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Research article

Low-calorie and carrot pulp incorporated shrikhand from low-fat cow milk: Optimization and quality evaluation

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Abstract: The present study was undertaken to standardize the milk fat, stevia level, and optimize fortification of carrot pulp at 10, 20 or 30 % levels separately replacing the chakka for production of low-fat and low-sugar functional shrikhand, a fermented Indian dessert from cow milk. On the basis of sensory evaluation, it was determined that the most favorable shrikhand was prepared using milk with 1.5% fat and replacing 60% of the sugar with stevia. Additionally, the incorporation of carrot pulp at a 20% level was identified as the optimal choice. This carrot pulp-enriched shrikhand was further assessed for its physico-chemical attributes such as pH, thiobarbituric acid reacting substances (TBARS) value and water activity, microbiological quality (including total plate count, coliform, psychrophilic, yeast and mold counts), and sensory characteristics over a 9-day period, with evaluations at intervals of three days (0, 3, 6, and 9 days), and then it was compared with the control. Although the mean TBARS values showed an increasing trend, the values of carrot pulp treated shrikhand (0.497 mg manolaldehyde/kg) was significantly ($p < 0.05$) lower than control (0.582 mg manolaldehyde/kg) samples during the 9 days storage period. Further, the sensory evaluation results of shrikhand with carrot pulp exhibited significantly higher ($p < 0.05$) mean scores for color, appearance, and overall acceptability. The microbiological quality parameters of both products (control and treated) remained within permissible limits, when stored under refrigerated conditions for

up to 9 days. In conclusion, shrikhand with 20% carrot pulp is recommended due to its ability to add value to the product by enhancing its functional properties and overall acceptability.

Keywords: Shrikhand; low-sugar; low-fat; carrot pulp; sensory evaluation

1. Introduction

Among various fermented milk products, shrikhand occupies a unique place in the Indian sweet dishes. It is one of the major indigenous fermented milk products, prepared from lactic fermented curd and a semi-soft, healthful, delicious whole milk dessert popular in western part of India (Gujarat & Rajasthan). It is made with chakka (strained yoghurt/curd) which is finely mixed with sugar and flavoring agents [1,2], apart from fruits, nuts, sugar, cardamom, saffron and other spices. Although shrikhand is a concentrated source of milk fat, protein, calories, and minerals, the amount of sugar (more than 40%) and fat (8–12%) present in shrikhand limits its consumption. As a result, the calorie conscious consumers, diabetics and persons suffering with Coronary Heart Diseases (CHDs) cannot relish it [3]. Therefore, demand for reduced calorie and low-fat milk products are now becoming quite popular, as these can help the body to lower the risk of chronic degenerative or gastrointestinal issues [4]. In this context, stevia is a natural sweetener obtained from the leaf of *Stevia rebaudiana,*a perennial herb from the Asteraceae family plant. The species *S. rebaudiana Bertoni*, commonly known as sugar leaf, or simply stevia, is widely grown for its sweetness. Steviol glycosides (SGs) are the secondary metabolites responsible for the sweetness of stevia [5], which is much higher than sucrose. Apart from being a non-caloric sugar substitute, which is beneficial against diabetes disease, it improves digestion and prevents tooth enamel decay [6].

Recently, there has been an increased trend to fortify cultured milk products with fruit or vegetable pulps to enhance the versatility of flavor, texture, and color. The association of fruits and vegetables with cultured dairy products has endorsed healthy perception in the consumer mind, as these contain significant levels of biologically active components and important phytonutrients namely, vitamins, minerals, antioxidants, and dietary fibers that provide specific health benefits beyond the traditional nutrients [7]. Current evidence collectively demonstrates that fruit and vegetable intake reduce the risk of various types of cancers, CHD, hypertension, and possibly delayed onset of age-related indicators [8,9]. One such vegetable is carrot, which has intrinsic nutritional value, with rich dietary fiber, vitamins, and mineral contents, which make food products more functional and beneficial to health.

Although research on different quality parameters of shrikhand incorporating pulp from different fruits such as kiwi [10,11], apple [12], custard apple and stevia [13], papaya [14], mango [15], jamun [16], date [17], etc. have been conducted, no information is available for utilizing carrot pulp in shrikhand. Considering the demand for low fat and low sugar traditional dairy foods fortified with vegetable pulp, the present investigation was undertaken to standardize the milk fat and stevia level, optimize incorporation level of carrot pulp in chakka, and study the refrigerated storage quality of developed shrikhand at 3-day intervals up to 9 days.

2. Materials and methods

2.1. Sources of raw materials

Fresh and clean whole cow milk, obtained from Dairy Technology Section of ICAR-IVRI, Izatnagar (Uttar Pradesh), was analyzed for various parameters and for the preparation of shrikhand. Cow milk was passed through a cream separator to obtain skim milk and cream. The skim milk and cream were used to standardize the milk as per the experimental plan. Household curd was used as starter culture for the setting of Dahi. Good quality white crystalline food grade cane sugar was procured from the local supermarket. The sugar was ground in a laboratory grinder for mixing with chakka to manufacture shrikhand. Stevia powder (Zydus Wellness Products Ltd, Mumbai, India) and fresh carrots used for the study were purchased from the local supermarket. The carrots were washed and subjected to blanching in hot water maintaining a temperature of 60 °C for 15 min to deactivate the enzymes and prolong the storage period, and then were chopped and grinded in a domestic mixer for sufficient time, until a fine consistency of pulp was obtained.

2.2. Optimization of fat % in milk for the preparation of low-fat shrikhand

Shrikhand was prepared by the traditional method suggested by Aneja et al. [18]. Whole cow milk was pre-heated to 40 °C before being subjected to the cream separator for the preparation of skimmed milk. Whole milk in different proportions (4.5, 3, 1.5, or 0.5%) was mixed to optimize fat percentage for the preparation of low fat shrikhand. The most acceptable product selected as per the sensory evaluation was used to carry out further studies.

2.3. Optimization of stevia level in chakka to prepare low-calorie shrikhand

Shrikhand was made following the previously mentioned procedure, with the addition of fine sugar at a 35% weight ratio to the chakka, serving as the control (C). The sugar content in shrikhand was subsequently substituted at three different levels with fine stevia powder, resulting in sugar-to-stevia ratios of 60:40, 40:60, and 20:80 for T1, T2, and T3, respectively. The selection of the optimal stevia level in chakka for the preparation of low-calorie shrikhand was based on sensory acceptability. Based on the sensory acceptability, shrinkand prepared with 60% sugar replacement with stevia was found comparatively better than T1 and T3.

2.4. Optimization of carrot pulp level for making functional shrikhand

Again, shrikhand was prepared using chakka, with the incorporation of carrot pulp at three distinct levels: 10, 20, and 30%, individually replacing chakka in the formulation. These variants were labeled as T1, T2, and T3, respectively. Similarly, shrikhand prepared from chakka without any carrot pulp was regarded as the control (C). The chakka was produced in larger quantities from cow's milk, with optimized levels of fat (1.5%) and stevia powder (60%). The extent of carrot pulp inclusion in the shrikhand was fine-tuned based on the results of sensory assessments, paving the way for further research.

2.5. Determination of storage quality and shelf life of low-fat, low-sugar functional shrikhand fortified with carrot

The shrikhand containing the most preferred level of carrot pulp (20%) (T1) was compared with the control (C), which was prepared without any carrot pulp to replace the chakka. Both products were packaged in PET jars and stored at a refrigerated temperature of 4 ± 1 °C. Over a period of 9 days, various parameters including physico-chemical factors such as pH, thiobarbituric acid reacting substances (TBARS) value, and water activity, sensory attributes, and microbiological quality (total plate count, coliform count, psychrophilic count, yeast and mold counts) were analyzed at regular intervals of three days (0, 3, 6, and 9 days) during the storage duration.

2.6. Physico-chemical analysis

The pH of the milk and shrikhand samples was determined by using digital pH meter (p^H tutor, Eutech instruments). The water activity of shrikhand samples were measured using a hand-held, portable digital water activity meter (Aqua lab dew point water activity meter 4TE, USA) as per the method adopted by Das et al. [19]. The titrable acidity of the milk and shrikhand samples was determined according to the method of AOAC [20]. The solid not fat (SNF) %, total solids (TS) % and specific gravity of milk was calculated as per the standard procedures of FSSAI [21] and AOAC [20], respectively.

2.7. Thiobarbituric acid reacting substances value

The TBARS value of shrikhand was determined by using the distillation method [22] with suitable modifications. Ten grams of sample was mixed with 25 mL of pre-cooled 20% trichloroacetic acid (TCA) solution for 2 min. The content was then quantitatively transferred into a beaker by rinsing with 25 mL of chilled distilled water, well mixed and filtered through Whatman filter paper No. 1. Then, 3 mL of TCA extract (filtrate) was mixed with 3 mL of TBA reagent (0.005 M) in test tubes and placed in a water bath at 70˚C for 35 minutes. A blank sample was made by mixing 3 mL of 10% TCA and 3 mL of 0.005 M TBA reagent. Absorbance (O.D.) was measured at a fixed wavelength of 532 nm with a scanning range of 531–533 nm using a spectrophotometer (Spectramax, M5, USA). The TBARS value was calculated as mg malonaldehyde per kg of sample by multiplying O.D. value with a factor 5.2.

2.8. Proximate composition of milk

The moisture, protein, fat, and ash contents of the milk was estimated using a hot air oven, Kjeldahl assembly, Gerber centrifuge/Soxhlet extraction apparatus and Muffle furnace, respectively as per methods described by AOAC [20].

2.9. Microbiological analysis

The total plate count (TPC), psychrophilic count, coliform count, and yeast and mold counts of the samples were enumerated following the methods as described by American Public Health Association [23].

2.10. Sensory evaluation

An experienced sensory panel consisting of the scientists and post graduate students of the Division of Livestock Products Technology, ICAR-IVRI, Izatnagar (U.P.) evaluated the test samples for different sensory attributes, based on eight-point hedonic score card method [24]. The panelists were briefed about the nature of the experiments without disclosing the identity of the samples and were asked to rate them on an eight-point descriptive scale for different attributes like color and appearance, flavor, body and texture, sweetness, and over acceptability. Plain potable water was provided to rinse the mouth in between the samples.

2.11. Statistical analysis

The data collected from the experiments were consolidated and subjected to statistical analysis using SPSS-20 statistical software (Version 20, IBM, USA). Duplicate samples were taken for each parameter for which six samples were collected (except sensory evaluation). This entire experimental procedure was repeated three times, resulting in a total of six observations for all parameters. In the case of sensory evaluation, there were 18 observations. Duncan's multiple range tests were used to compare the means for significant differences. The statistical significance was determined at a 95% confidence level ($p < 0.05$).

3. Results and discussion

3.1. Chemical analysis of milk

The chemical analysis of the cow milk used in the present study is presented in Table 1. The data clearly suggests that the milk was of good quality and the percentage of total solid, fat, protein, and titrable acidity were within the limit of legal standards for cow milk as described by De [25].

Table 1. Analysis of milk for the preparation of shrikhand (Mean±SE).

Parameters	Percentage (%)
Moisture	87.83 ± 0.04
Fat	4.57 ± 0.04
Protein	3.25 ± 0.01
Solid not fat (SNF)	7.57 ± 0.04
Total solid (TS)	12.15 ± 0.03
Ash	0.69 ± 0.01
Titrable acidity	0.13 ± 0.001

3.2. Optimization of fat level in milk to prepare low fat shrikhand

The mean sensory scores of shrikhand prepared from milk with different fat levels *viz.* 4.5, 3.0, 1.5, and 0.5% are presented in Figure 1. The product prepared from milk with 0.5% milk (T3) fat showed significantly ($p < 0.05$) lower scores as compared to control (4.5%), T1 (3.0%), and T2 (1.5%). As expected, the control sample showed the highest mean score values for appearance and color, flavor,

body and texture, sweetness, and overall acceptability. The sensory scores for the product with 1.5% fat showed no significant ($p > 0.05$) difference with product prepared from 3% fat milk and a direct relationship between fat content and overall acceptability of the product was observed. Similar to our study, Aykan et al. [26], Kim et al. [27], and Saleh et al. [28] have also prepared low-fat vanilla ice cream and yoghurt, respectively. In a study conducted by Reddam and Prabhakar [29], four different milk fat level (6.0, 4.5, 3.0, and 0.5%) were used for paneer preparation and according to hedonic scale and proximate analysis, paneer prepared from milk with initial 3.0% fat was acceptable with good hedonic points.

Various researchers have also prepared dairy products, including shrikhand using milk fat from buffalo, goat, cow, etc., and the use of milk fat up to 6% has been reported [13]. But apart from being expensive, the increased milk fat had no significant effect on acidity and pH of the final product. Therefore, considering the health benefits and sensory scores, the optimum milk fat level of 1.5% to prepare low fat shrikhand in this study seems to be appropriate.

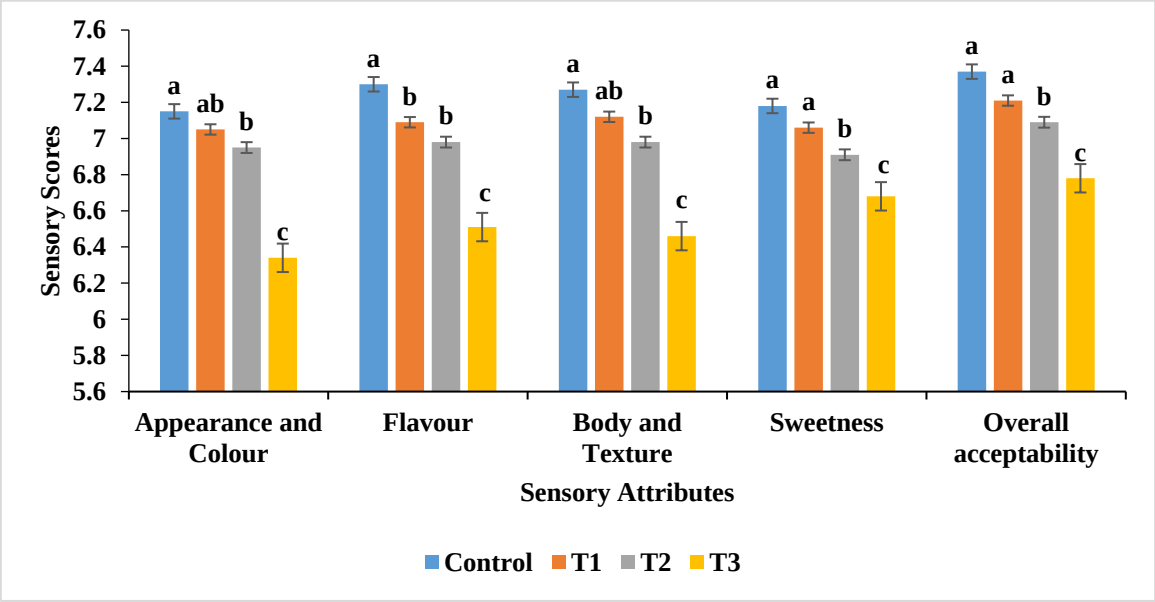

Figure 1. Sensory attributes of shrikhand prepared from cow milk with different fat levels; Mean with different superscripts differ significantly ($p < 0.05$); n = 18 for each treatment; Control: 4.5% fat milk; T1:3% fat milk; T2:1.5% fat milk; T3:0.5% fat milk.

3.3. Optimization of stevia level in chakka to prepare low calorie shrikhand

To optimize the level of stevia powder to prepare low sugar shrikhand, different versions of shrikhand were prepared by replacing the sugar with stevia at three different levels *viz*. 40, 60, and 80% and subjected to sensory evaluation. Mean sensory scores of shrikhand with different levels of stevia powder are given in Figure 2. It was observed that the scores for important sensory attributes such as appearance and color, flavor, body and texture, sweetness, and overall acceptability were the highest for control (C) and decreased with increasing stevia levels. The product with 80% stevia (T3) showed significantly ($p < 0.05$) lower sensory scores. Significant differences ($p < 0.05$) in flavor and sweetness scores were observed in control and 40 % stevia (T1), while all other sensory parameters showed non-

significant ($p > 0.05$) differences. Although, the scores were significantly ($p < 0.05$) lower for T2 and T3 with stevia levels 60% and 80% respectively as compared to control, the scores of T1 and T2 were comparable and above very good category. Hence, based on sensory scores and considering the effect of sugar on human health, the optimum level of stevia was adjudged as 60% to prepare the low fat, low sugar shrikhand.

Several researchers have used stevia as a sweetener to replace sugar in kesar peda [30], milk shake [31] and chocolate milk [32]. Replacing sugar in dietetic kulfi, Giri et al. [6] observed a decrease in the sensory perception with increasing the level of stevia. Replacing >50% sugar with stevia resulted in bitterness, lack of brownish appearance and presence of icy texture in dietetic kulfi. Likewise, the sensory attributes were the best scored, when sucrose and stevia were added (1:1) in strawberry flavored yoghurt [33] suggesting that up to 50% sucrose replacements with stevia were more acceptable by the consumers.

Similarly, in an experiment conducted by Tondare and Hembade [15], sensory properties of amrakhand samples with sucrose and stevia leaf extract powder in the ratio of 30:70 was found to be better than control with 100:0 sucrose and stevia leaf powder. In an experiment conducted by Alizadeh [31], where five different treatments of fruit milk shakes were prepared with sucrose/stevia in the ratios of 100:0, 75:25, 50:50, 25:75, and 0:100, the recommended ratio of sucrose/stevia in beverage was 25:75. From these findings, it can be concluded that stevia is a good choice to develop low sucrose dairy products for health-conscious people. Our study suggests that 60% sugar replacement with stevia level had no adverse impact on sensorial acceptance of the product.

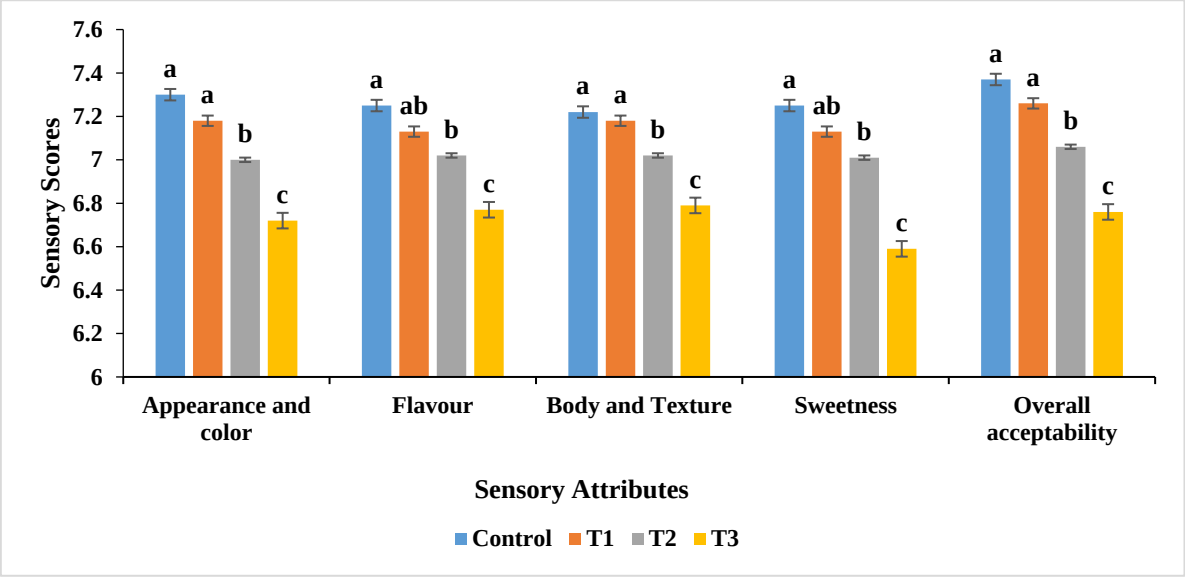

Figure 2. Sensory attributes of shrikhand prepared from cow milk by replacing sugar with different levels of stevia; Mean with different superscripts differ significantly ($p < 0.05$); n = 18 for each treatment; Control: 100% sugar; T1: 40% sugar replacement with stevia; T2: 60% sugar replacement with stevia; T3: 80% sugar replacement with stevia.

3.4. Optimization of the level of carrot pulp for the preparation of functional shrikhand

This study was conducted to optimize the level of incorporation of carrot pulp for the preparation

of shrikhand by replacing chakka at three different levels (10, 20, and 30%). Mean sensory scores of shrikhand with different levels of carrot pulp are presented in Figure 3. No significant difference ($p > 0.05$) was observed among the appearance and color scores of the control (C) and product with 20% carrot pulp (T2). Although no significant ($p > 0.05$) difference was observed among the treatment product with 30% carrot pulp (T3) and product with 10% carrot pulp (T2), but T3 in comparison showed the lowest mean appearance and color score.

The mean scores for the flavor of T2 were significantly ($p < 0.05$) higher compared to the control and other treatments, whereas. the flavor score of control t and product with 10% carrot pulp (T1) had no significant difference ($p > 0.05$). The treatment product with 30% carrot pulp (T3) showed significantly ($p < 0.05$) lower mean scores for flavor and this may be attributed to high level of carrot pulp that masked the original flavor of the product. Likewise, the mean scores for body and texture of shrikhand with 10% carrot pulp (T1) was comparable to that of the control (C) and 20% carrot pulp (T2). On the other hand, the product with 30% carrot pulp (T3) showed significantly lower ($p < 0.05$) mean scores for the body and texture. In a study, Kumar et al. [34] have also reported a decrease in texture of shrikhand with increased levels of apple pulp.

The mean scores for sweetness of shrikhand treatment product with 10% and 20% carrot pulp were comparable to that of the control product, whereas the treatment product with 30% carrot pulp (T3) showed significantly lower ($p < 0.05$) scores for sweetness. The results of this study are in agreement with the findings of El-Said et al. [35], as the workers also reported a decreased sweetness score in stirred yoghurt, when pomegranate peel extracts were added at the highest level (35%).

Mean scores for the overall acceptability of product showed no significant difference ($p < 0.05$) between control and treatment product with 20% carrot pulp, but there was significant difference ($p < 0.05$) among the treatment products. Furthermore, the mean scores for the treatment product with 30% carrot pulp showed significantly lower ($p < 0.05$) overall acceptability scores. Hence, based on sensory scores, the optimum level of replacement of chakka with carrot pulp was judged to be 20%.

Several reports are available on blending of fruit or vegetable pulps in the preparation of dairy products. Excellent quality carrot-yoghurt could be prepared by blending milk in different proportions with 5–20% carrot juice before fermentation [36]. Nigam et al. [37] conducted a study to prepare shrikhand by incorporating papaya pulp at 20, 40, and 60% replacing chakka to increase the nutritional quality and overall acceptability. According to the researchers, shrikhand prepared with 20% level of papaya pulp was the most acceptable. In a similar line of study, Suryawanshi et al. [14] blended 10, 20, and 30% papaya pulp in probiotic shrikhand and the most acceptable sensory scores were obtained with 20% papaya pulp incorporated shrikhand. Studying the development of shrikhand incorporated with kiwi (*Actinidia deliciosa*) pulp, Kedaree et al. [38] concluded that shrikhand blended with 15% kiwi pulp had better overall acceptability than the other treatments. Development of functional shrikhand incorporating aqueous extracts (20%) of orange fruit peels had a better sensory evaluation report compared to the control [39]. The overall acceptability of shrikhand blended with 20% unripe banana pulp was better on the basis of sensory score as compared to other treatments and control [40]. Assessing the incorporation of various levels of custard apple pulp, Kamble [13] concluded that shrikhand prepared with 10% custard apple pulp had improved sensory attributes compared to others.

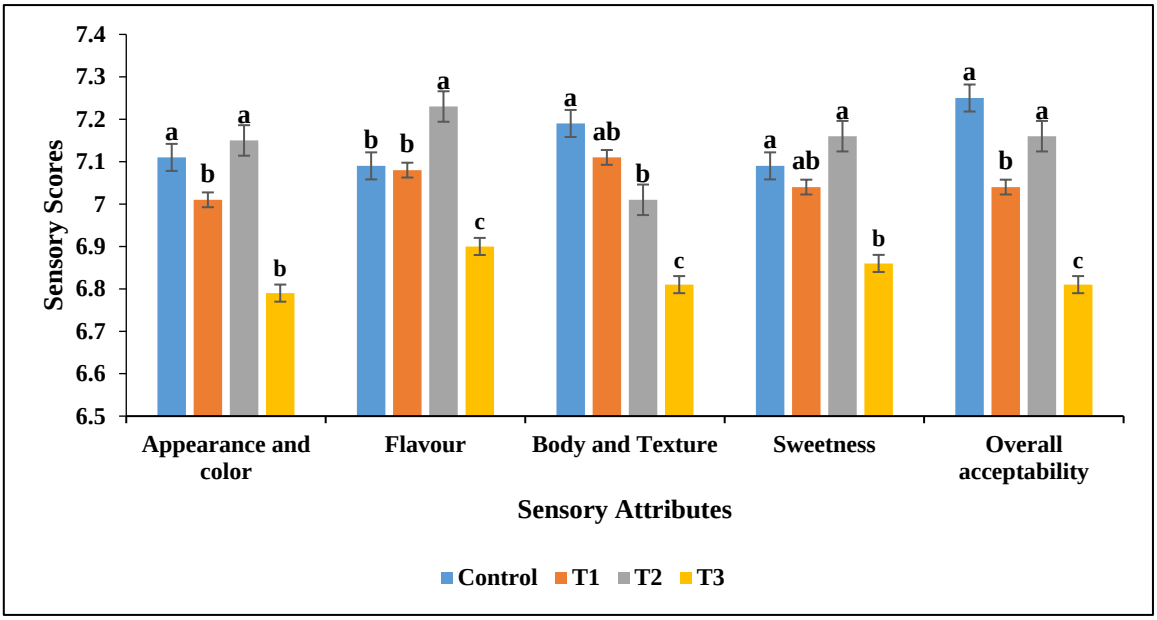

Figure 3. Sensory attributes of shrikhand prepared by incorporating carrot pulp at different levels replacing the chakka; Mean with different superscripts differ significantly ($p < 0.05$); n = 18 for each treatment; Control: 100% chakka; T1: with 10% carrot pulp; T2: with 20% carrot pulp; T3: with 30% carrot pulp.

Development of goat milk shrikhand incorporated with 25 % apple fruit pulp improved the texture and overall acceptability scores compared to other treatments [12]. However, Joshna et al. [41] recorded increased scores of all sensory attributes and the highest acceptability of fruit based chakka desserts incorporated with 70 % sweetened fruit pulp of fig, star fruit, or blueberry over 30 or 50%. From this, it can be deduced that the level of incorporation of pulp in different desserts depends on the intensity of fruit or vegetable flavor and overall sensory acceptability of the end product.

3.5. Determination of storage quality and shelf life of carrot pulp incorporated functional shrikhand:

The storage quality of shrikhand with optimum level of carrot pulp (T-20%) was evaluated in terms of physico-chemical, microbiological and sensory characteristics, and compared with control (C). Both the products (C and T) were packed in PET jars and analyzed every three days, for nine days during storage at refrigerated temperature (4 ± 1 °C).

3.5.1. Physico-chemical properties

The changes in physico-chemical characteristics of the control and product with optimum level of carrot pulp (20%) were evaluated over the period of storage and are presented in Table 2.

Table 2. Effect of refrigerated storage (4 ± 1 °C) on physico-chemical properties of control and selected product packed in PET jar*.

Refrigerated storage period (Days)				
pH				
Treatment	0day	3rd day	6th day	9th day
C	4.23 ± 0.005^{aB}	4.16 ± 0.006^{Bb}	4.11 ± 0.006^{cB}	4.07 ± 0.003^{dB}
T	4.28 ± 0.003^{aA}	4.19 ± 0.007^{Ba}	4.15 ± 0.008^{cA}	4.10 ± 0.004^{dA}
Water activity (a_w)				
C	0.963 ± 0.007^{dB}	0.971 ± 0.007^{cB}	0.977 ± 0.006^{bB}	0.982 ± 0.007^{aB}
T	0.973 ± 0.004^{dA}	0.982 ± 0.007^{cA}	0.987 ± 0.003^{bA}	0.991 ± 0.004^{aA}
TBARS value (mg malonaldehyde/kg)				
C	0.387 ± 0.004^{dA}	0.498 ± 0.002^{cA}	0.535 ± 0.001^{bA}	0.582 ± 0.001^{aA}
T	0.384 ± 0.002^{dB}	0.424 ± 0.003^{Cb}	0.445 ± 0.002^{bB}	0.497 ± 0.001^{aB}

*Mean with different superscripts row wise (small letters) and column wise (capital letters) differ significantly ($p < 0.05$); n = 6; Control: 100% chakka; T: with 20% carrot pulp

pH

The average pH of control and treatment product indicated a decreasing trend from 0 day to 9th day of storage period (Table 2). However, the pH value of shrikhand with carrot pulp remained significantly ($p < 0.05$) higher than the control during the entire period of storage. Para et al. [42] also reported a decrease in the pH of shrikhand during storage. The lowering of pH might have been due to lipolysis that leads to fatty acid release during storage. Furthermore, the acidic nature of the ingredients used might have contributed to the increase in pH level.

Water activity

The mean value for water activity (a_w) in both the products showed a gradual increasing trend with a significant increase ($p < 0.05$) from 3rd day to 9th day of storage (Table 2). The a_w of the control product remained significantly lower ($p < 0.05$) than treatment product throughout the storage period. This may be due to the high moisture content of carrot pulp in shrikhand in comparison to chakka that increased the moisture content of treatment product.

TBARS value

The TBARS values were evaluated to assess lipid oxidation in control (C) and treatment product with 20 % carrot pulp (T). The mean TBARS value of control and treatment products indicated an increasing trend. The increase in TBARS value on storage might be attributed to increased lipid oxidation and production of volatile metabolites during storage. However, the TBARS value of treated shrikhand was significantly ($p < 0.05$) lower than control samples during storage study, which may be due to antioxidant effect of carrot pulp. In a study by Kumar et al. [34], an increase in TBARS value of shrikhand was also observed, but the increase was lower in treatment product incorporated with apple pulp, which was attributed to antioxidant effect of apple pulp.

3.5.2. Microbiological quality

The microbiological quality (total plate count, psychrophilic count, coliform count, yeast and mold count) for control and carrot pulp incorporated shrikhand was analyzed on 0, 3rd, 6th, and 9th day of storage at refrigerated temperature (4 ± 1 °C) and the mean ± SE values are presented in Table 3.

Table 3. Effect of refrigerated storage (4 ± 1 °C) on microbiological quality of control and selected product packed in PET jar*.

Refrigerated storage period (Days)				
Total plate count (X 10^4 cfu/g)				
Treatment	0 day	3rd day	6th day	9th day
C	2.06 ± 0.16^{d}	2.42 ± 0.07^{c}	2.85 ± 0.04^{bA}	3.16 ± 0.02^{aA}
T	2.05 ± 0.15^{d}	2.40 ± 0.05^{c}	2.81 ± 0.07^{bB}	3.08 ± 0.03^{aB}
Psychrophilic count ($\log_{10}$ cfu/g)				
C	ND	ND	ND	1.96 ± 0.01^{b}
T	ND	ND	ND	1.92 ± 0.02^{b}
Coliform count ($\log_{10}$ cfu/g)				
C	ND	ND	ND	1.008 ± 0.02^{a}
T	ND	ND	ND	1.005 ± 0.02^{a}
Yeast & mold count ($\log_{10}$ cfu/g)				
C	ND	ND	ND	0.793 ± 0.03^{a}
T	ND	ND	ND	0.791 ± 0.03^{a}

*Mean with different superscripts row wise (small letters) and column wise (capital letters) differ significantly ($p < 0.05$); n = 6; Control: 100% chakka; T: with 20% carrot pulp.

Total plate count

The total plate count followed a gradual increasing trend in the treatment product as well as the control, with an increase in storage period. The TPC of the control and treatment product were comparable until the 3rd day of storage, but control showed significantly ($p < 0.05$) higher TPC compared to the treatment product from 6th day onwards.

Similar increase in mean values of TPC with increase in days of storage under refrigeration have been reported by different workers in shrikhand prepared by incorporating apple pulp [34] and kiwi pulp [11] and also dietetic Kashmiri saffron phirne prepared from reconstituted skim milk [43].

Psychrophilic count

The psychrophiles were not detected up to the 6th day of storage in the control and the treatment product. It may be attributed to retardation of the log phase, because of reduced metabolic rate due to sudden change in the physical environment. On the 9th day of storage, although psychrophiles were detected, there was no significant difference ($p < 0.05$) in counts between the control and treatment products. Absence of psychrophiles in fresh samples and its consistent increase with increase in days of storage aligns with the reports in various dairy products such as paneer [19], milk nuggets [44],

dietetic Kashmiri saffron phirne prepared from reconstituted skim milk [43], and shrikhand prepared by incorporating apple pulp [34].

Coliform count

Coliforms were not detected up to the 6th day of storage in the control and treatment product. However, they were detected on the 9th day of storage. It might be due to thermal injury to the bacterial cells during the boiling of the milk before preparation of the product and the fact that some injured bacterial cells might have rejuvenated after lag phase and then entered active multiplication phase. A similar finding was reported by Kumar et al. [34] that coliform was not detected in apple pulp incorporated shrikhand during the entire period of storage. Bhat et al. [43] also reported zero coliform in Kashmiri saffron phirne during refrigerated storage. Das et al. [19] and Buch et al. [45] also observed no coliform in paneer treated with different natural preservatives during refrigerated storage.

Yeast and mold count

Yeast and mold were not detected up to the 6th day of storage in the control and treatment product. Although detected on the 9th day of storage, no significant difference ($p < 0.05$) was found between the yeast and mold counts of the control and treatment product. Thakur et al. [46] reported yeast and mold count in fruit fortified shrikhand with different levels of mango pulp in the range of 0.93–1.3l cfu/g. A similar finding was also reported by Kahate et al.[40] that there was a significantly ($p < 0.05$) increasing yeast and mold count observed in unripe banana incorporated shrikhand during storage period.

3.5.3. Sensory attributes

The mean sensory scores of shrikhand incorporated with 20% carrot pulp (T) and the control (C) during storage are presented in Table 4. The mean score for appearance and color showed a significantly ($p < 0.05$) decreasing trend with increasing storage days for both the control and product with 20% carrot pulp. However, the score of the treatment product was significantly ($p < 0.05$) higher than the control product on all the days of storage. Likewise, the mean score of flavor for the control and treatment product, although decreasing over the storage period, was significantly ($p < 0.05$) higher for the treatment product than control. This may be due to characteristic flavor imparted by carrot pulp incorporation in shrikhand.

The mean score for body and texture of the control and treatment product showed a gradual and significant ($p < 0.05$) decreasing trend with increase in storage days, but the control product had higher body and texture scores. Although non-significant ($p > 0.05$), the decrease in the texture score of treated products could be due to an increase in moisture content of shrikhand with optimum level of carrot pulp.

The mean score of sweetness for control and treatment product on 0 day of storage had no significant difference ($p > 0.05$). However, the control and treatment product showed highly significant difference ($p < 0.05$) from the 3rd day onwards. The mean scores for sweetness of the control and treatment product showed significantly ($p < 0.05$) decreasing trends with increase in storage days.

Mean scores for overall acceptability of the control and treatment product showed a gradual and

significant ($p < 0.05$) decreasing trend throughout the storage days. The mean scores for overall acceptability of the control and treatment product showed no significant ($p > 0.05$) difference up to the 3rd day of storage, and after that it was significantly ($p > 0.05$) higher for the treatment product.

Das et al. [19], Nigam et al. [37], and Bhat et al. [43] also reported similar declines in the sensory parameters of various dairy products during refrigerated storage. Patel et al. [47] reported that overall acceptability of chakka decreased with an increase in storage period due to deterioration of flavor. Likewise, Joshna et al. [41] recorded sensory attributes of fruit based chakka desserts within the acceptable range during storage study for about 10 days at 5 °C. From our study, it can be concluded that shrikhand prepared with 1.5% fat milk and stevia as 60% replacement of sugar and incorporated with 20% carrot pulp may be stored up to 9 days under refrigeration without marked changes in the quality.

Table 4. Sensory quality of control and selected product packed in PET jar and stored at refrigerated storage (4 ± 1 °C)*.

Refrigerated storage period (Days)				
Appearance and color				
Treatment	0 day	3rd day	6th day	9th day
C	7.13 ± 0.03^{Ab}	6.93 ± 0.04^{bB}	6.54 ± 0.03^{cB}	6.05 ± 0.02^{dB}
T	7.21 ± 0.03^{aA}	7.01 ± 0.01^{bA}	6.68 ± 0.02^{A}	6.34 ± 0.02^{dA}
Flavor				
C	7.02 ± 0.02^{aB}	6.86 ± 0.05^{bB}	6.36 ± 0.04^{cB}	6.02 ± 0.01^{dB}
T	7.10 ± 0.02^{aA}	6.94 ± 0.04^{bA}	6.61 ± 0.03^{cA}	6.20 ± 0.03^{dA}
Body and texture				
C	7.11 ± 0.03^{aA}	6.91 ± 0.04^{bA}	6.66 ± 0.03^{cA}	6.45 ± 0.05^{dA}
T	7.04 ± 0.05^{aB}	6.88 ± 0.07^{bB}	6.54 ± 0.08^{cB}	6.30 ± 0.09^{dB}
Sweetness				
C	7.05 ± 0.02^{aA}	6.94 ± 0.02^{bB}	6.79 ± 0.04^{cB}	6.38 ± 0.03^{dB}
T	7.09 ± 0.03^{aA}	7.01 ± 0.03^{aA}	6.84 ± 0.03^{bA}	6.58 ± 0.02^{cA}
Overall acceptability				
C	6.97 ± 0.04^{aA}	6.87 ± 0.04^{bA}	6.57 ± 0.03^{cB}	6.19 ± 0.03^{bB}
T	7.1 ± 0.04^{aA}	6.91 ± 0.03^{bA}	6.65 ± 0.02^{cA}	6.23 ± 0.03^{dA}

*Mean with different superscripts row wise (small letters) and column wise (capital letters) differ significantly ($p < 0.05$); n = 6; Control: 100% chakka; T1: with 20% carrot pulp.

4. Conclusions

Considering the demand for low fat and low sugar traditional dairy foods, the present investigation was undertaken to standardize the technology for the production of low fat and low sugar shrikhand. Based on sensory scores, 1.5% fat milk was judged to be optimum. Furthermore, sugar in shrikhand with an optimum level of milk fat was replaced with different levels of stevia powder, and 60% replacement of sugar with stevia was judged to be the optimum. Shrikhand prepared with 1.5% fat milk and 60% sugar replacement with stevia was incorporated with different levels of carrot pulp separately, replacing the chakka, and 20% incorporation level was found to be optimum for each separately. The control and the treatment products with 20% carrot pulp were evaluated for various

physico-chemical, sensory, and microbial characteristics. Sensory evaluation revealed that mean scores for color,appearance and overall acceptability were significantly higher in carrot pulp blended shrikhand. Furthermore, microbiological quality parameters were within permissible limits for both the products. From this study, it can be concluded that the developed shrikhand can be stored at refrigerated storage temperature for 9 days without marked change in the quality, but shrikhand with 20% carrot pulp may be preferred because of the value addition it offers, enhancing functional properties and acceptability of the product.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of interest

All authors declare no conflicts of interest in this paper.

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