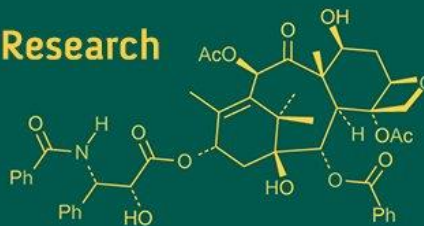


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Lactobacillus acidophilus postbiotic (Cell-Free Supernatant) as a natural biopreservative for refrigerated paneer

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Abstract

Paneer, a popular acid- and heat-coagulated Indian soft cheese, is highly perishable owing to its high moisture and nutrient content, limiting its shelf life to about 5-6 days under aerobic refrigerated storage. The present study evaluated partially purified cell-free supernatant (CFS) of *Lactobacillus acidophilus* as a natural biopreservative for paneer. The CFS exhibited broad-spectrum antibacterial activity, showing the highest inhibition against *K. pneumoniae* (29.4 mm) and *E. coli* (22.2 mm). Paneer samples treated with 5.0% (T₁), 7.5% (T₂) and 10.0% (T₃) CFS were compared with an untreated control (T₀), stored at 4 ± 1 °C, and analysed at 3-day intervals for total plate count (TPC), coliform count, yeast and mould count, pH, titratable acidity and sensory attributes. TPC rose in all treatments but was significantly ($p < 0.05$) retarded in T₃, which recorded the lowest counts throughout; coliforms were absent in all samples, and yeast and mould appeared only in T₃ (1.271 log₁₀ cfu/g) on day 12. The decline in pH and rise in titratable acidity were significantly moderated in T₃, which remained sensorily acceptable up to day 9, whereas T₀, T₁ and T₂ became unacceptable after day 6. Thus, 10.0% partially purified CFS of *L. acidophilus* effectively extended the shelf life of paneer from 6 to 9 days under refrigerated storage without adversely affecting its sensory quality.

Keywords: Paneer, Biopreservation, *Lactobacillus acidophilus*, Cell-free supernatant, Antimicrobial activity, Shelf life, Refrigerated storage

1. Introduction

Paneer is one of the most popular indigenous heat-and-acid coagulated milk products of the Indian subcontinent, prepared by precipitating hot milk with a food-grade acidulant such as citric acid, lactic acid or sour whey, followed by drainage and pressing of the coagulum. A rich source of milk fat, protein, fat-soluble vitamins and minerals, it forms the base for a wide range of culinary and snack preparations and its demand has grown steadily in both domestic and export markets (Kumar *et al.*, 2014) [14]. However, its high moisture content (50-60%), near-neutral pH and abundant nutrients make it an ideal substrate for spoilage and pathogenic microorganisms. Consequently, freshly prepared paneer held under aerobic refrigerated storage (4-7 °C) retains acceptable quality for only about five to six days, after which surface sliminess, off-flavour, discoloration and mould growth render it unfit for consumption (Sen *et al.*, 2023) [24], a major constraint for its organised marketing, distribution and export.

Several approaches have been explored to prolong its shelf life, including refrigerated and frozen storage, hurdle technology, modified atmosphere and vacuum packaging, chemical preservatives such as sorbates and benzoates, antimicrobial edible coatings and thermal treatments. However, each has practical limitations: chemical preservatives are increasingly resisted by consumers who prefer clean-label foods and may impart undesirable sensory changes; thermal and high-pressure interventions demand capital investment and can alter texture; and packaging-based methods add cost without eliminating the intrinsic microbial hazard (Chaudhary *et al.*, 2019) [8]. These limitations have intensified the search for safe, natural and cost-effective alternatives.

Biopreservation, the extension of shelf life and enhancement of food safety using microorganisms and/or their metabolites, has emerged as a promising natural strategy.

Lactic acid bacteria (LAB) are central to this approach owing to their long history of safe use and Generally Recognised As Safe (GRAS) status (Silva *et al.*, 2018) [25], producing a broad spectrum of inhibitory compounds including organic acids, hydrogen peroxide, diacetyl, carbon dioxide and bacteriocins (Vieco-Saiz *et al.*, 2019) [26]. The cell-free supernatant (CFS) recovered from LAB cultures contains these soluble metabolites and can be applied directly to foods as a non-viable biopreservative, avoiding the technological uncertainties of adding live cultures to non-fermented products (Nataraj *et al.*, 2020; Moradi *et al.*, 2020) [18, 17]. *Lactobacillus acidophilus*, a well-characterised probiotic species, yields a CFS with strong antibacterial and antifungal activity against food spoilage organisms and pathogens (Şanlıer *et al.*, 2019; Zommiti *et al.*, 2020) [23, 29], and its partial purification and concentration can enhance inhibitory potency while removing viable cells, particularly suited to a delicate dairy matrix such as paneer. As information on the dose-dependent efficacy of partially purified *L. acidophilus* CFS in paneer remains limited, the present study was undertaken to evaluate the effect of different levels (5.0, 7.5 and 10.0%) of partially purified CFS on the physicochemical, microbiological and sensory quality of paneer during refrigerated storage, and to determine the level that most effectively prolongs its shelf life.

2. Materials and Methods

2.1 Preparation of paneer

Paneer was prepared from standardised fresh buffalo milk following the standard method. The milk was filtered, standardised and heated to about 82-85 °C for 5 min, then cooled to approximately 70 °C. Coagulation was carried out by gradual addition of a 1-2% citric acid solution (at about 70 °C) with gentle stirring until clear whey separated. The coagulum was allowed to settle, transferred to a muslin-lined hoop and pressed at a pressure of about 2-3 kg/cm² for 15-20 min. The pressed block was removed, immersed in chilled potable water, drained, cut into uniform cubes and used for further treatment. All operations were performed under strict hygienic conditions to minimise adventitious contamination.

2.2 Preparation of the biopreservative and treatment

The partially purified cell-free supernatant (CFS) was obtained from an actively growing culture of *Lactobacillus acidophilus* grown in de Man, Rogosa and Sharpe (MRS) broth at 37 °C for 24 h. Cells were removed by centrifugation (10,000 × g, 10 min, 4 °C) and the resulting supernatant was neutralised, treated to precipitate the antimicrobial fraction, partially purified using 70% saturated ammonium sulphate and concentrated using dialysis to yield the biopreservative used in this study. The partially purified CFS was applied uniformly as a thin surface coating over freshly prepared paneer cubes so as to deliver four treatments: T₀, untreated control; T₁, 5.0% partially purified CFS; T₂, 7.5% partially purified CFS; and T₃, 10.0% partially purified CFS. After the surface coating was allowed to set, the samples were packaged and stored at 4 ± 1 °C, and drawn at 3-day intervals (0, 3, 6, 9 and 12 days) for analysis.

2.3. Antimicrobial activity of partially purified CFS

The antimicrobial activity of the test samples was evaluated by the agar disc diffusion method following CLSI (2018) guidelines, as described by Balouri *et al.* (2016) [4]. Bacterial suspensions were adjusted to a 0.5 McFarland standard ($\approx 1.5 \times 10^8$ CFU/mL) and swabbed uniformly onto Mueller-Hinton Agar plates. Sterile filter paper discs (6 mm) loaded with the test samples were placed on the inoculated agar and solvent (negative control). The plates were incubated at 37 °C for 18-24 h, after which the diameter of the zone of inhibition was measured in millimetres. All tests were performed in triplicate, and results were expressed as mean ± standard deviation.

2.4 Physicochemical analysis

2.4.1. pH: The pH of the paneer samples was determined by macerating 10 g of sample in 10 ml of warm distilled water to form a smooth slurry and recording the value using a calibrated digital pH meter at each storage interval (AOAC, 2016) [1].

2.4.2. Titratable acidity: Titratable acidity was estimated by titrating a known weight of macerated sample against standard 0.1 N sodium hydroxide using phenolphthalein as indicator, and expressed as percent lactic acid (AOAC, 2016) [1].

2.5 Microbiological analysis

2.5.1. Total plate count (TPC): Total plate count was enumerated by the standard pour-plate technique on plate count agar after appropriate serial decimal dilutions, with plates incubated at 37 °C for 48 h. Counts were expressed as log₁₀ colony forming units per gram (log₁₀ cfu/g) (APHA, 2015) [2].

2.5.2. Coliform count: Coliform counts were determined by the pour-plate method using violet red bile agar, with plates incubated at 37 °C for 24 h; characteristic dark pink to red colonies were counted and expressed as log₁₀ cfu/g (APHA, 2015) [2].

2.5.3. Yeast and mould count: Yeast and mould were enumerated on acidified potato dextrose agar incubated at 25 °C for 3-5 days, and the counts expressed as log₁₀ cfu/g (APHA, 2015) [2].

2.6 Sensory evaluation and shelf-life study

Sensory quality of the stored paneer was assessed by a trained panel using a 9-point hedonic scale (9 = like extremely, 1 = dislike extremely) for appearance and colour, body and texture, flavour, after-taste and overall acceptability (Meilgaard *et al.*, 2016) [16]. Samples scoring 6.0 and above on overall acceptability were considered acceptable for consumption. The shelf life of each treatment under refrigerated storage was determined on the basis of the combined microbiological quality and the day up to which the samples retained an acceptable overall acceptability score.

2.7 Statistical analysis

All experiments were carried out in triplicate and the data were subjected to analysis of variance (ANOVA). Treatment and storage means were compared and differences considered significant at $p < 0.05$. In the tables, means

bearing different lowercase superscripts within a row (effect of storage) and different uppercase superscripts within a column (effect of treatment) differ significantly; NS, *, ** and *** denote non-significant, and significance at $p < 0.05$, 0.01 and 0.001, respectively.

3. Results and Discussion

3.1. Antimicrobial activity of the partially purified CFS

The partially purified cell-free supernatant (CFS) of *L. acidophilus* exhibited broad-spectrum antibacterial activity against all four pathogens, with the largest zone of inhibition against *Klebsiella pneumoniae* (29.4 ± 0.05 mm), followed by *Escherichia coli* (22.2 ± 0.03 mm), while weaker activity was recorded against *Pseudomonas aeruginosa* (10.3 ± 0.02 mm) and *Staphylococcus aureus* (10.1 ± 0.08 mm). This inhibition is attributed to organic acids, hydrogen peroxide and bacteriocin-like compounds that disrupt the cell membrane and lower the intracellular pH (Balouiri *et al.*, 2016) [4]. The strong activity against *K. pneumoniae* and *E. coli* indicates that the active metabolites effectively penetrated the outer membrane of these Gram-negative bacteria, in agreement with El-Mokhtar *et al.* (2020) [10]. The weaker effect on *P. aeruginosa* reflects its intrinsic resistance through membrane impermeability, efflux pumps, and biofilm formation, whereas the low activity against *S. aureus* may be strain-dependent. Overall, the CFS shows promising but organism-selective antibacterial potential that could be enhanced through further purification or concentration.

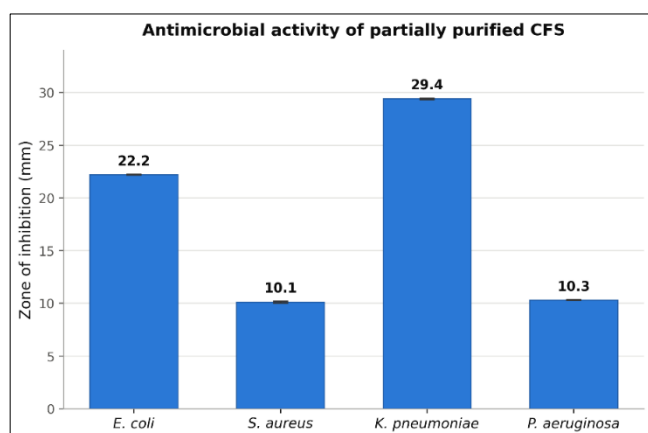


Fig 1: Antimicrobial activity of partially purified CFS of *L. acidophilus*

3.2. Microbial analysis

3.2.1. Total plate count

The total plate count of all paneer samples increased significantly ($p < 0.05$) with advancing storage (Fig. 2). Initial counts on day 0 were statistically similar (4.72 – 4.75 $\log_{10}$ cfu/g), confirming a comparable and hygienic microbial load at the start. Counts then rose in every treatment, since refrigeration only slows and does not stop, the proliferation of psychrotrophic and mesophilic microorganisms utilising the abundant moisture and nutrients of paneer (Woraprayote *et al.*, 2016) [27]. By day 6 the control reached 5.30 $\log_{10}$ cfu/g, whereas the rise was markedly slower in the CFS-treated samples, most notably in T₃ (5.09 $\log_{10}$ cfu/g on day 6 and 5.29 $\log_{10}$ cfu/g on day 9). This suppression is attributed to the organic acids and bacteriocin-like peptides in the partially purified CFS of *L. acidophilus*, which disrupt the cytoplasmic membrane and

lower the intracellular pH of target cells (Barcenilla *et al.*, 2022) [6]. The dose-dependent effect, with T₃ (10.0% CFS) most inhibitory, indicates that a higher metabolite concentration exerted stronger bacteriostatic action, in agreement with Sen *et al.* (2023) [24].

As per FSSAI requirements, the total plate count for paneer should not exceed ≈ 4.70 $\log_{10}$ cfu/g, with an upper limit of ≈ 5.0 $\log_{10}$ cfu/g (FSSAI, 2020) [11]. Accordingly, the control, T₁ and T₂ exceeded this limit beyond day 6, whereas T₃ kept the count within the acceptable range (5.09 – 5.29 $\log_{10}$ cfu/g) up to day 9.

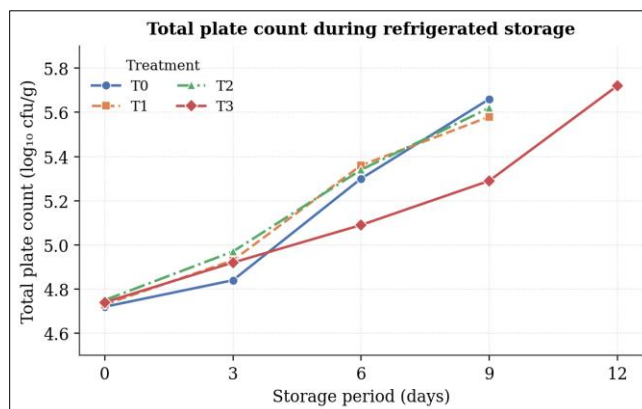


Fig 2: Changes in the total plate count ($\log_{10}$ cfu/g) of the biopreserved paneer during refrigerated storage

3.2.2 Coliform count

Coliforms were not detected (ND) in any of the treatments throughout the storage period. The complete absence of coliforms reflects the effective post-manufacture heat treatment of paneer, the use of an acidic coagulation process and the maintenance of strict hygienic conditions during preparation, handling and packaging, since coliforms are recognised indicators of insanitary practice and post-processing contamination (Ibrahim *et al.*, 2021) [13]. The organic acids and antimicrobial peptides of LAB metabolites are known to be particularly effective against Gram-negative enteric bacteria by sensitising and permeabilising their outer membrane, which further supports the absence of coliforms in the CFS-treated samples (Gharsallaoui *et al.*, 2016) [12]. This result complies fully with the FSSAI requirement for paneer, which stipulates that the coliform count should not exceed 10 cfu/g at the acceptable level and 100 cfu/g as the maximum permissible limit (FSSAI, 2020) [11]; all samples were therefore well within the prescribed standard and safe with respect to coliform contamination.

3.2.3 Yeast and mould count

Yeast and mould were not detected in the control, T₁, T₂ or T₃ up to the 9th day; a low count of 1.271 $\log_{10}$ cfu/g appeared only in T₃ on the 12th day. Since the control, T₁ and T₂ were spoiled and discarded after day 6 and T₃ after day 9 on the basis of sensory rejection, this small fungal population in T₃ represents the very late onset of surface mould growth once the antifungal metabolites had been depleted. The prolonged absence of yeast and mould reflects the antifungal activity of the *L. acidophilus* CFS, which contains organic acids together with low-molecular-weight compounds such as phenyllactic and hydroxy fatty acids that inhibit fungal spore germination and hyphal growth (Sadiq *et al.*, 2019) [22]. The superior protection of T₃ is consistent

with its higher metabolite load and agrees with reports that LAB cell-free supernatants delay fungal spoilage in stored foods (Mani-López *et al.*, 2022) [15]. All values remained within the FSSAI limit for paneer (yeast and mould not exceeding 100 cfu/g; FSSAI, 2020) [11] throughout the acceptable storage life of every treatment.

3.3. pH

The pH of all paneer samples decreased progressively and significantly ($p < 0.05$) during refrigerated storage (Fig.3). The initial pH values were statistically similar (5.44-5.45) across the treatments. The steady decline in pH is primarily due to the continued production of lactic and other organic acids by the residual and growing microflora fermenting the lactose retained in paneer, together with the acids already contributed by the CFS (Punia Bangar *et al.*, 2022) [20]. The fall in pH was sharpest in the untreated control, which dropped from 5.45 to 4.57 by the 9th day, indicating rapid and uncontrolled acidification associated with heavier microbial growth. In contrast, T₃ maintained a significantly higher pH (4.92 on the 9th day) than the other treatments, because its stronger antimicrobial action restrained the acid-producing spoilage population and thus slowed the pace of acidification (Behera *et al.*, 2018) [7]. A similar gradual reduction in the pH of soft cheeses and paneer during cold storage has been reported by Özogul and Hamed (2018) [19], who attributed it to ongoing microbial and enzymatic acid formation. The better retention of pH in T₃ is a further indication of its superior keeping quality.

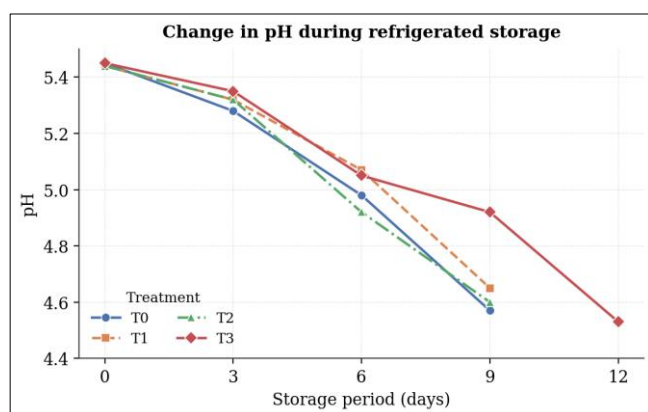


Fig 3: Changes in the pH of the biopreserved paneer during refrigerated storage

3.4. Titratable acidity

The titratable acidity of all treatments increased significantly ($p < 0.05$) with storage, mirroring the decline in pH (Figure.4). The initial acidity was uniform (0.434-0.436% lactic acid) among the samples. The rise in acidity results from the accumulation of lactic acid and other organic acids generated by the fermentation of residual

lactose by the surviving and multiplying microflora during storage (Şanlıer *et al.*, 2019) [23]. The increase was steepest in the untreated control, whose acidity rose sharply to 1.157% by the 9th day, reflecting the vigorous, unchecked microbial acid production accompanying its high plate count. In the treated samples the rise was significantly moderated and T₃ showed the slowest development of acidity (only 0.570% on the 9th day), because its higher load of antimicrobial metabolites suppressed the acid-forming spoilage organisms (Zapašnik *et al.*, 2022) [28]. This inverse relationship between titratable acidity and microbial-driven pH change is consistent with the trend documented for paneer during refrigerated storage by Kumar *et al.* (2014) [14] and Ramasamy *et al.* (2026) [21]. The lower terminal acidity of T₃ confirms its more stable physicochemical quality and, in turn, its longer shelf life.

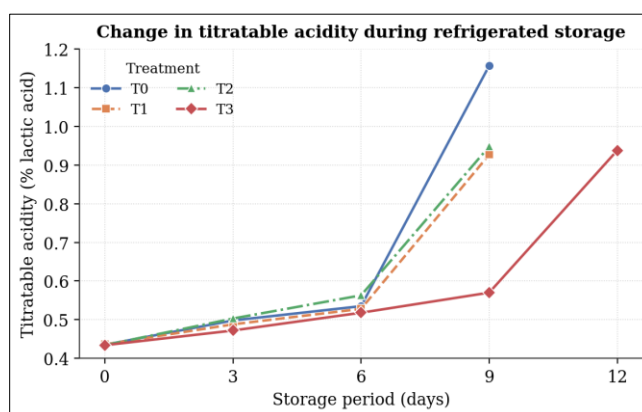


Fig 4: Changes in the titratable acidity (% lactic acid) of the biopreserved paneer during refrigerated storage

3.5. Sensory quality

The sensory scores for appearance and colour, body and texture, flavour, after-taste and overall acceptability declined progressively in all treatments as storage advanced (Table 1). This general deterioration is the cumulative outcome of microbial growth, rising acidity, moisture migration, textural hardening and the development of sour and stale off-flavours that are characteristic of ageing paneer (Meilgaard *et al.*, 2016) [16]. In the untreated control, T₁ and T₂, all attributes fell steeply and the overall acceptability dropped to about 5.9-6.0 by the 9th day, below the acceptability threshold, whereas T₃ retained distinctly superior scores, with an overall acceptability of 7.88 on the 6th day and 7.54 on the 9th day.

The better sensory retention of T₃ is a direct reflection of its restrained microbial and biochemical spoilage, and is in line with observations that biopreservative treatments help preserve the freshness and organoleptic quality of stored dairy products (Aspri *et al.*, 2020) [3].

Table 1: Sensory parameters of the biopreserved paneer during refrigerated storage

Sensory parameters	Treatment	Storage days					F value
		0 th day	3 rd day	6 th day	9 th day	12 th day	
Appearance and colour	T ₀	8.90±0.06 ^{aA}	7.95±0.08 ^{bB}	7.20±0.03 ^{cC}	5.90±0.05 ^{dB}	—	478.8**
	T ₁	8.90±0.08 ^{aA}	8.15±0.04 ^{bA}	7.25±0.03 ^{cB}	5.95±0.07 ^{dB}	—	466.8**
	T ₂	8.85±0.07 ^{aA}	8.10±0.06 ^{bA}	7.40±0.03 ^{cB}	6.00±0.03 ^{dB}	—	571.1**
	T ₃	8.90±0.08 ^{aA}	8.30±0.03 ^{bA}	8.15±0.06 ^{bA}	7.50±0.08 ^{cA}	6.25±0.04 ^d	269.4**
	F value	0.1 ^{NS}	6.7*	123.8**	163.9**	—	
Body and Texture	T ₀	8.60±0.07 ^{aA}	8.15±0.06 ^{bB}	7.15±0.09 ^{cB}	6.10±0.07 ^{dB}	-	230.4**
	T ₁	8.85±0.05 ^{aA}	8.10±0.03 ^{bB}	7.35±0.08 ^{cB}	5.95±0.05 ^{dB}	-	497.8**

	T ₂	8.60±0.06 ^{aA}	8.10±0.06 ^{bB}	7.45±0.05 ^{cB}	5.95±0.04 ^{dB}	-	468.7 ^{**}
	T ₃	8.60±0.08 ^{aA}	8.45±0.04 ^{aA}	7.85±0.03 ^{bA}	7.55±0.07 ^{bA}	6.20±0.09 ^c	209.1 ^{**}
	F value	3.6 ^{NS}	11.7 ^{**}	19.4 ^{**}	174.3 ^{**}	-	-
	T ₀	8.60±0.06 ^{aA}	8.10±0.03 ^{bB}	7.25±0.08 ^{cB}	5.85±0.06 ^{dB}	-	399.5 ^{**}
	T ₁	8.85±0.04 ^{aA}	8.10±0.09 ^{bB}	7.45±0.04 ^{cB}	5.80±0.03 ^{dB}	-	553.6 ^{**}
Flavour	T ₂	8.80±0.08 ^{aA}	7.80±0.03 ^{bC}	7.40±0.03 ^{cB}	5.80±0.08 ^{dB}	-	426.5 ^{**}
	T ₃	8.65±0.07 ^{aA}	8.35±0.03 ^{aA}	7.75±0.08 ^{bA}	7.45±0.03 ^{bA}	6.05±0.09 ^c	241.7 ^{**}
	F value	3.4 ^{NS}	18.7 ^{**}	11.5 ^{**}	226.3 ^{**}	-	-
	T ₀	8.85±0.07 ^{aA}	8.10±0.08 ^{bB}	7.15±0.05 ^{cB}	6.10±0.09 ^{dB}	-	259.1 ^{**}
	T ₁	8.55±0.03 ^{aB}	7.90±0.08 ^{bB}	7.30±0.05 ^{cB}	5.95±0.03 ^{dB}	-	458.9 ^{**}
After taste	T ₂	8.35±0.03 ^{aB}	7.95±0.04 ^{bB}	7.15±0.06 ^{cB}	6.05±0.09 ^{dB}	-	289.9 ^{**}
	T ₃	8.90±0.06 ^{aA}	8.45±0.03 ^{bA}	7.75±0.05 ^{cA}	7.65±0.09 ^{cA}	6.00±0.09 ^d	263.2 ^{**}
	F value	26.1 ^{**}	16.1 ^{**}	29.1 ^{**}	104.3 ^{**}	-	-
	T ₀	8.74±0.03 ^{aA}	8.07±0.03 ^{bB}	7.19±0.03 ^{cC}	5.99±0.03 ^{dB}	-	1569.9 ^{**}
	T ₁	8.79±0.03 ^{aA}	8.06±0.03 ^{bB}	7.34±0.03 ^{cB}	5.91±0.02 ^{dB}	-	1947.9 ^{**}
Overall Acceptability	T ₂	8.65±0.03 ^{aA}	7.99±0.02 ^{bB}	7.35±0.02 ^{cB}	5.95±0.03 ^{dB}	-	2044.5 ^{**}
	T ₃	8.76±0.04 ^{aA}	8.39±0.02 ^{bA}	7.88±0.03 ^{cA}	7.54±0.04 ^{dA}	6.12±0.04 ^e	849.8 ^{**}
	F value	3.4 ^{NS}	49.1 ^{**}	117.9 ^{**}	666.4 ^{**}	-	-

The absence of any adverse sensory effect from the CFS itself indicates that partially purified *L. acidophilus* metabolites can be incorporated without imparting off-flavours, an important advantage over chemical preservatives (Chikindas *et al.*, 2018) [9].

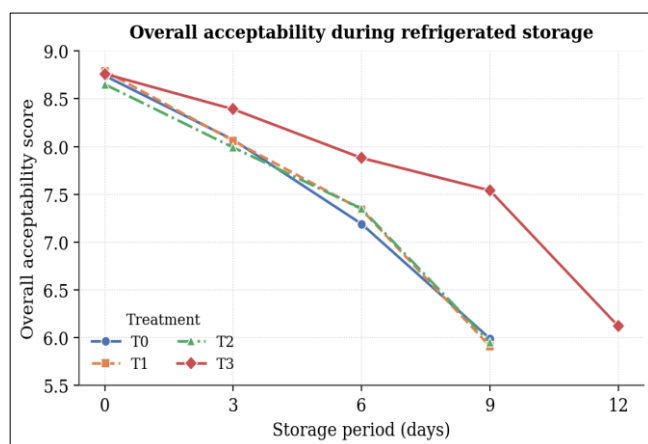


Fig 5: Changes in the overall acceptability score of the biopreserved paneer during refrigerated storage

3.6. Shelf life under refrigerated storage

Considering the combined microbiological and sensory quality, the shelf life of the untreated control (T₀), T₁ (5.0% CFS) and T₂ (7.5% CFS) was limited to 6 days under refrigerated storage at 4 ± 1 °C. In these samples the total plate count and titratable acidity had risen appreciably and, critically, the overall acceptability score fell to the region of 5.9-6.0 by the 9th day, at which point the product was judged organoleptically unacceptable. In contrast, T₃ (10.0% CFS) retained an acceptable overall acceptability score (7.54) together with low microbial counts and the continued absence of coliforms and yeast and mould up to the 9th day, thereby extending its shelf life to 9 days. Beyond the 9th day, T₃ also became unacceptable, as reflected by the appearance of yeast and mould (1.271 log₁₀ cfu/g) and the drop in overall acceptability to 6.12 on the 12th day. Thus, treatment with 10.0% partially purified CFS of *L. acidophilus* extended the shelf life of paneer by three days relative to the control, T₁ and T₂, demonstrating a clear dose-dependent biopreservative benefit (Silva *et al.*, 2018; Vieco-Saiz *et al.*, 2019) [25, 26].

4. Conclusion

The present study demonstrates that partially purified cell-free supernatant (CFS) of *Lactobacillus acidophilus* is an effective natural biopreservative for extending the refrigerated shelf life of paneer. The CFS showed broad-spectrum antibacterial activity, with the highest zone of inhibition against *K. pneumoniae* (29.4 ± 0.05 mm) and *E. coli* (22.2 ± 0.03 mm) and weaker activity against *P. aeruginosa* (10.3 ± 0.02 mm) and *S. aureus* (10.1 ± 0.08 mm), highlighting its potential as a natural antimicrobial agent. Among the levels evaluated, 10.0% CFS (T₃) was the most effective, significantly retarding the rise in total plate count, delaying yeast and mould onset, moderating the decline in pH and rise in titratable acidity, and preserving superior sensory quality. Coliforms were absent in all samples, and all counts remained within FSSAI limits throughout the acceptable shelf life. On the basis of combined microbiological and sensory quality, the shelf life of the control, T₁ and T₂ was restricted to 6 days, whereas T₃ remained acceptable up to 9 days. Thus, 10.0% partially purified CFS of *L. acidophilus* offers a safe, natural and consumer-friendly means of enhancing the keeping quality of paneer without adversely affecting its sensory characteristics and merits consideration for commercial adoption after further validation.

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