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SS Ajmi
Department of Dairy Technology, Verghese Kurien Institute of Dairy and Food Technology, Mannuthy, Thrissur, Kerala, India

SN Rajakumar
Professor and Head, Department of Dairy Technology, Verghese Kurien Institute of Dairy and Food Technology, Mannuthy, Thrissur, Kerala, India

KB Divya
Assistant Professor, Department of Dairy Technology, Verghese Kurien Institute of Dairy and Food Technology, Mannuthy, Thrissur, Kerala, India

CH Aysha
Assistant Professor, Department of Dairy Microbiology, Verghese Kurien Institute of Dairy and Food Technology, Mannuthy, Thrissur, Kerala, India

SV Aparna
Assistant Professor, Department of Food Microbiology, Verghese Kurien Institute of Dairy and Food Technology, Mannuthy, Thrissur, Kerala, India

Corresponding Author:
SS Ajmi
Department of Dairy Technology, Verghese Kurien Institute of Dairy and Food Technology, Mannuthy, Thrissur, Kerala, India

Study on the effect of levels of tricalcium citrate tetrahydrate on organoleptic properties of Shrikhand

SS Ajmi, SN Rajakumar, KB Divya, CH Aysha and SV Aparna

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Abstract
Shrikhand, a traditional Indian fermented dairy dessert, is celebrated for its rich texture, distinct flavor, and nutritional value. With growing consumer interest in nutrient-enriched foods, fortifying shrikhand with calcium has gained significance. This study explores the incorporation of tricalcium citrate tetrahydrate (TCCT), a bioavailable calcium salt, into shrikhand and its impact on organoleptic properties such as flavor, texture, appearance, and overall acceptability. Various levels of TCCT were assessed to identify the optimal fortification level that enhances nutritional content without compromising sensory attributes. Sensory evaluation was conducted using a 9-point hedonic scale, and statistical analysis revealed significant differences in sensory scores at higher fortification levels.The findings highlight that fortifying shrikhand with TCCT up to 200 ppm improves calcium content while maintaining desirable sensory properties. Levels exceeding 200 ppm resulted in unfavorable changes, such as a chalky aftertaste and altered texture. This study underscores the potential of TCCT-fortified shrikhand as a functional food product, meeting a portion of the recommended daily calcium intake while preserving consumer acceptability.

Keywords: Shrikhand, tricalcium citrate tetrahydrate, fortification, sensory evaluation, organoleptic properties

Introduction
Shrikhand is prepared by straining dahi (yogurt) to remove whey and blending the resultant chakka with sugar and flavoring agents. As consumer demand for nutrient-enriched foods grows, there is an increasing interest in fortifying traditional foods like shrikhand with calcium. Tricalcium citrate tetrahydrate, a bioavailable calcium salt, is a promising candidate for fortification due to its neutral taste and functional properties.

The selection of calcium salts for fortification depends on several factors like compatibility with manufacturing processes, effect on sensory attributes, stability, and bioavailability. The possibility of fortification using commercial calcium salts such as calcium citrate, calcium lactate, calcium gluconate, calcium carbonate, calcium chloride, and calcium phosphate was reviewed. Even though inorganic calcium salts have more calcium content, they are less chosen in food and beverages due to their poor solubility.

Calcium lactate gluconate, natural milk calcium, encapsulated calcium, and bioorganic calcium are the novel calcium sources available for fortification. Flame Atomic Absorption Spectrometry (FAAS), Graphite Furnace Atomic Absorption Spectrometry (GFAAS), and Inductively Coupled Plasma Optical Emission Spectrometry (ICP OES) are the commonly used techniques for the determination of trace elements in food (Baig *et al*., 2019) [1].

Ranjan *et al*. (2005) [3] investigated the bioavailability and physicochemical properties of calcium-fortified buffalo milk. Calcium chloride, calcium lactate, and calcium gluconate at the rate of 50 mg calcium/100 ml milk were the salts selected for the study. The resulting decrease in pH was restored using the addition of disodium phosphate. When compared with unfortified milk, decreased heat stability, curd tension, and increased viscosity were observed for calcium-fortified buffalo milk. The results also inferred that absorption/retention was comparatively higher for organic salts.

Unal *et al*. (2005) [4] reported that bioavailability of calcium from yogurt is higher as the acidic pH of yogurt ionizes calcium and facilitates more intestinal calcium absorption than that of milk.

Yonis *et al*. (2013) [5] documented the influence of calcium salts on rheological and sensorial properties of banana-stirred yogurt. Calcium gluconate and calcium lactate added at levels of one percent and two percent respectively showed no negative influence on sensory properties. The prepared yogurt had a more firm structure, which could be related to the increase in colloidal calcium phosphate cross-linking.

Liutkevičius *et al*. (2016) [2] developed a functional whey beverage containing calcium lactate (150 mg calcium), Vitamin D3 (0.75 µg), and prebiotic dietary fiber (2.5 g). The study on its effect on human health showed a significant decrease in low-density lipoprotein cholesterol and triglycerides when consumed (500 ml) daily over a period of 21 days.

The study aims to evaluate the influence of TCCT fortification at different concentrations on the sensory attributes of shrikhand, thereby determining the optimal level for enhancement without compromising consumer acceptability.

Materials and Methods

The study was carried out in the Department of Dairy Technology, Verghese Kurien Institute of Dairy and Food Technology (VKIDFT), Mannuthy.

Fortification of milk with calcium salt

Calculated amount of calcium salt was added to milk and thoroughly mixed for complete dissolution before pasteurization.CT was incorporated at four different levels: 0 ppm (control), 100 ppm, 200 ppm, and 300 ppm of the chakka weight. The mixtures were homogenized to ensure uniform distribution. Different calcium salts, including calcium gluconate and calcium lactate, were initially tested for fortification. However, TCCT was finalized due to its superior sensory and functional properties.

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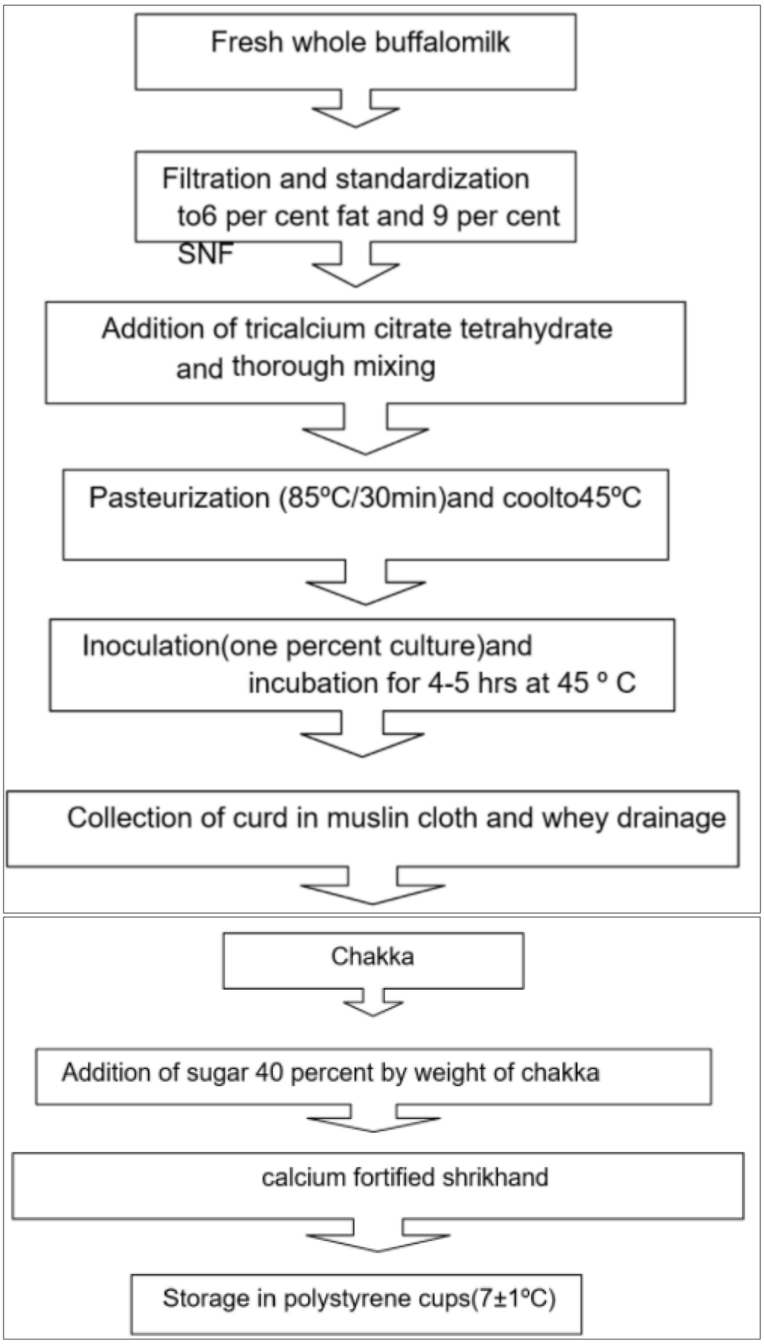
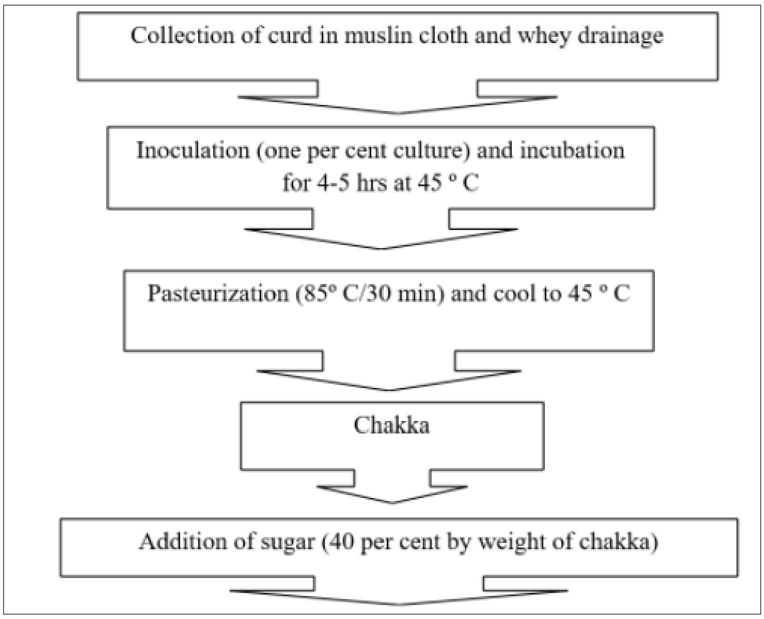
Preparation of Shrikhand: Fresh chakka was prepared by straining dahi through a muslin cloth under refrigeration for 12 hours. The chakka was then mixed with powdered sugar (30% w/w) and homogenized thoroughly.





Tricalcium citrate tetrahydrate fortified Shrikhand

Fig 1: Flow chart for the preparation of calcium fortified shrikhand

Sensory Evaluation: The product was subjected to sensory analysis for its flavor, color and appearance, body and texture, sweetness, and overall acceptability. A sensory panel of five trained judges evaluated the samples using a 9-point hedonic scale.

Statistical Analysis: Data were analyzed using the Kruskal-Wallis test to evaluate differences in sensory scores across treatments. Significance was set at $p<0.05$.

Estimation of Calcium Content

Calcium content in shrikhand was estimated by using Atomic Absorption Spectroscopy (AAS) (Perkin Elmer, Model-Pinaacle 900H) according to IS: 12760:2012. Shrikhand samples were subjected to dry digestion before aspirated into the flame of AAS. Air acetylene flame was used for calcium estimation in AAS.

Results and Discussion

The preliminary trials were conducted by preparing shrikhand from milk fortified with three different levels of TCT at the rate of 100 ppm (TC1), 200 ppm (TC2) and 300 ppm (TC3). The resultant products were compared with control shrikhand (T_0) for sensory attributes. The sensory scores were subjected to statistical analysis and the effect of different levels of TCT fortification on sensory attributes of shrikhand is summarized in Table 1

Table 1: Effect of different levels of tricalcium citrate tetrahydrate on sensory scores of shrikhand

Parameters	T_1	TC1	TC2	TC3	Chi- square value
Flavour	8.17±0.11	7.83±0.17	7.75±0.11	7.67±0.11	7.18^{ns}
Colour and Appearance	8.08±0.15	7.67±0.17	7.50±0.22	7.42±0.15	7.17^{ns}
Body and Texture	8.00±0.13 ^{a}	7.67±0.17 ^{a}	7.58±0.15^{a}	6.83±0.17 ^{b}	13.07**
Sweetness	7.92±0.15	7.58±0.20	7.50±0.22	7.42±0.20	3.32^{ns}
Overall Acceptability	8.00±0.13 ^{a}	7.75±0.11 ^{a}	7.67±0.11^{a}	7.17±0.11 ^{b}	13.07**

Figures are Mean ± Standard error of sensory scores by five selected judges in six replications, $^{a-b}$ Figures in a row with different superscripts differ significantly, **- significant at one percent level ($p<0.01$), ^{ns}- non significant

The chi-square (χ^2) values for attributes like flavor, color and appearance, body and texture, sweetness, and overall acceptability of TCCT-fortified shrikhand were found to be 7.18, 7.17, 13.07, 3.32, and 13.07, respectively. The results revealed that responses such as body and texture and overall acceptability exhibited a significant difference at the 1 percent level, whereas all the other responses were non-significant ($p>0.05$).

The addition of TCCT up to 200 ppm had a minimal effect on the flavor profile, with mean scores remaining above 7. However, at 300 ppm, a slight chalky aftertaste was noted, leading to a reduction in flavor scores (mean: 6.2±0.3). No significant difference was found between TC1 (100 ppm) and TC2 (200 ppm) when compared to T_0 (control). TCCT fortification enhanced the firmness and creaminess of shrikhand up to 200 ppm, as reflected by higher texture scores (mean: 8.1±0.2). However, fortification at a level of 300 ppm (TC3) was found to be unacceptable in preliminary trials as it resulted in poor consistency.

No significant differences in appearance scores were observed across the samples ($p>0.05$), indicating that TCCT did not affect the visual appeal of the product.

Shrikhand fortified with 200 ppm TCCT achieved the highest overall acceptability score (mean: 8.0±0.2), balancing enhanced calcium content and sensory attributes. The 300 ppm level exhibited a decline in acceptability due to textural and flavor issues. Therefore, TC1 and TC2 were selected as the minimum and maximum levels of TCCT to be added to shrikhand.

Calcium Content and Percentage Recovery: The estimated calcium content of control and optimized shrikhand samples were presented in Table 2. The recovery of calcium from optimized shrikhand was calculated as 84.8 percent.

Table 2: Estimated calcium content of control and optimized shrikhand

	Calcium content (mg/100ml)	T-value
Control Shrikhand	144.55±0.01	1574**
Optimized Shrikhand	166.81±0.01	

Figures are mean ± Standard error of three replications, **-significant at one percent level (p<0.01)

The calcium content of control and optimized shrikhand was estimated using the AAS method, as shown in Table 2. Fortification with tricalcium citrate tetrahydrate significantly (p<0.01) increased calcium content in optimized shrikhand, which contained 166.8 mg/100 g compared to 144.5 mg/100 g in the control. Mehta (2013) [6] reported similar calcium levels in shrikhand brands across Maharashtra. The calcium recovery in optimized shrikhand was 84%, compared to 75.82% in calcium-fortified ice cream (Rajarajan *et al*., 2017) [7]. Kiradar *et al*. (2017) [8] noted 5.6% calcium loss in yogurt serum.
According to ICMR (2020), the RDA for calcium is 1000 mg/day. A 200 g serving of optimized shrikhand can provide 33.4% of an adult's daily calcium requirement

Conclusion
This study concludes that fortifying shrikhand with tricalcium citrate tetrahydrate (TCCT) up to 200 ppm effectively enhances its calcium content while maintaining desirable sensory attributes. Higher fortification levels (300 ppm) resulted in a chalky aftertaste and compromised texture, emphasizing the importance of optimization. The findings demonstrate the potential of TCCT-fortified shrikhand as a functional food, capable of contributing significantly to daily calcium intake. Future studies may explore alternative fortification strategies to further improve nutritional value without affecting product acceptability.

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