



ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2025): 4.97
IJAFS 2025; 7(12): 282-287
www.agriculturaljournals.com
Received: 03-09-2025
Accepted: 07-10-2025

SS Kahandal
PhD Scholar, Department of
AHDS, PGI, MPKV, Rahuri,
Maharashtra, India

DK Kamble
Professor and Head,
Department of AHDS, PGI,
MPKV, Rahuri, Maharashtra,
India

BD Patil
Associate Professor,
Department of AHDS, PGI,
MPKV, Rahuri, Maharashtra,
India

DD Patange
Associate Professor, Division of
AHDS, RSCM College of
Agriculture, Kolhapur,
Maharashtra, India

PK Lokhande
Associate Professor,
Department of Biochemistry,
MPKV, Rahuri, Maharashtra,
India

MR Patil
Associate Professor,
Department of Statistics,
MPKV, Rahuri, Maharashtra,
India

Corresponding Author:
SS Kahandal
PhD Scholar, Department of
AHDS, PGI, MPKV, Rahuri,
Maharashtra, India

Individual and combined effect of Nisin and Natamycin on sensory attributes Of *Shrikhand*

SS Kahandal, DK Kamble, BD Patil, DD Patange, PK Lokhande and MR Patil

DOI: <https://www.doi.org/10.33545/2664844X.2025.v7.i12d.1054>

Abstract

Sensory evaluation plays a vital role not only in product development but also in determining the shelf life of a product. From the consumers point of view, the sensory status of the product is the primary characteristics based on which the quality of the product is decided. Sensory parameters of biopreservative (nisin and natamycin) treated *shrikhand* samples studied during storage included colour and appearance, body and texture, flavour and overall acceptability. As the storage period progressed, the score for colour and appearance, body and texture, flavour and overall acceptability were decreased. Based on sensory evaluation, *shrikhand* without biopreservatives (T₀) and *shrikhand* treated with natamycin at 10 ppm (T₃) and 15 ppm (T₄) could be stored for 35 days at 5±1 °C. *Shrikhand* treated with nisin at 400 IU/g (T₁) and 500 IU/g (T₂), as well as combinations of nisin and natamycin 400 IU + 10 ppm (T₅), 400 IU + 15 ppm (T₆), 500 IU + 10 ppm (T₇), and 500 IU + 15 ppm (T₈) maintained acceptable quality and could be stored for 42 days at 5±1 °C.

Keywords: Nisin, Natamycin, *Shrikhand*, Sensory evaluation etc

Introduction

Milk is an ideal food consumed by human since ancient times. Practices of converting milk into various milk products have been developed years ago. *Shrikhand* is an indigenous ethnic fermented milk food that assumes special importance due to its pleasant taste. Shelf life is defined as the number of days a product can be stored at a certain temperature and can be consumed safely, without deterioration of sensory characteristics such as taste, colour and texture. The shelf life is therefore determined by organoleptic quality. Biopreservation is defined as the extension of shelf life and enhanced safety of foods by the use of natural or controlled microbiota and/or antimicrobial compounds (Ananou *et al.* 2007) [2]. Nisin is a natural antimicrobial peptide produced by strains of *Lactococcus lactis subsp. lactis* that effectively inhibits Gram-positive bacteria and also the outgrowth of spores of *Bacilli* and *Clostridia*. Additionally, it has been used as a biopreservative and a potential agent in pharmaceutical, veterinary and health care products (Arauz *et al.*, 2009) [3]. Natamycin is a polyene macrolide natural anti-fungal agent produced by fermentation of the bacterium *Streptomyces natalensis*. Natamycin (previously known as pimaricin) has an extremely effective and selective mode of action against a very broad spectrum of common food spoilage yeast and mould, with most strains being inhibited by concentrations of 1 to 15 ppm of natamycin (Hondrodinou *et al.*, 2011) [8].

Materials and Methods

Materials

The fresh, clean whole buffalo milk was procured from local market of Rahuri, Ahmednagar (MS). The freeze-dried culture of LF-40 was procured from National Collection of Dairy culture (NCDC) unit, NDRI, Karnal (Haryana) and used @ 1 per cent of milk for preparation of dahi for every trial. All chemicals required for the analytical work were used of analytical (AR) or guaranteed reagent (GR) grade manufactured by Merk, India Ltd / Glaxo India Ltd. Nisin and Natamycin a biopreservatives were obtained as a complimentary sample from Danisco Ingredients, Danisco India Pvt. Ltd., DLF Corporate Park, Gurgaon, Haryana, India.

Polypropylene cups (100 gm capacity) used for storing and serving of *shrikhand*, were procured from Tarsons Products Pvt. Ltd., Kolkata, India.

Table 1: Treatment detail

Treatment Code	Treatment details
T ₀	Absolute Control
T ₁	Ni 400 IU/g of <i>shrikhand</i>
T ₂	Ni 500 IU/g of <i>shrikhand</i>
T ₃	Na 10 ppm of <i>shrikhand</i>
T ₄	Na 15 ppm of <i>shrikhand</i>
T ₅	Ni 400 IU/g of <i>shrikhand</i> + Na 10 ppm of <i>shrikhand</i>
T ₆	Ni 400 IU/g of <i>shrikhand</i> + Na 15 ppm of <i>shrikhand</i>
T ₇	Ni 500 IU/g of <i>shrikhand</i> + Na 10 ppm of <i>shrikhand</i>
T ₈	Ni 500 IU/g of <i>shrikhand</i> + Na 15 ppm of <i>shrikhand</i>

Ni-Nisin, Na-Natamycin

Preparation of *Shrikhand*

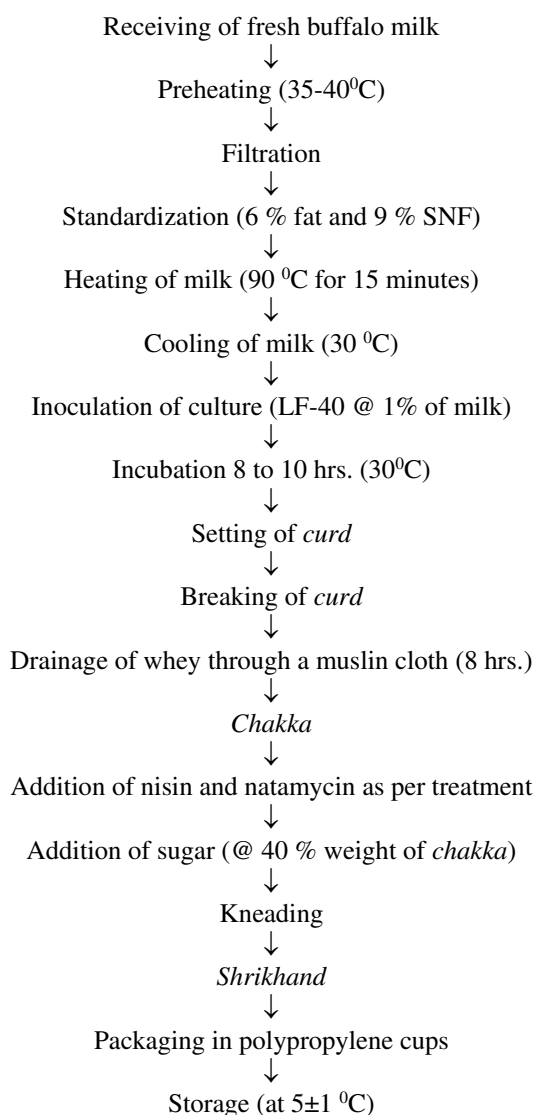


Fig1: Flow diagram for preparation of *shrikhand* added with biopreservative (nisin and natamycin)

Results and Discussion

Individual and Combined Effect of Nisin and Natamycin on Changes in Sensory Attributes of *Shrikhand* During Storage at 5±1 °C

Sensory Evaluation of *Shrikhand*

Sensory evaluation of both fresh and stored control and experimental *shrikhand* samples was carried out by a semi-trained panel of five judges from the Department of Animal Husbandry and Dairy Science. The samples were assessed for colour and appearance, body and texture, flavour, and overall acceptability using a 9-point Hedonic scale according to Amerine *et al.* (1965) ^[1].

Statistical Analysis

Data generated during the course of investigation was analyzed with the help of statistical design namely Factorial Completely Randomized Design (FCRD) as described by Snedecor and Cochran (1967) ^[29].

Colour and appearance

The colour and appearance scores of *shrikhand* stored at 5 ± 1 °C showed a steady decline across all treatments (Table 1), reflecting progressive physicochemical and microbial changes during storage.

The control (T_0) deteriorated most rapidly, with scores dropping from 8.75 on day 0 to 6.02 by day 35, after which the product was considered spoiled. This confirmed that the absence of biopreservatives accelerated microbial growth and pigment degradation.

Table 2: Individual and combined effect of nisin and natamycin on changes in colour and appearance score* of *shrikhand* during storage at 5 ± 1 °C

Treatment	Storage period (Days)							
	0	7	14	21	28	35	42	Mean
T_0	8.75	8.55	8.20	7.73	7.00	6.02	-	7.71 ⁱ
T_1	8.77	8.68	8.52	8.10	7.63	7.08	6.03	7.83 ^c
T_2	8.76	8.63	8.45	8.03	7.55	7.01	6.00	7.78 ^f
T_3	8.75	8.57	8.23	7.75	7.03	6.04	-	7.73 ^g
T_4	8.75	8.56	8.21	7.74	7.01	6.03	-	7.72 ^h
T_5	8.77	8.71	8.59	8.24	7.77	7.18	6.09	7.91 ^a
T_6	8.77	8.68	8.53	8.14	7.67	7.10	6.05	7.85 ^b
T_7	8.76	8.66	8.51	8.08	7.61	7.05	6.03	7.81 ^d
T_8	8.76	8.65	8.49	8.07	7.59	7.04	6.01	7.80 ^e
Mean	8.76 ^a	8.63 ^b	8.41 ^c	7.99 ^d	7.43 ^e	6.73 ^f	6.04 ^g	7.80
Source	S.E.m ($\pm$)				CD at 5 %			
Days (D)	0.003				0.008			
Treatment (T)	0.003				0.009			
D x T	0.009				0.025			

* The average value of four replication

(-) Indicates that the product was spoiled and no further analysis was carried out

Samples treated with nisin alone (T_1 and T_2) retained colour and appearance slightly better than the control, with mean scores of 7.83 and 7.78. Although nisin slowed bacterial spoilage, scores approached 6.00 by day 42, indicating limited protection over longer storage. Treatments containing only natamycin (T_3 and T_4) followed a similar pattern, with mean scores of 7.73 and 7.72, reflecting its stronger action against yeasts and mould than bacteria. A clearer improvement was seen in treatments combining nisin and natamycin (T_5 to T_8). T_5 (nisin 400 IU/g + natamycin 10 ppm) achieved the highest mean score (7.91), followed by T_6 , T_7 and T_8 . The superior retention of visual quality in T_5 suggests a synergistic antimicrobial effect, where nisin controlled bacterial spoilage and natamycin inhibited yeasts and mould, together reducing pigment breakdown and surface discoloration. The moderate concentrations in T_5 also appeared optimal, avoiding potential preservative interactions seen at higher levels. Overall, colour and appearance scores declined significantly ($p < 0.05$) over time, and the combined use of nisin and natamycin, particularly in T_5 , was most effective in maintaining the visual quality of *shrikhand* during refrigerated storage. These findings are consistent with earlier studies showing that nisin and natamycin help retain colour and appearance in a wide range of dairy products during storage. Kamble (2023) [13] reported a steady decline in colour and appearance scores in custard apple *shrikhand*, with slower deterioration in nisin treated samples. Similar improvements in visual quality with nisin have been documented in fermented milk products such as *nono* (Olasupo *et al.*, 1996) [20], salted sorghum *lassi* (Shaikh, 2008) [28], mango *lassi*

(Khurana, 2006) [15] and *lassi* fortified with different nisin levels (Chaure, 2010) [4]. Studies on pasteurized milk (Radha, 2014) [21] and paneer (Kankhare, 2005; Ranmode, 2010; Das, 2017) [14, 23, 6] also confirm that nisin slows sensory degradation by reducing microbial and oxidative changes.

Natamycin has shown comparable effects. Treated *yoghurt* maintained stable appearance scores throughout refrigerated storage (El-Diasty *et al.*, 2009) [7], while *khoa* and cheese exhibited higher score retention due to reduced fungal growth (Vaquil, 2018; Jalilzadeh *et al.*, 2020) [31, 9]. Combined treatments of nisin and natamycin have further strengthened visual quality preservation in processed *cheese* sauces (Saad *et al.*, 2015) [25], strained *yoghurt* (Misirlilar *et al.*, 2012) [2], and Doda *burfi* under MAP conditions (Chawla *et al.*, 2021) [5]. Several researchers have also documented a steady decline in the colour and appearance of control *shrikhand* during storage, confirming the pattern observed in the present study.

Body and texture

The body and texture scores of *shrikhand* stored at 5 ± 1 °C decreased steadily across all treatments (Table 2). This decline reflects moisture migration, whey separation and microbial or biochemical changes that gradually weaken firmness and smoothness during storage. The control (T_0) showed the fastest deterioration, with scores falling from 8.00 on day 0 to 6.03 by day 35, after which the product was spoiled. Nisin treated samples (T_1 and T_2) retained higher scores than the control, with mean values of 7.42 and 7.37. Nisin slowed the activity of Gram-positive bacteria and helped maintain structural stability, although its effect weakened after extended storage. Natamycin-only treatments (T_3 and T_4) showed mean scores of 7.31 and 7.30. These samples benefited from reduced yeast and mould activity but lacked antibacterial protection, making them slightly less effective than the nisin treatments.

Table 3: Individual and combined effect of nisin and natamycin on changes in body and texture score* of *shrikhand* during storage at 5 ± 1 °C

Treatment	Storage Period (Days)							
	0	7	14	21	28	35	42	Mean
T_0	8.00	7.91	7.68	7.30	6.82	6.03	-	7.29 ⁱ
T_1	8.03	8.01	7.89	7.69	7.38	6.95	6.02	7.42 ^c
T_2	8.02	7.98	7.85	7.62	7.29	6.86	6.00	7.37 ^f
T_3	8.00	7.92	7.70	7.31	6.84	6.06	-	7.31 ^g
T_4	8.00	7.91	7.69	7.30	6.83	6.05	-	7.30 ^h
T_5	8.03	8.02	7.98	7.89	7.60	7.14	6.09	7.54 ^a
T_6	8.03	8.00	7.93	7.73	7.42	6.99	6.05	7.45 ^b
T_7	8.02	8.01	7.89	7.65	7.33	6.89	6.02	7.40 ^d
T_8	8.02	8.00	7.87	7.64	7.31	6.88	6.01	7.39 ^e
Mean	8.02 ^a	7.97 ^b	7.83 ^c	7.57 ^d	7.20 ^e	6.65 ^f	6.03 ^g	7.39
Source	S.E.m ($\pm$)				CD at 5 %			
Days (D)	0.003				0.008			
Treatment (T)	0.003				0.009			
D x T	0.008				0.023			

* The average value of four replication

(-) Indicates that the product was spoiled and no further analysis was carried out

The combined treatments (T_5 to T_8) performed best. T_5 (nisin 400 IU/g + natamycin 10 ppm) achieved the highest mean score (7.54), followed by T_6 , T_7 and T_8 . The improved texture stability in T_5 indicates complementary antimicrobial

activity that limited acid production, proteolysis and whey expulsion. The moderate concentrations used in this treatment also supported preservation without negative sensory effects. Body and texture scores declined significantly ($p < 0.05$) with increasing storage time in all samples. However, the combined preservative system in T₅ was most effective in maintaining desirable texture attributes and extending the physical stability of *shrikhand* during refrigerated storage.

The body and texture scores of *shrikhand* declined steadily with increasing storage time, mainly due to moisture loss and microbial activity. These observations agree with earlier studies. Kamble (2023) [13] reported a rapid decline in control samples of custard apple *shrikhand*, while nisin treated samples showed slower deterioration, indicating improved stability. Similar findings were reported for *nono* by Olasupo *et al.* (1996) [20], who noted that low nisin levels enhanced consistency, whereas excessive concentrations weakened texture. Nisin also extended the acceptable consistency period of *nono* during refrigerated storage.

Studies on fermented milk products support this trend. Chaure (2010) [4], Shaikh (2008) [28] and Khurana (2006) [15] showed that nisin effectively slowed texture degradation in *lassi*, salted sorghum *lassi* and mango *lassi*, extending the acceptable storage period. Positive effects were also reported in quarg cheese (Kadiya, 2009) [10] and *paneer*, where nisin helped preserve texture quality throughout storage (Ranmode, 2010; Kankhare, 2005; Das, 2017) [23, 14, 6].

Natamycin has shown similar benefits. Jalilzadeh *et al.* (2020) [9] demonstrated improved *cheese* texture at 8±1 °C with natamycin, and Vaquil (2018) [31] observed better body and texture in natamycin treated *khoa* due to reduced yeast and mould activity. Combined treatments have provided even greater protection. Misirlilar *et al.* (2012) [18] found that both nisin and natamycin maintained the consistency of strained *yoghurt* during 28 days of storage. Chawla *et al.* (2021) [5] and Saad *et al.* (2015) [25] reported superior texture retention in Doda *burfi* and processed *cheese* sauces when both preservatives were used together. A similar pattern of decline in untreated *shrikhand* has been reported by several researchers.

Flavour

The flavour score of *shrikhand* declined steadily across all treatments during storage at 5±1 °C (Table 3). This reduction was associated with gradual biochemical and microbial changes such as acid development, lipid oxidation and the formation of volatile compounds that affect sensory perception. The control (T₀) showed the fastest deterioration, with scores decreasing from 8.02 on day 0 to 6.05 by day 35, after which the product was spoiled. The rapid decline in T₀ reflected uncontrolled microbial growth and associated off flavour formation. Samples treated with nisin alone (T₁ and T₂) showed a slower reduction in flavour scores, reaching 6.02 and 6.00 by day 42, with mean scores of 7.46 and 7.40. Nisin helped suppress spoilage bacteria, improving flavour retention compared to the control, although its limited effect on yeasts and moulds still allowed gradual deterioration.

Natamycin-only treatments (T₃ and T₄) followed a similar trend. Both spoiled by day 35, with mean scores of 7.26 and 7.25. This outcome reflected the selective activity of natamycin against yeasts and moulds, which did not fully

prevent bacterial changes responsible for flavour decline. Combined treatments (T₅ to T₈) provided the strongest flavour stability throughout storage. T₅ (nisin 400 IU/g + natamycin 10 ppm) recorded the highest mean score (7.55), followed by T₆, T₇ and T₈. The improved performance of T₅ suggests a synergistic effect, where nisin controlled Gram-positive bacteria and natamycin inhibited yeasts and moulds, together reducing off-flavour development. The moderate preservative levels in T₅ also helped maintain the natural flavour profile.

Table 4: Individual and combined effect of nisin and natamycin on changes in flavour score* of *shrikhand* during storage at 5±1 °C

Treatment	Storage period (Days)						
	0	7	14	21	28	35	42
T ₀	8.02	7.88	7.59	7.21	6.70	6.05	-
T ₁	8.04	7.98	7.90	7.78	7.54	6.98	6.02
T ₂	8.03	7.94	7.84	7.70	7.44	6.88	6.00
T ₃	8.02	7.90	7.62	7.23	6.73	6.07	-
T ₄	8.02	7.89	7.60	7.22	6.71	6.06	-
T ₅	8.04	8.01	7.96	7.88	7.68	7.16	6.09
T ₆	8.04	8.00	7.92	7.80	7.56	7.00	6.04
T ₇	8.03	7.97	7.88	7.75	7.48	6.93	6.01
T ₈	8.03	7.96	7.87	7.73	7.47	6.91	6.00
Mean	8.03 ^a	7.95 ^b	7.80 ^c	7.59 ^d	7.26 ^e	6.67 ^f	6.03 ^g
Source	S.E.m (±)				CD at 5 %		
Days (D)	0.003				0.008		
Treatment (T)	0.003				0.009		
D x T	0.008				0.023		

* The average value of four replication

(-) Indicates that the product was spoiled and no further analysis was carried out

Overall, the results show that combining nisin and natamycin was more effective than using either preservative alone. Treatment T₅ offered the best protection against flavour deterioration and supported extended storage stability without compromising sensory quality.

These observations agree with earlier work showing that nisin helps preserve flavour in a variety of fermented and dairy products during storage. Kamble (2023) [13] reported a faster decline in flavour in control custard apple *shrikhand* than in the nisin treated sample. Similar benefits of nisin on flavour stability have been documented in *nono* (Olasupo *et al.*, 1996) [20], *Doogh* (Shahbazi, 2016) [27], *lassi* (Chaure, 2010; Shaik, 2008; Kakde, 2010) [4, 28, 11], carrot-based *yoghurt* drinks (Rashmi, 2014) [24], and mango *lassi* (Khurana, 2006) [15]. These studies consistently show slower deterioration of sensory quality when nisin is used.

Improved flavour retention with nisin has also been reported in *paneer* by several researchers (Kankhare, 2005; Ranmode, 2010; Mane *et al.*, 2007; Das, 2017) [14, 23, 17, 6], as well as in quarg *cheese* (Kadiya, 2009) [10] and pasteurized milk (Radha, 2014) [21]. In all cases, nisin delayed microbial spoilage and extended flavour acceptability.

Natamycin produced similar results in *yoghurt* (El-Diasty *et al.*, 2009) [7], *cheese* (Jalilzadeh *et al.*, 2020) [9], and *khoa* (Vaquil, 2018) [31], where treated samples maintained better flavour scores than the control during storage. Combined treatments of nisin and natamycin further enhanced flavour preservation in strained *yoghurt* (Misirlilar *et al.*, 2012) [18], processed *cheese* sauces (Saad *et al.*, 2015) [25], and Galotyri *cheese* (Kallinteri *et al.*, 2013) [12]. Chawla *et al.* (2021) [5] also found that their combined use slowed flavour decline in Doda *burfi*. A progressive reduction in flavour scores of

control *shrikhand* during storage has been reported by numerous authors.

Overall acceptability

The overall acceptability of all *shrikhand* samples declined progressively during storage at 5 ± 1 °C (Table 4).

Table 5: Individual and combined effect of nisin and natamycin on changes in overall acceptability score* of *shrikhand* during storage at 5 ± 1 °C

Treatment	Storage period (Days)							
	0	7	14	21	28	35	42	Mean
T ₀	8.26	8.11	7.82	7.41	6.84	6.03	-	7.41 ⁱ
T ₁	8.28	8.22	8.10	7.86	7.52	7.00	6.02	7.57 ^c
T ₂	8.27	8.18	8.05	7.78	7.43	6.92	6.00	7.52 ^f
T ₃	8.26	8.13	7.85	7.43	6.87	6.05	-	7.43 ^g
T ₄	8.26	8.12	7.83	7.42	6.85	6.04	-	7.42 ^h
T ₅	8.28	8.25	8.18	8.00	7.68	7.16	6.09	7.66 ^a
T ₆	8.28	8.23	8.13	7.89	7.55	7.03	6.05	7.59 ^b
T ₇	8.27	8.21	8.09	7.83	7.47	6.95	6.02	7.55 ^d
T ₈	8.27	8.20	8.07	7.81	7.46	6.94	6.00	7.54 ^e
Mean	8.27 ^a	8.18 ^b	8.01 ^c	7.71 ^d	7.30 ^e	6.68 ^f	6.03 ^g	7.53
Source	S.E.m (±)				CD at 5 %			
Days (D)	0.003				0.008			
Treatment (T)	0.003				0.009			
D x T	0.009				0.024			

* The average value of four replication

(-) Indicates that the product was spoiled and no further analysis was carried out

Although initial scores were similar across treatments (8.26 to 8.28), significant differences ($p < 0.05$) emerged as storage advanced. The control (T₀) deteriorated rapidly and spoiled after day 35 due to unchecked microbial activity, which affected flavour, texture and appearance. Samples treated with nisin alone (T₁ and T₂) or natamycin alone (T₃ and T₄) maintained higher acceptability than the control. Nisin treatments showed mean scores of 7.57 (T₁) and 7.52 (T₂), while natamycin treatments recorded 7.43 (T₃) and 7.42 (T₄). These results show that each preservative independently slowed quality loss, although their effectiveness was limited with extended storage.

Combination treatments (T₅ to T₈) performed consistently better than individual applications. T₅ (nisin 400 IU/g + natamycin 10 ppm) achieved the highest mean acceptability score (7.66), followed by T₆ (7.59), T₇ (7.55) and T₈ (7.54). The combined antimicrobial action of nisin and natamycin likely controlled bacterial and fungal growth more efficiently, helping preserve sensory attributes for a longer period. The superior performance of T₅ reflects an optimal balance of preservative concentrations that protected product quality without affecting flavour. Overall, acceptability scores declined significantly ($p < 0.05$) with increasing storage time, and the interaction between treatment and storage period was significant. The combination of nisin 400 IU/g and natamycin 10 ppm (T₅) was the most effective in maintaining sensory quality and extending the shelf life of *shrikhand* during refrigerated storage.

These results agree with earlier research showing that biopreservatives help slow the decline in overall acceptability of dairy products during storage. Kamble (2023) [13] reported a rapid decrease in acceptability in control custard apple *shrikhand*, while nisin treated samples

deteriorated more slowly. Similar trends were documented in *lassi* by Chaure (2010) [4], Shaikh (2008) [28] and Kumar (1993) [16], who noted that nisin improved flavour and storage stability compared to controls. *Paneer* studies also support these findings; Ranmode (2010) [23], Das (2017) [6] and Kankhare (2005) [14] all reported higher acceptability in nisin treated samples throughout storage. Radha (2014) [21] observed that nisin enhanced the shelf life and sensory quality of pasteurized milk.

Natamycin has shown comparable benefits in fermented milk and *cheese* products. El-Diasty *et al.* (2009) [7], Misirlilar *et al.* (2012) [18] and Sara *et al.* (2014) [26] reported that natamycin treated *yoghurt* maintained higher sensory scores during extended storage. Similar improvements were noted in *paneer* (Sreeramaya, 2022) [30], Iranian UF *cheese* (Nottagh, 2020) [19], and various *cheese* types treated with natamycin (Jalilzadeh *et al.*, 2020; Ramos *et al.*, 2012) [9, 22]. Combined treatments provided the best sensory stability. Saad *et al.* (2015) [25] and Kallinteri *et al.* (2013) [12] showed that nisin and natamycin together preserved sensory quality more effectively than either preservative alone. Enhanced acceptability with combined treatments was also reported in *khoa* (Vaquil, 2018) [31] and *Doda burfi* (Chawla *et al.*, 2021) [5]. A consistent decline in acceptability of untreated *shrikhand* during storage has been documented by numerous researchers.

Conclusion

From the present study it was concluded that, during storage of *shrikhand*, the sensory scores for all attributes were decreased significantly ($p < 0.05$) in eight samples. On the basis of sensory evaluation, *shrikhand* without biopreservatives (T₀) and *shrikhand* treated with natamycin at 10 ppm (T₃) and 15 ppm (T₄) could be stored for 35 days at 5 ± 1 °C. *Shrikhand* treated with nisin at 400 IU/g (T₁) and 500 IU/g (T₂), as well as combinations of nisin and natamycin 400 IU + 10 ppm (T₅), 400 IU + 15 ppm (T₆), 500 IU + 10 ppm (T₇), and 500 IU + 15 ppm (T₈) maintained acceptable quality and could be stored for 42 days at 5 ± 1 °C. Treatment T₅ (nisin 400 IU/g + natamycin 10 ppm) demonstrated superior sensory quality, along with an extended shelf life of *shrikhand*, compared to the control (T₀) and other biopreservative treatments throughout the storage period. Hence, the combination of nisin (400 IU/g) and natamycin (10 ppm) is recommended as an effective treatment for the preservation of *shrikhand*.

References

1. Amerine MA, Pangborn RM, Roessler EB. *Principles of sensory evaluation of food*. New York (USA): Academic Press Inc.; 1965.
2. Ananou S, Maqueda M, Martinez-Bueno M, Valdivia E. Biopreservation, an ecological approach to the safety and shelf-life of foods. In: Communicating current research and educational topics and trends in applied microbiology. Badajoz (Spain): Formatex; 2007. p. 475-486.
3. Arauz LJ, Jozala AF, Mazzola PG, Penna TC. Nisin biotechnological production and application: a review. *Trends Food Sci Technol*. 2009;20(3-4):146-154.
4. Chaure CR. Effect of nisin on shelf life of *lassi* [MSc thesis]. Rahuri (India): Mahatma Phule Krishi Vidyapeeth; 2010.

5. Chawla R, Sivakumar S, Kaur H, Mishra SK. Effect of starch-based edible antimicrobial films and modified atmospheric packaging on extended life of composite sweetmeat. *Carbohydrate Polymer Technologies and Applications*. 2021;2:100055.
6. Das AB. Antimicrobial and antioxidant activities of crude extract of Indian curd and its application in livestock products [MVSc thesis]. Izatnagar (India): ICAR-Indian Veterinary Research Institute; 2017.
7. El-Diasty ME, El-Kaseh RM, Salem RM. The effect of natamycin on keeping quality and organoleptic characters of yoghurt. *Arab J Biotechnol*. 2009;12(1):41-48.
8. Hondrodinou O, Kourkoutas Y, Panagou EZ. Efficacy of natamycin to control fungal growth in natural black olive fermentation. *Food Microbiol*. 2011;28(3):621-627.
9. Jalilzadeh A, Hesari J, Peighambaroust SH, Javidipour I. Effect of whey protein-based edible coating containing natamycin and lysozyme-xanthan gum conjugate on shelf life of ultrafiltered white cheese. *J Food Bioprocess Eng*. 2020;3:168-177.
10. Kadiya KS. Development of functional quarg cheese with extended shelf life [MTech thesis]. Karnal (India): National Dairy Research Institute; 2009.
11. Kakade AM. Studies on the alternative stabilizer in pearl millet-based fermented milk beverage and its shelf-life extension [MTech thesis]. Karnal (India): National Dairy Research Institute; 2010.
12. Kallinteri LD, Kostoula OK, Savvaidis IN. Efficacy of nisin and/or natamycin to improve the shelf-life of Galotyri cheese. *Food Microbiol*. 2013;36(1):176-181.
13. Kamble KB. Optimization of custard apple (*Annona squamosa* L.) enriched shrikhand using stevia as a natural sweetener [PhD thesis]. Rahuri (India): Mahatma Phule Krishi Vidyapeeth; 2023.
14. Kankhare DH. Studies on preservation of paneer [PhD thesis]. Rahuri (India): Mahatma Phule Krishi Vidyapeeth; 2005.
15. Khurana HK. Development of technology for extended shelf life fruit lassi [PhD thesis]. Karnal (India): National Dairy Research Institute; 2006.
16. Kumar N. Effect of nisin on the behaviour and ultrastructure of selected lactic and non-lactic microorganisms [PhD thesis]. Karnal (India): National Dairy Research Institute; 1993.
17. Mane SH, Kankhare DH, Rasane DS, Patil SR. Application methods and levels of nisin for improving shelf life of paneer. In: *Proceedings of the International Conference on Traditional Dairy Foods*; 2007 Nov 14-17; Karnal, India. Karnal: NDRI; 2007. p. 125.
18. Misirlilar F, Kinik O, Yerlikaya O. Effect of protective culture and biopreservatives on strained yoghurt quality. *Afr J Microbiol Res*. 2012;6(22):4696-4701.
19. Nottagh S, Hesari J, Peighambaroust SH, Rezaei-Mokarram R, Jafarizadeh-Malmiri H. Effectiveness of edible coating based on chitosan and natamycin on biological, physicochemical and organoleptic attributes of Iranian ultrafiltered cheese. *Biologia*. 2020;75:605-611.
20. Olasupo NA, Akinsanya SM, Oladele OF, Azeez MK. Evaluation of nisin for the preservation of nono, a Nigerian fermented milk product. *J Food Process Preserv*. 1996;20(1):71-78.
21. Radha K. Nisin as a biopreservative for pasteurized milk. *Indian J Vet Anim Sci Res*. 2014;43(6):436-444.
22. Ramos OL, Pereira JO, Silva SI, Fernandes JC, Franco MI, Lopes-da-Silva JA, *et al*. Evaluation of antimicrobial edible coatings from a whey protein isolate base to improve the shelf life of cheese. *J Dairy Sci*. 2012;95(11):6282-6292.
23. Ranmode AK. Evaluation of efficacy of nisin as a preservative for paneer [MTech thesis]. Anand (India): Anand Agricultural University; 2010.
24. Rashmi MR. Development of carrot-based yoghurt drink [MTech thesis]. Bidar (India): Karnataka Veterinary, Animal and Fisheries Sciences University; 2014.
25. Saad SA, El-Mahdi LD, Awad RA, Hassan ZMR. Processed cheese sauces with different preservative systems. *Integr Food Nutr Metab*. 2015;2(1):136-141.
26. Sara AE, Ekbal MA, Adham MA, Hamdi AM. Role of natamycin fortification to extend shelf life of plain yoghurt. *Benha Vet Med J*. 2014;27:140-149.
27. Shahbazi Y. Antibacterial effect of *Ziziphora clinopodioides* essential oil and nisin against *Salmonella typhimurium* and *Staphylococcus aureus* in doogh, a yoghurt-based Iranian drink. *Vet Res Forum*. 2016;7(3):213-219.
28. Shaik AH. Studies on shelf-life extension of cereal-based fermented milk beverage [MTech thesis]. Karnal (India): National Dairy Research Institute; 2008.
29. Snedecor GW, Cochran WG. *Statistical methods*. 6th ed. Calcutta (India): Oxford and IBH Publishing Co.; 1967.
30. Sreerama K. Effect of natamycin on the microbiological quality of paneer [MTech thesis]. Bidar (India): Karnataka Veterinary, Animal and Fisheries Sciences University; 2022.
31. Vaquil. Studies on utilization of milk solids for khoa making by semi-automatic machine [PhD thesis]. Hisar (India): Lala Lajpat Rai University of Veterinary and Animal Sciences; 2018.