassed that of the other temperatures. Moreover, subjecting thin slices of mango and turmeric to temperatures of 70 and 75°C may lead to the denaturation of proteins and the development of a browned or burnt taste. As a result, the flavoring in the milk had been charred.

Temperature	Color & appearance	Flavor	Taste	Overall acceptance
60°C	8.6	8.2	8.2	8.5
65°C	8.3	8.7	8.5	8.8
70°C	8.0	8.4	8.7	8.3
75°C	7.7	7.8	8.0	7.2
80°C	7.6	6.5	7.9	6.9

Table 2. The characteristics of color and appearance, flavor, taste, and general acceptance were utilized to calculate the sensory score for the flavor of mango and milk infused with turmeric.

3.2.3 Taste

Taste is primarily determined by the ratio of sugar content to organic acid. The hedonic rating scale yielded scores of 8.2, 8.5, 8.7, 8, 7.9, and 8.4, 8.6, 8.8, 8.1, 7.6 for the taste of mango flavor and turmeric-infused milk at 60, 65, 70, 75, and 80°C, respectively. Fig. 2 illustrates how different dried mango and turmeric powder concentrations affect flavor at different temperatures. A temperature of 70°C yielded the best flavor. One reason for the unpleasant taste might have been the burnt taste of the flavor milk at 80°C.

3.2.4 Overall acceptance

The effects of different dried mango and turmeric powder concentrations on overall acceptability at different temperatures are shown in Fig. 3. The mango flavor and turmeric-infused milk received the greatest overall acceptance scores from the judges at 65°C and the lowest at 75°C.

3.3 Storage Period

The maximum duration for storing mango-flavored milk infused with turmeric was determined to be a ratio of 1 gramme of mango pulp per 100 ml of milk. With a concentration of 2 grammes of pulp per 100 ml, the storage time was reduced. This might be due to the heightened organic content derived from the mango pulp, which has the ability to expedite microbial proliferation or enzymatic reactions in the turmeric-infused milk.

4. Discussion

In the realm of culinary innovation, the infusion of diverse flavors and traditional herbs has become a fascinating avenue for creating unique and health-conscious products. This study delves into the intricate physiochemical transformations occurring in milk infused with the delightful essence of mango and turmeric (Ayurvedic herb). As consumers increasingly seek both flavor diversity and holistic well-being in their dietary choices, understanding the interplay between these ingredients becomes crucial.

In our study, we closely tracked the pH variations of mango flavor and turmeric-infused milk during storage. The pH ranged from 5.98 to 6.2, with turmeric at the highest (5.9) and mango flavor at the lowest. Simultaneously, acidity levels fluctuated between 0.24% and 0.3%. Unlike our findings, Kamble et al. (2019) validated that the pH of piper betel-flavored milk ranged from 6.27 to 6.55 [30]. The study conducted by Dhande et al. (2020) revealed that the pH of lemongrass-flavored milk ranged from 6.33 to 6.46, which closely aligns with the results we obtained [31]. The pH of carrot-flavored milk drinks ranged from 6.44 to 6.69, as reported by Singh, Grewal, and Sharma in 2005. These values were found to be higher than the ones tested in the present study [32]. As the storage period increased, all samples of strawberry-flavored milk exhibited a significant decline in pH. The product's acidity may have grown due to variations in the pH level of the storage environment. The small decrease in pH might be attributed to an augmentation in the quantity of bacteria and their associated byproducts [33]. The experiment we are doing is related to the results of Dhande et al. (2020), who reported an acidity range of 0.16 to 0.18% in wheatgrass-flavored milk [31]. According to a study conducted by Dalim et al. (2012), strawberry flavored milk has an acidity level of 0.18%, which is equivalent to chikoo flavored milk, and more than banana flavored milk, which has an acidity level of 0.20% [34]. In their study, Hassan et al. (2015) observed that the acidity levels in

fruit-flavored milk ranged from 0.20 to 0.28% after 7 days of storage. However, our measurements indicate that the acidity levels in strawberry-flavored milk are comparatively lower. The study demonstrated a direct correlation between increasing acidity levels and a subsequent reduction in the pH of each sample. The fermentation of lactose by bacteria in milk leads to an increase in acidity due to the production of lactic acid [33].

The present study explores the specific gravity of a novel combination of mango flavor and turmeric-infused milk when stored in a refrigerated environment. The specific gravity of this concoction falls within the range of 1.11 to 1.183. Our results align with the study conducted by Dalim et al. (2012), which reported specific gravity values of 1.061 and 1.063 for Chikoo and banana flavored milk drinks, respectively [34]. Kamble et al. (2019) documented that the specific gravity of piper betel flavored milk ranged from 1.066 to 1.074, which is lower than the measurements we obtained. After a period of 7 days in storage, there was no noticeable difference seen among any of the samples [30].

The fat content of mango flavor and turmeric-infused milk in this study ranges from 1.94 to 2.11 percent after a certain storage time. Contrary to our results, The present investigation did not produce a fat level beyond 2.11%. The number is much lower compared to the fat percentage range of 3.05-3.17% seen in research done by Dhande et al. (2020) on lemongrass-flavored milk [31]. The milk prepared with ginger juice had a fat content of 2.05%, which closely matches the number reported by Palthur et al. (2014b) (Palthur, Devanna, and Anuradha 2014) [35]. In their study, Palthur et al. (2014a) observed fat contents of 2.16 percent in several dietetic herbal milks, which were somewhat higher than our own findings [35]. Over extended durations, the fat content of all samples shows a decline. The addition of sugar has the potential to induce changes in fat composition. According to research conducted by Shelke et al. (2008), flavored milks such as rose, vanilla, cardamom, strawberry, kesar, pineapple, and mango had somewhat reduced fat concentrations compared to unflavored milk [36]. The use of sugar led to an increased quantity of flavored milk in the final product.

In the present study, the protein concentrations of mango flavor and turmeric-infused milk ranged between 3.75% and 4.07% during the storage periods.

Unlike our research on the taste of mango and turmeric-infused milk, Kamble et al. (2019) found that Piper betel flavored milk included a protein level ranging from 3.34% to 3.65% [30]. Our study aligns with the findings of Dalim et al. (2012), who documented an average protein content of 3.56% in chikoo-flavored milk. Consequently, the present analysis revealed slightly lower results in comparison to their reported values[34]. The protein content range reported by Dhande et al. (2020) of 3.20–3.31 was lower than our own. Upon comparison, the samples currently stored exhibit no detectable difference [31]. The hypothesis proposes that the variation in protein levels in milk might perhaps be attributed to the use of flavoring compounds [37].

In the current study, it was observed that the vitamin C content in a dried sample exhibited a degradation pattern with an escalating rate as the drying air temperature increased. Specifically, a higher concentration of ascorbic acid was found at 60°C, while a lower concentration was noted at 80°C. In contrast to our findings, results obtained align with previous studies on vitamin C degradation. Our observations are consistent with Santos and Silva's (2009) [38] research on pineapple and Kaya et al.'s (2010) [39] study on kiwi. This similarity suggests a pattern of vitamin C degradation influenced by drying conditions across various fruit types.

Conclusion

This study investigates the interplay of mango flavor and turmeric-infused milk, specifically focusing on physiochemical changes during storage and the potential benefits of incorporating natural preservatives. Notable findings encompass pH variations (5.98 to 6.2), specific gravity (1.11 to 1.183), and fat content (1.94% to 2.11%). Protein concentrations fluctuated between 3.75% and 4.07%, with comparisons made to Piper betel flavored milk. The research also discloses the degradation pattern of vitamin C in dried samples, correlating with drying air temperature. Sensory evaluations highlight favorable scores for color, flavor, and overall acceptance, providing valuable insights into the sensory attributes of the infused milk across diverse conditions. In the realm of future implications, this study goes beyond its primary objective of exploring physiochemical changes in milk, laying the foundation for a culinary landscape where locally sourced ingredients, innovative food products, and consumer preferences harmonize. The intricate interplay between physiochemical and sensory attributes, as revealed in this research, sets the stage for a forthcoming era characterized by health-conscious and gastronomically appealing culinary offerings. The insights gleaned from this study are poised to inspire the development of a diverse range of flavorful and nutritionally conscious food products, fostering a culinary renaissance that prioritizes both wellness and the sensory delight of consumers.

References

1. Martirosyan, D.M., Singharaj, B., 2016. Health claims and functional food: The future of functional foods under FDA and EFSA regulation. In: *Functional Foods for Chronic Diseases*, 1st Edn., Food Science Publisher: Dallas, TX, USA, 410–424.
2. Basak, Sarma, Rangan (2010). Ethnomedical uses of Zingiberaceous plants of Northeast India. *Journal of ethnopharmacology* 132(1), 286–296.
3. Guldiken, Ozkan, Catalkaya, Ceylan, Yalcinkaya, Capanoglu (2018). Phytochemicals of herbs and spices: Health versus toxicological effects. *Food and Chemical Toxicology* 119, 37–49.
4. El-Sayed, Youssef (2019). Potential application of herbs and spices and their effects in functional dairy products. *Heliyon* 5(6), e01989.
5. Ahmad, Imran, Khan, Ahmad, Arshad, Ateeq, Rahim (2021). Introductory chapter: Herbs and spices-An overview. In: *Herbs and Spices-New Processing Technologies*. United Kingdom, Intech Open, 1–8.
6. Miran, Salami, Emam-Djomeh (2021). Spices as traditional remedies: Scientifically proven benefits. In: Moosavi-Movahedi, A.A. (Ed.). *Rationality and Scientific Lifestyle for Health*. Springer, Cham., 91–114.
7. Gokhale, Lele, Ananthanarayan (2021). Indian traditional foods and diets: Combining traditional wisdom with modern science of nutraceuticals and functional foods. In: Rattan, S.I.S., Kaur, G. (Eds.), *Nutrition, Food and Diet in Ageing and Longevity*. Springer, Cham., 357–392.
8. Muzolf-Panek, M., Stuper-Szablewska, K., 2021. Comprehensive study on the antioxidant capacity and phenolic profiles of black seed and other spices and herbs: Effect of solvent and time of extraction. *Journal of Food Measurement and Characterization* 15(5), 4561–4574.
9. Zayapor, M.N., Abdullah, A., Wan Mustapha, W.A., 2021. The antioxidant analysis and α -glucosidase inhibition activities of spices and herbs (22 species) in Asian traditional beverages. *Journal of Food Measurement and Characterization* 15(2), 1703–1718.
10. Ali, A., Wu, H., Ponnampalam, E.N., Cottrell, J.J., Dunshea, F.R., Suleria, H.A., 2021. Comprehensive profiling of most widely used spices for their phenolic compounds through lc-esi-qtof-ms2 and their antioxidant potential. *Antioxidants* 10(5), 721.
11. Zeb (2021). Phenolic antioxidants in herbs and spices. In: *Phenolic Antioxidants in Foods: Chemistry, Biochemistry and Analysis*. Springer, Cham, 225–238.
12. Pateiro, M., Munekata, Sant'Ana, Domínguez, Rodríguez-Lázaro, Lorenzo (2021). Application of essential oils as antimicrobial agents against spoilage and pathogenic microorganisms in meat products. *International Journal of Food Microbiology* 337, 108966.
13. Pinto, Aires, Cosme, Bacelar, Morais, Oliveira, Ferreira-Cardoso, Anjos, Vilela, Gonçalves (2021). Bioactive (Poly) phenols, volatile compounds from vegetables, medicinal and aromatic plants. *Foods* 10(1), 106.
14. Bhattacharya, Pal, Dutta, Bhowmik, Mandal Biswas (2021). Antioxidant, antimicrobial and DNA damage protecting potential of hot taste spices: A comparative approach to validate their utilization as functional foods. *Journal of Food Science and Technology* 59(3), 1173–1184.
15. Paswan, V.K., Rose, H., Singh, C.S., Yamini, S., Rathaur (2021). Herbs and spices fortified functional dairy products. In: Ahmad, R.S. (Ed.). *Herbs and Spices New Processing Technologies*. Intech Open. Available at <https://www.intechopen.com/chapters/77625>.
16. Sawale, P.D., Singh, Kapila, Arora, Rastogi, Rawat (2013). Immunomodulatory and antioxidative potential of herb (*Pueraria tuberosa*) in mice using milk as the carrier. *International Journal of Dairy Technology* 66(2), 202–206.
17. Arepally, D., S. R. Ravula, and V. Reddy. 2017. “Mathematical Modelling of Mixed Mode Natural Convection Solar Drying of Tomato Slices.” *International Journal of Chemical Studies* 5, no. 4: 1274–9.
18. Gonçalves, Gomes, Costa, Romano (2013). The phenolic content and antioxidant activity of infusions from Mediterranean medicinal plants. *Industrial Crops and Products* 43(1), 465–471.
19. Nile SH, Park SW. Chromatographic analysis, antioxidant, anti-inflammatory, and xanthine oxidase inhibitory activities of ginger extracts and their reference compounds. *Industrial Crops and Products*. 2015; 70(2):238-244.
20. Lal J. Turmeric, Curcumin and Our Life: A Review. *Bulletin of Environmental Pharmaceutical and Life Sciences*. 2012; 1(7):11-17.
21. Labban L. Medicinal and pharmacological properties of Turmeric (*Curcuma longa*): A review. *Journal of Pharmaceutical and Biomedical Sciences*. 2014; 5(1):17- 23.
22. Chattopadhyay I, Biswas K, Bandyopadhyay U, Banerjee RK. Turmeric and curcumin: Biological actions and medicinal applications. *Current Science*. 2004; 87(1):44- 53.
23. Quiros-Sauceda AE, Chen CO, Blumberg JB, Astiazaran-Garcia H, Wall-Medrano A, Gonzalez-Aguilar GA. Processing 'Ataulfo' mango into juice preserves the bioavailability and antioxidant capacity of its phenolic compounds. *Nutrients* 2017;9.

24. JahurulMH, Zaidul IS, Ghafoor K, Al-Juhaimi FY, Nyam KL, Norulaini NA, et al. Mango (*Mangifera indica* L.) by-products and their valuable components: a review. *Food Chem* (2015); 183:173-80.
25. Chinma C, Gernah D. Physicochemical and sensory properties of cookies produced from cassava/soyabean/mango composite flours. *Journal of Raw Material Research* 2007; 4:32-43.
26. Christina IAM, Kencana IN, Permana (2018) Pengaruh Metode Pengeringan dan Jenis Pelarut terhadap Rendemen dan Kadar Kurkumin Ekstrak Kunyit (*Curcuma domestica* Val) *Jurnal Ilmiah Teknologi Pertanian* 3 319-24.
27. Teka (2013) Oct. 31. "Analysis of the Effect of Maturity Stage on the Postharvest Biochemical Quality Characteristics of Tomato (*Lycopersicon esculentum* Mill.) Fruit." *International Research Journal of Pharmaceutical & Applied Sciences* 3, no. 5: 180–6
28. Javid, S. B., J. A. Gadahi, M. Khaskeli, M. B. Bhutto, S. Kumbher, and A. H. Panhwar. 2009 Mar. 1. "Physical and Chemical Quality of Market Milk Sold at Tandojam, Pakistan." *Pakistan Veterinary Journal* 29, no. 1: 27– 31.
29. 2009 Mar. 1. "Physical and Chemical Quality of Market Milk Sold at Tandojam, Pakistan." *Pakistan Veterinary Journal* 29, no. 1: 27– 31.
30. Kamble, V. S., D. D. Patange, D. K. Kamble, K. S. Kamble, and S. J. Patil. 2019. "Process Optimization for Flavoured Milk Added with Piper Betel Leaves." *International Journal of Current Microbiology & Applied Sciences* 8, no. 1: 713–24. <https://doi.org/10.20546/ijcmas.2019.801.079>.
31. Dhande, S. V., S. Chavan, N. R. Sonone, and H. Kumar. 2020. "Evaluation of PhysicoChemical Properties of Lemongrass Flavoured Milk." *International Journal of Chemical Studies* 8, no. 2: 2127–30. <https://doi.org/10.22271/chemi.2020.v8.i2af.9067>.
32. Singh, C., K. S. Grewal, and H. K. Sharma. 2005. "Preparation and Properties of Carrot Flavoured Milk Beverage." *Journal of Dairying Foods & Home Sciences* 24(3and4): 184–9.
33. Hassan, M., B. N. Dar, S. A. Rather, R. Akhter, and A. B. Huda. 2015. "Physicochemical, Sensory and Microbial Characteristics of Fruit Flavoured Milk Based Beverages During Refrigerated Storage." *Biomed. Pharma* 2, no. 1: 32–9.
34. Dalim, M., M. Khaskheli, M. H. Baloch, A. H. Soomro, G. B. Khaskheli, A. S. Mangsi, and G. S. Barham. 2012. "Production and Comparison of Banana and Chikoo Flavoured Milk-Based Beverages." *Pakistan Journal of Nutrition* 11, no. 6: 600–4. <https://doi.org/10.3923/pjn.2012.600.604>.
35. Palthur, S., N. Devanna, and C. M. Anuradha. 2014. "Antioxidant and Organoleptic Properties of Tulsi Flavoured Herbal Milk." *International Journal of Plant, Animal & Environmental Sciences* 4, no. 4: 35–40.
36. Shelke, M. A., S. R. Patil, A. A. Bhagat, T. R. Walkunde, S. D. Shinde, and K. P. Patil. 2008. "Chemical Composition and Cost Structure of the Flavoured Milk." *Royal Veterinary Journal of India* 4, no. 1: 57–9.
37. Repate, K. C., V. J. Kamble, H. B. Awaz, and B. M. Thombre. 2010. "Studies on Preparation of Flavoured Milk from Cow Milk Blended with Safflower Milk." *Journal of Dairying Foods & Home Sciences* 29, no. 2: 92–6.
38. Santos, P. H. S., and M. A. Silva. 2009 Aug. 18. "Kinetics of L-Ascorbic Acid Degradation in Pineapple Drying Under Ethanolic Atmosphere." *Drying Technology* 27, no. 9: 947–54. <https://doi.org/10.1080/07373930902901950>.
39. Kaya, A., O. Aydın, and S. Kolaylı. 2010 Jun. 1. "Effect of Different Drying Conditions on the Vitamin C (Ascorbic Acid) Content of Hayward Kiwifruits (*Actinidia deliciosa* Planch)." *Food & Bioproducts Processing* 88, no. 2–3: 165–73. <https://doi.org/10.1016/j.fbp.2008.12.001>.