



Effect of storage conditions on sensory profile of soy-fortified shrikhand[#]

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Abstract

The enrichment of traditional dairy-based desserts such as shrikhand with soy protein represents a viable strategy for enhancing nutritional quality. Despite this potential, limited attention has been directed towards the influence of storage on the sensory profile of such fortified products. The present study systematically evaluated the temporal variations in sensory attributes of soy-fortified shrikhand during refrigerated storage. Experimental samples were prepared with 24.5% soy milk (SS) and compared against a control (CS), both stored at 4 ± 1 °C. Sensory evaluation was conducted at intervals of 0, 7, 14, 21, and 28 days by a trained panel, focusing on colour and appearance, flavour, texture, sweetness and overall acceptability of the product. Statistical analysis was performed using SAS software to determine significant changes over time. Results indicated that scores for colour and appearance were significantly higher ($P < 0.05$) in control samples across all storage intervals. Flavour scores for both variants declined significantly ($P < 0.05$) with prolonged storage, with intergroup differences becoming significant after 21 days. Texture scores for soy-fortified shrikhand remained superior for the control sample throughout the storage period. However, sweetness and overall acceptability ratings of the fortified product were significantly lower than those of the control.

Keywords: soy milk, shrikhand, sensory evaluation, soy fortification

India continues to be one of the largest global producers of milk, with sustained growth in its dairy sector over recent decades. According to the National Dairy Development Board (NDDB), national milk production reached 239.3 million tonnes in the fiscal year 2023–24. Fermented dairy products account for nearly 7% of the total milk utilized in India and primarily include dahi (curd), shrikhand (sweetened concentrated curd), and lassi (stirred curd), which resemble yogurt, quark, and stirred yogurt in Western markets (Sarkar, 2008; Singh & Singh, 2014).

Soy milk provides an economical and abundant alternative to bovine milk (Singh et al., 2016). It is naturally free from cholesterol and lactose and contains isoflavone phytoestrogens that are reported to possess anti-carcinogenic

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potential (Wolfe et al., 2003; Kumar et al., 2014). Consequently, soy-based products are suitable for individuals with lactose intolerance, milk protein allergies, or those following plant-based dietary practices (Božanić et al., 2011; Singh et al., 2014). The growing base of health conscious-consumers in India is increasingly turning towards functional foods, thereby encouraging the incorporation of bioactive ingredients into traditional dairy products through technological innovation (Snigdha et al., 2023). Regular consumption of 25 g of soy protein per day, when combined with a diet low in saturated fat, has been associated with a reduced risk of cardiovascular diseases (Verma et al., 2013).

Shrikhand, a popular Indian dessert characterized by its creamy texture and mildly sour-sweet flavour, is widely consumed in western India and prepared from lactic-fermented curd (Singh et al., 2016; Singh et al., 2018). Incorporating soy milk into *shrikhand* presents an innovative means of improving its nutritional profile while necessitating a comprehensive evaluation of its sensory properties. Sensory evaluation during storage plays a critical role in ensuring product quality, consumer acceptability and competitiveness in the dairy industry. Against this backdrop, the present study investigated the sensory changes in soy-fortified *shrikhand* during refrigerated storage (4 ± 1 °C), with emphasis on flavour, colour and appearance, texture, sweetness and overall acceptability.

Materials and Methods

Study location

The present investigation was carried out at the Department of Animal Husbandry and Dairying, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India.

Raw materials

Starter cultures of *Lactobacillus delbrueckii* ssp. *bulgaricus* (NCDC 009) and *Streptococcus thermophilus* (NCDC 074) were procured from the National Collection of Dairy Cultures (NCDC), Dairy Microbiology Division, ICAR-NDRI, Karnal, Haryana, India. Cow milk and other required materials were obtained from the facilities of the Department of Animal Husbandry & Dairying, Banaras Hindu University.

Preparation of soy milk and soy-fortified *shrikhand*

Soy milk and soy-fortified *shrikhand* were produced following the procedures outlined by Singh et al. (2014) and Singh and Rashmi (2024). Control *shrikhand* (CS) was standardized to 4.5% fat and 8.5% SNF by using cow milk, skim milk powder (96.5% TS) and fresh cream (30% Fat and 5% SNF). Milk was heated at 85°C for 30 minutes. It was then cooled down at 37 ± 1 °C and inoculated

by the starter culture (*Lactobacillus delbrueckii* subsp. *bulgaricus* NCDC 009 and *Streptococcus thermophilus* NCDC 074) at the rate of 3.0% and incubated at 37°C up to a desired acidity of 0.90% lactic acid. Coagulum was then crushed and was transferred to a muslin cloth and hanged till complete drainage of whey. The semi solid mass left after drainage of whey is called *chakka*; the base for *shrikhand*. Cane sugar was added at the level of 30% by the weight of *chakka*. The mixture was well kneaded for uniform mixing and *shrikhand* prepared.

Soy fortified *shrikhand* (SS) was standardized to 4.5% fat and 8.5% SNF by using soymilk at the rate of 24.5% with cow milk, skim milk powder (96.5% TS) and fresh cream (30% fat and 5% SNF). The next steps are same as given in manufacturing of control *shrikhand*.

Sensory evaluation

An expert panel of ten semi-trained judges (seven males and three females) from the Department of Animal Husbandry and Dairying along with the Centre of Food Science and Technology, I. Ag. Sc., Banaras Hindu University, participated in sensory analysis. Samples were coded with three-digit random numbers and presented in closed containers. Each panellist evaluated three samples per treatment under controlled laboratory conditions (25 °C, 60% relative humidity). To minimize bias, panellists received prior orientation on evaluation procedures.

Sensory attributes assessed included colour and appearance, flavour, texture, sweetness, and overall acceptability by using a nine-point hedonic scale (1 = dislike extremely, 9 = like extremely), as described by Amerine et al. (1965).

Statistical analysis

Data obtained from sensory evaluation was analysed using the SAS statistical software package (Version 9.1; SAS Institute Inc., Cary, NC, 2006). Treatment means were compared using Duncan's Multiple Range Test (Montgomery, 1997) to determine statistical significance.

Results and discussion

Effect of storage on colour and appearance

The colour and appearance scores of *shrikhand* ranged from 8.46 ± 0.0058 to 8.25 ± 0.0058 in soy-fortified samples (SS), and from 8.81 ± 0.0033 to 8.41 ± 0.0033 in control samples (CS) (Table 1; Fig. 1). Results clearly indicated that CS consistently exhibited significantly higher ($p < 0.05$) colour and appearance scores compared to SS across all storage intervals. Both treatments demonstrated a progressive decrease ($p < 0.05$) in colour and appearance during extended storage, likely due to microbial activity contributing to spoilage. These findings are similar with Kumar et al. (2011), who reported significant reductions

Table 1. Effect of storage on sensory attributes of soy fortified *shrikhand* (SS) and control *shrikhand* (CS) samples

Storage	Colour & Appearance		Flavour		Texture		Sweetness		Overall Acceptability	
	SS	CS	SS	CS	SS	CS	SS	CS	SS	CS
0 Day	8.46±0.0058 ^a	8.81±0.0033 ^a	8.45±0.0058 ^{aA}	8.75±0.0033 ^a	7.60±0 ^{aA}	7.58±0.0033 ^{abAB}	8.75±0.0058 ^{aA}	8.77±0.0058 ^{aA}	8.30±0 ^{aA}	8.76±0.0033 ^a
7 th Day	8.41±0.0058 ^b	8.72±0.0033 ^b	8.14±0.0088 ^b	8.36±0.0033 ^{bA}	7.59±0.0033 ^{bA}	7.56±0.0033 ^{bb}	8.14±0.019 ^{bb}	8.22±0.0088 ^b	8.033±0.033 ^b	8.41±0.0058 ^b
14 th Day	8.36±0.0058 ^c	8.68±0.0033 ^c	7.62±0.013 ^{cb}	7.97±0.0067 ^c	7.58±0 ^{abAB}	7.42±0.0033 ^c	7.70±0.052 ^c	8.16±0.0088 ^{cb}	7.80±0.012 ^c	8.26±0.0088 ^{aA}
21 st Day	8.31±0.0058 ^d	8.59±0.0033 ^d	6.90±0.058 ^d	7.63±0.0067 ^{db}	7.11±0.0067 ^{bc}	7.10±0 ^{dc}	6.43±0.012 ^d	7.20±0.0033 ^d	7.57±0.010 ^{db}	7.53±0.019 ^{db}
28 th Day	8.25±0.0058 ^e	8.41±0.0033 ^e	4.97±0.067 ^e	6.43±0.067 ^e	6.83±0.033 ^c	6.80±0 ^e	5.24±0.015 ^e	6.02±0.020 ^e	7.25±0.0058 ^e	7.30±0.0033 ^e

Values bearing different small superscripts (a, b, c) in a column differ significantly (Duncan test, P<0.05)

Values bearing different capital superscripts (A, B, C) in between column differ significantly (Duncan test, P<0.05)

CS=Control *shrikhand* samples,

SS= Soy fortified *shrikhand* samples (optimised level)

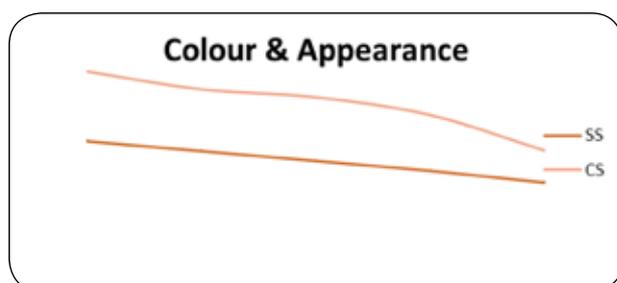


Fig. 1. Changes in colour and appearance score of *shrikhand* during storage

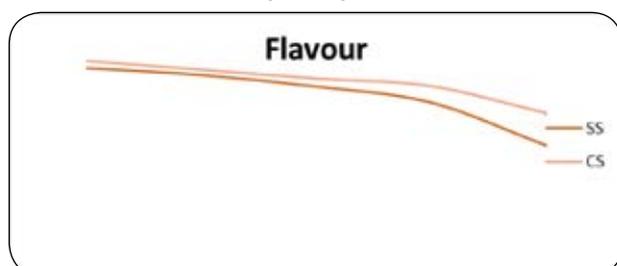


Fig. 2. Changes in flavour score of *shrikhand* during storage

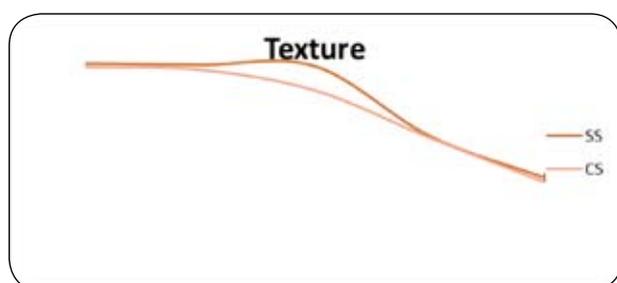


Fig. 3. Changes in texture score of *shrikhand* during storage

in colour scores of *shrikhand* fortified with apple pulp and *Celosia argentea*. Similarly, Nigam et al. (2009) observed comparable trends when papaya pulp was incorporated into *shrikhand*.

Effect of storage on flavour

Flavour, encompassing both taste and aroma, is a critical determinant of consumer acceptance. As shown

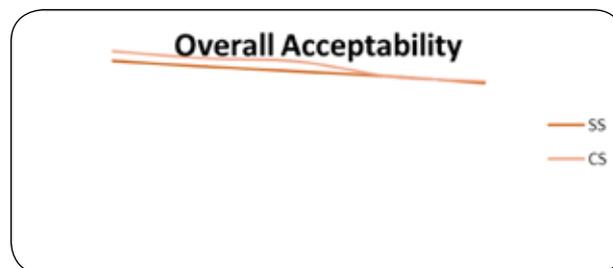


Fig. 4. Changes in sweetness score of *shrikhand* during storage

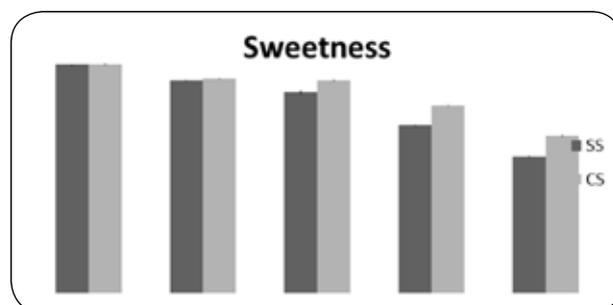


Fig. 5. Changes in overall acceptability score of *shrikhand* during storage

in Fig. 2, flavour scores for both SS and CS declined significantly ($p<0.05$) with increasing storage duration. Up to the 21st day, differences between treatments were not statistically significant; however, beyond this point, CS outperformed SS significantly ($p<0.05$).

The decline in flavour scores over time may be attributed to spoilage microorganisms, which elevate acidity and impart bitterness. At 28 days, SS samples were deemed unacceptable in terms of flavour, likely due to the inherent bitterness associated with soy milk. Comparable decreases in flavour during storage have been documented in *shrikhand* fortified with papaya pulp (Nigam et al., 2009) and with apple pulp and *Celosia argentea* (Kumar et al., 2011).

Effect of storage on texture

The texture scores of SS ranged between 7.60 ± 0.0000 and 6.83 ± 0.033 , while CS scores varied from

7.58 ± 0.0033 to 6.80 ± 0.0000 (Table 1; Fig. 3). Texture deterioration was significant ($P < 0.05$) after the 14th day in SS and after the 7th day in CS. Despite these declines, SS consistently maintained superior texture scores compared to CS throughout storage. This difference may be explained by a lower moisture content in SS, which contributed to better firmness. Supporting evidence is provided by Nigam et al. (2009), who noted declining texture scores in papaya-enriched *shrikhand*, and by Kumar et al. (2011), who observed similar reductions with apple pulp and *Celosia argentea* additions.

Effect of storage on sweetness

Sweetness scores declined significantly ($P < 0.05$) with storage time in both treatments, ranging from 8.75 ± 0.0058 to 5.24 ± 0.015 in SS and from 8.77 ± 0.0058 to 6.02 ± 0.020 in CS (Table 1; Fig. 4). Differences between treatments were non-significant at the 7th day (SS) and 14th day (CS), but CS consistently recorded higher sweetness scores thereafter. The lower sweetness in SS is likely attributable to the absence of natural sweetening components in soy milk and enhanced microbial activity during storage. Similar outcomes have been reported by Nigam et al. (2009), Kumar et al. (2011), and Sonawane et al. (2007) in fortified *shrikhand* formulations.

Effect of storage on overall acceptability

Overall acceptability scores, which integrate all sensory parameters, declined significantly ($P < 0.05$) with storage duration in both treatments. SS scores ranged from 8.30 ± 0.0000 to 7.25 ± 0.0058, whereas CS ranged from 8.76 ± 0.0033 to 7.30 ± 0.0033 (Table 1; Fig. 5). At day 0 and day 14, differences between treatments were not significant ($p > 0.05$). However, at later intervals, CS maintained significantly higher ($p < 0.05$) acceptability compared to SS, except on the 21st day, when no significant difference was observed.

The decline in overall acceptability is most likely due to microbial activity and associated spoilage during prolonged storage. Patel et al. (1993) similarly reported reductions in acceptability of *chakka* during storage, primarily due to flavour deterioration. Comparable trends have also been noted by Verma (2013), Kumar et al. (2011), Nigam et al. (2009) and Sonawane et al. (2007), reinforcing that extended refrigerated storage adversely affects the sensory properties of dairy products.

Conclusion

The present study evaluated how refrigerated storage (4 ± 1 °C) influenced the sensory profile of control (CS) and soy-fortified (SS) *shrikhand* over a 28-day period. Storage duration had a significant effect ($P < 0.05$) on all assessed sensory attributes in both CS and SS. At all storage intervals, the control *shrikhand* consistently maintained higher colour and appearance scores (8.81 ±

0.0033 to 8.41 ± 0.0033) than the soy-fortified variant (8.46 ± 0.0058 to 8.25 ± 0.0058). Over time, flavour decreased in both treatments, with statistically significant divergence observed after day 21; by day 28, the soy-fortified *shrikhand* was judged unacceptable. Texture scores were higher in SS throughout storage, yet both treatments experienced significant declines - by day 14 in SS and as early as day 7 in CS. Sweetness decreased gradually for both, though CS maintained higher perceived sweetness from day 7 onward. Overall acceptability declined steadily over storage, with the control formulation consistently rated superior to the soy-fortified version, except on day 21. Based on the sensory data, the acceptable shelf life under the tested refrigerated conditions appears to be 21 days for soy-fortified *shrikhand* and 28 days for control *shrikhand*.

These findings demonstrate that while soy-fortified *shrikhand* can be stored under refrigeration with acceptable sensory quality for up to three weeks, soy incorporation adversely affects certain sensory attributes, particularly flavour, colour/appearance, and overall acceptability, over extended storage. Future studies should explore adjustments in formulation (e.g., level of soy substitution, flavour masking, natural stabilizers) to improve the sensory stability of soy-fortified *shrikhand* and potentially extend its shelf life.

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Conflict of Interest

The authors declare that no conflicts of interest are related to this study.

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