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RESEARCH ARTICLE

# Storage related changes in short-set cream cheese manufactured using thermophilic starter culture and direct acidification technique

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**Abstract:** Cream cheese is a fresh acid curd variety with semi-soft body, manufactured by the gradual, quiescent acid gelation of milk. The typical flavour profile of cream cheese is cultured diacetyl with little bit lactic acid flavour as well as aroma. It is envisaged that demand of cream cheese will increase in upcoming years due to its application as spread and it having higher nutritional value compared to similar products available in the market. The purpose of the study was to observe changes in sensory, physicochemical and microbial quality during storage in short-set cream cheese samples manufactured by using thermophilic starter culture and direct acidification technique and was compared with control cream cheese manufactured using mesophilic starter culture. All the three samples i.e., control cream cheese made using mesophilic culture (MC), cream cheese made using thermophilic culture (TC) and cream cheese made using laboratory grade lactic acid (SLA) were stored in re-closable polypropylene tubs at 7 ± 2°C. During storage study, flavour score, FFA, tyrosine value were significantly affected by storage period (P), treatment (T) and the interaction of T × P. Moisture, pH, titratable acidity, sensory parameters (except flavour) were significantly affected only by storage period (P) and treatment (T). All the three samples had storage stability up to 15 days at 7 ± 2°C.

**Keywords:** cream cheese, short-set, thermophilic culture, mesophilic culture, direct acidification

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## Introduction

Generally, fermented dairy products have been contemplated as essential foods because they provide good nutrition and immunity boosting effects to consumers. Cheese belongs to first and most popular manufactured food products. Cream cheese is a soft, mild, rich, unripened cheese and is a creamy white, slightly acidic product with a diacetyl flavor (Hirpara *et al*, 2016b). As per FSSAI (2020), cream cheese (Rahmfrischkase) is defined as a soft, unripened cheese made by coagulating pasteurized cow and/or buffalo milk, or mixtures thereof, and pasteurized cream with cultures of harmless lactic acid-producing bacteria with or without the addition of suitable coagulating enzymes. It should have not more than 55 % moisture and not less than 70 % fat on dry matter basis. It is usually manufactured by the coagulation of cream or mixture of milk and cream by acidification with starter culture (Krishna and Ghosh, 2019). Cream cheese had a more acidic flavour and contained less saturated aldehyde and ketone compounds, such as, hexanal and 2-nonanone (Pettersen et al. 2005). It is used widely as a spread to replace butter which contain ~80 percent fat. The high fat level not only increases its cost but also makes it unsuitable for those who are fat conscious. In cream cheese, the presence of non-fat solids makes it nutritionally more balanced (Hirpara *et al*, 2016a). In upcoming years, it is envisaged that the demand for cream cheese would continuously increase due to its application as value -added ingredient in various products, like spread in bread, a major ingredient in Cheese cake, etc. due to its superior nutritive value (especially protein). Though Cream cheese belongs to unripened type of cheese, around 24 to 48 h are required after manufacturing to get Cream cheese with proper fat crystallization and product structuring (FAO/WHO, 2007). Short-set cream was manufactured using thermophilic lactic culture as well as by direct-acidification technique that reduced setting time to a greater extent. Cold pack cream cheese had a shelf-life up to 3 weeks while in case of hot pack Cream cheese, the product remained acceptable till about 3 months (Kosikowski and Mistry, 1999; Lucey, 2003). One of the main issues with cream cheese that reduces its shelf life is microbial deterioration. When kept over an extended period of time, Cream cheese is more prone to growth of bacteria or molds that are heat resistant. Most spoilage microorganisms can be destroyed in cream cheese using

the processing periods and temperatures employed in its production. Therefore, it is crucial to prevent the recontamination of cream cheese. However, specific aims of this current study were: (i) to assess shelf life of optimized Cream cheese; (ii) to observe changes in the physico-chemical parameters (such as, moisture, pH, titratable acidity, free fatty acids, tyrosine value) and microbiological parameters (such as, aerobic plate count, coliform count and yeast and mold count) in the optimized Cream cheese samples during their storage at 7 ± 2°C.

**Materials and methods**

The methodology and formulation for production of Cream cheese involved different stages for the process optimization based on cold pack method as reported by (Krishna and Ghosh, 2019) with some modifications.

**Materials**

The whole milk and Cream used for manufacturing of short-set cream cheese was procured from Anubhav Dairy, Department of Dairy Processing and Operations (DDPO), Kamdhenu University, Anand. DVS culture used were Delvo Tec DX 33B DSL (mixed culture strain of *Lactococcus lactis* spp. *lactis*, *Lactococcus lactis* spp. *cremoris*, *Lactococcus lactis* spp. *lactis biovar diacetylactis* and *Leuconostoc* spp.) and Delvo fresh – DH 1040 DSL (*Streptococcus thermophilus*) supplied by DSM Nutritional Products India Pvt. Ltd. Laboratory grade lactic acid AR, supplied by Molychem, Mumbai, India, while Rennet (Maxiren®1800 Granulate) and Diacetyl (as a flavoring compound) was procured from DSM Nutritional Products India Pvt. Ltd. Iodized salt manufactured by M/S. Tata Chemicals Ltd., Mumbai was purchased from a local market in Anand.

**Manufacture of Cream cheese**

Milk was standardized to 12 % fat by addition of cream, homogenized at 65°C, followed by pasteurization at a temperature of 80°C for 30 sec. Then, pasteurized milk was divided into three parts for three treatments. For manufacture of control sample, one part of pasteurized milk was cooled down to 22°C, followed by addition of DVS mesophilic culture at a rate of 1.0U/1000 kg per kg of milk, incubated at 22°C for 16 to 18 h for curd formation. For experimental sample one, second part of milk was cooled down to 45°C, followed by addition of DVS thermophilic culture at a rate of 1.0U/1000 kg of milk. Then, the milk was incubated at 45°C for 3.5 to 4.0 h for curd formation. For second experimental sample, the third part of milk was cooled down to below 10°C, followed by addition of 20 % lactic acid to increase acidity to 0.5 % of lactic acid, heated to 25°C, added with rennet at a rate of 2.0g per 100 kg of milk. Then, milk was heated to 31°C and held at such temperature for 1 h for setting of milk. For all the three experimental samples, after the curd formation, curd was stirred, followed by washing the curd using hot water at a temperature of 76°C and then the curd was hung for 2 h to allow removal of whey. After that, salting and smoothening were done in all the three samples. The cream cheese curd formed using mesophilic culture, thermophilic culture and laboratory grade lactic acid were denoted as MC, TC and SLA samples, respectively. The short-set technique led to 55 per cent of time reduction in case of Cream cheese prepared by thermophilic culture and 70 per cent for that of Cream cheese prepared by direct acidification method. In case of TC and SLA, diacetyl was added at a rate of 0.02 and 0.03 %. All three samples were packaged in reclosable polypropylene (PP) cups, stored in refrigerator at a temperature of 7±2°C for assessment of shelf-life.

**Analysis of samples during storage**

The optimized short-set cream cheese samples as well the control cream cheese sample were subjected to sensory evaluation, physico-chemical analysis and microbiological quality analysis during storage at 7±2°C at every 3 days interval till the products remained acceptable.

**Sensory evaluation of Cream cheese during storage study**

The sensory evaluation of Cream cheese samples was done by panel of 12 judges (on the basis of duo-trio test) using 100-point scale during storage study. Details of sensory score card were referred from Singh and Tewari (1990).

**Physico-chemical attributes**

Moisture content of the product was determined by the gravimetric method (AOAC, 1995). Titratable acidity and pH of the cheese samples were measured by the method recommended in the manual of Association of Official Agricultural Chemists (AOAC, 1980). The pH readings were taken on a digital pH meter (CH-8603, M/s. Mettler Toledo AG, Schwerzenbach). Proteolytic activity expressed in terms of tyrosine value of Cream cheese was estimated by the method given by Arnott et al. (1957). The FFA content of the cheese samples was measured as per the method described by Deeth and Fitz-Gerald (1976) using BDI reagent.

**Microbiological analysis**

All the three experimental cream cheese samples were analyzed for the Aerobic Plate Count (APC) using standard plate count agar, Coliform count and Yeast and Mold count (YMC) by the methods as described in IS: 5550 (2005). The microbiological counts were expressed as log cfu/g for APC, while it was expressed as cfu/g for coliform count and YMC (FSSAI, 2012).

**Statistical analysis**

During storage study, the information in the form data (from sensory, physico-chemical and microbial parameters) of Cream cheese samples were examined using Factorial Completely

Randomized Design (Steel and Torrie, 1980). The results were analyzed using Analysis of variance. All tests were checked at 5 % level of significance.

**Results and discussion**

**Changes in Sensory Parameters of Cream Cheese during Storage at 7 ± 2°C**

During storage, Cream cheese goes through a several physico-chemical, biochemical and microbial changes such as alterations of lipolytic activity, proteolysis, acidity, pH, aerobic plate count, yeast and mold count, coliform count, etc. Ultimately, changing of these properties affects sensory parameters of Cream cheese. Therefore, accurate judgement of the organoleptic quality of Cream cheese helps to identify defects and make corrections to them. By this way, quality of Cream cheese can be improved as well as shelf-life also can be extended before launching of the product in the commercial market.

All the Cream cheese samples including control (MC) and the experimental samples (TC and SLA) were taken for sensory evaluation at every 3 days' interval. The sensory parameters studied were colour and appearance, flavour, body and texture, spreadability and total score based on 100-point scale as delineated in Table 1. After 18th day, there was drastic deterioration of sensory quality and the flavour scores obtained were below 60 % of the maximum score in all the experimental samples. Therefore, the samples of Cream cheese were analyzed till 18$^{th}$ day of storage at 7±2°C. As indicated in Table 1, colour and appearance score was significantly (P<0.05) reduced starting from Day 0 to the 18$^{th}$ day of storage. There was slight reduction in glossiness of the samples, resulting in reduction in colour and appearance scores during storage.

The extent of decrease in the colour and appearance scores denoted that Cream cheese sample made using thermophilic culture (TC) was comparatively more stable to changes in colour and appearance during storage (from 0 to 18 days) than control (MC) and SLA sample. Thus, indicating the role of starter culture in retaining better appearance of the product throughout the storage period. Such observed effect being more in cream cheese by thermophilic starter culture compared to mesophilic starter.

In the same line, Katsiari et al. (2009) observed that colour and appearance scores of Galotyri-type cheeses made from four different starter culture viz. two mesophilic (MA011 and Probat 222), one thermophilic (CH-1) and one mixed mesophilic/ thermophilic (CHOOZIT MT 1) was decreased during storage.

During storage, the mean flavour score of cream cheese using thermophilic starter was highest followed by control (MC) and SLA sample (Table 1). The flavour scores of the Cream cheese showed a progressive decline during the entire storage period. As can be observed in Table 1, the control Cream cheese sample (MC) was less stable to changes in flavour during storage (from 0 to 18 days) compared to TC and SLA samples. The extensive reduction in flavour scores for the MC sample can be attributed to comparatively higher moisture retention in the product accelerating the growth of micro-organisms during storage.

The average flavour scores remained acceptable (above 60 % of the maximum score) till 15th day of storage for all the products at 7±2°C. However, for the Cream cheese sample made by direct acidification technique (SLA), even though the product remained acceptable, there was prevalence of bitter aftertaste after 9$^{th}$ day of storage that drastically reduced its acceptability. The interaction effect (TxP) was also found to be significant, indicating both treatment as well as storage period had significant (P<0.05) effect on flavour scores of the cream cheese samples.

Similar observations have been reported by Katsiari et al. (2009) for deterioration of flavour scores of Galotyri-type cheeses made from four different starter culture viz. two mesophilic (MA011 and Probat 222), one thermophilic (CH-1) and one mixed mesophilic/thermophilic (CHOOZIT MT 1), during their 15 days storage at 4±1°C.

The changes in the body and texture scores of Cream cheese were affected significantly (P<0.05) by treatment as well as storage period. The interaction T × P remained unaffected statistically, as shown in Table 1. A linear decrease in body and texture scores of Cream cheese samples including control (MC) was observed during 18 days of storage at 7±2°C.

The values denoted that the body and texture of Cream cheese samples made using thermophilic starter culture (TC) deteriorated faster during storage (from 0 to 18 days) compared to control (MC) and SLA sample.

Katsiari et al. (2009) observed that body and texture score of Galotyri-type cheeses made from four different starter culture viz. two mesophilic (MA011 and Probat 222), one thermophilic (CH-1) and one mixed mesophilic/thermophilic (CHOOZIT MT 1) was decreased during their storage at 4±1°C.

As shown in Table 1, the spreadability scores of all the three Cream cheese samples decreased during 18 days of storage at 7±2°C. The Cream cheese sample made by direct acidification technique (SLA) was less stable to spreadability changes during storage compared to control (MC) and TC sample, the sample TC being the most stable.

The changes in the total sensory scores of Cream cheese were affected significantly (P<0.05) by treatment as well as storage period. The interaction T × P remained unaffected statistically, as can be observed in Table 1. The data indicated a significant linear decrease in total sensory scores for all the three products with increase in storage period from 0 to 18 days.

Table 1 reveals that the Cream cheese sample made by direct acidification technique (SLA) was significantly less stable to deteriorations, indicated by the sensory scores, during storage (from 0 to 18 days) compared to control (MC) and TC sample. The bitter aftertaste in the product after 9th day of storage resulted in poor sensory scores for the product. This bitterness could be due to formation of bitter peptides due to uncontrolled breakdown of proteins by residual renned during storage of the product. The hydrolysis of β-casein by rennet is the primary source of cheese bitter peptides (Meng et al. 2021).

**Chemical changes in Cream Cheese during Storage at 7 ± 2°C**

The changes in moisture content as well as physico-chemical changes during storage at 7±2°C of MC (Control), TC and SLA samples are reported in Table 2 to 6.

Moisture content in Cream cheese is very important parameter to determine extent of changes in sensory properties and growth of microorganisms during storage at 7 ± 2°C. As shown in Table 2, there was continuous decrease in percentage of moisture content of all samples i.e., control Cream cheese (MC), Cream cheese

**Table 1** Changes in sensory scores of cream cheese made using mesophilic culture (MC) thermophilic culture (TC) and laboratory grade lactic acid (SLA) during storage at 7±2°C

| Cheese sample | Days | | | | | | | Treatment (T) mean |
|---|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | 18 | |
| | | | | Colour and appearance Score* (Out of 15) | | | | |
| MC | 13.42 | 13.03 | 12.63 | 12.27 | 11.89 | 10.93 | 10.65 | 12.12[a] |
| TC | 13.38 | 13.11 | 12.64 | 12.11 | 11.85 | 11.33 | 10.90 | 12.19[a] |
| SLA | 12.52 | 12.27 | 11.99 | 11.52 | 10.94 | 10.49 | 10.05 | 11.40[b] |
| Period (P) mean | 13.11[a] | 12.81[b] | 12.42[c] | 11.97[d] | 11.56[e] | 10.92[f] | 10.53[g] | |
| | | T | | | P | | | T × P |
| CD (0.05) | | 0.15 | | | 0.23 | | | NS |
| | | | | Flavour Score* (Out of 50) | | | | |
| MC | 41.90 | 41.24 | 39.36 | 38.01 | 35.99 | 31.15 | 25.53 | 36.17[b] |
| TC | 45.63 | 43.68 | 41.94 | 40.20 | 37.91 | 34.66 | 28.83 | 38.98[a] |
| SLA | 39.20 | 38.08 | 35.43 | 30.88 | 27.73 | 26.52 | 23.75 | 31.66[c] |
| Period (P) mean | 42.24[a] | 40.99[b] | 38.91[c] | 36.36[d] | 33.88[e] | 30.78[f] | 26.04[g] | |
| | | T | | | P | | | T × P |
| CD (0.05) | | 0.45 | | | 0.69 | | | 1.19 |
| | | | | Body and texture score* (out of 20) | | | | |
| MC | 16.12 | 15.90 | 15.61 | 15.23 | 14.66 | 13.97 | 13.11 | 14.94[b] |
| TC | 16.81 | 16.49 | 16.18 | 15.92 | 15.52 | 14.65 | 13.59 | 15.59[a] |
| SLA | 14.47 | 14.12 | 13.81 | 13.53 | 13.26 | 12.86 | 12.59 | 13.52[c] |
| Period (P) mean | 15.80[a] | 15.50[a] | 15.20[b] | 14.89[b] | 14.48[b] | 13.83[c] | 13.10[d] | |
| | | T | | | P | | | T × P |
| CD (0.05) | | 0.27 | | | 0.41 | | | NS |
| | | | | Spreadability Score* (out of 10) | | | | |
| MC | 8.18 | 7.98 | 7.65 | 7.19 | 6.85 | 6.54 | 6.32 | 7.24[b] |
| TC | 8.30 | 8.12 | 7.85 | 7.54 | 7.29 | 7.10 | 6.63 | 7.55[a] |
| SLA | 7.49 | 7.29 | 7.13 | 6.93 | 6.66 | 6.28 | 5.71 | 6.78[c] |
| Period (P) mean | 7.99[a] | 7.80[b] | 7.54[c] | 7.22[d] | 6.93[e] | 6.64[f] | 6.22[g] | |
| | | T | | | P | | | T × P |
| CD (0.05) | | 0.11 | | | 0.15 | | | NS |
| | | | | Total Score*[#] (Out of 100) | | | | |
| MC | 84.69 | 83.16 | 80.24 | 73.61 | 74.38 | 67.59 | 60.60 | 74.90[b] |
| TC | 89.11 | 86.40 | 83.61 | 80.78 | 77.56 | 72.72 | 64.96 | 79.31[a] |
| SLA | 78.68 | 76.77 | 73.36 | 67.87 | 63.59 | 61.15 | 57.10 | 68.36[c] |
| Period (P) mean | 84.16[a] | 82.11[b] | 79.07[c] | 74.09[d] | 71.85[e] | 67.16[f] | 60.89[g] | |
| | | T | | | P | | | T × P |
| CD (0.05) | | 1.12 | | | 1.72 | | | NS |

*All values are average of three replications; # Package score of 5 was added to the total score

made with thermophilic starter culture (TC) and Cream cheese made by direct acidification technique (SLA) during the entire storage period of 18 days at 7±2°C. There was significant (P<0.05) loss of moisture in all Cream cheese samples affected by treatment (T) and storage period (P). The interaction T x P remained unaffected.

It was observed that Cream cheese made by direct acidification technique (SLA) was significantly more stable to changes in moisture content during storage period (from 0 to 18 days) compared to control (MC) and TC sample. The presence of starter bacteria, causing changes in protein structure, in control (MC) and TC samples might have caused higher loss of moisture during storage. Thus, higher moisture loss was observed in control Cream cheese sample (MC) followed closely by TC sample.

Similar trend has been observed in the study made by Perveen et al. (2011), they observed that moisture content in Cream cheese was decreased significantly (P<0.05) during storage at 4±1°C for 28 days. Pappa et al. (2022) also observed that moisture content decreased during storage of soft cheese prepared from goat milk with two different starter culture one being mixture of thermophilic (C-1) and mesophilic culture and another one was mesophilic (C-2).

Both pH and titratable acidity in Cream cheese are very important parameter to determine extent of changes in flavour profile and growth of microorganisms during storage. The changes in titratable acidity and pH in all three samples (MC, TC and SLA) are depicted in Table 3 and Table 4, respectively. The titratable acidity of all the samples i.e., control Cream cheese made using mesophilic starter culture (MC), Cream cheese made using thermophilic culture (TC) and Cream cheese made by direct acidification method (SLA) increased concomitantly and pH decreased during the storage period of 18 days at 7 ± 2°C.

Salman et al. (2022) also observed that titratable acidity increased during storage of soft cheese from cow milk with different LA bacteria viz. *Lactobacillus helveticus* ($S_1$), *Lactobacillus rhamnosus* ($S_2$) and *Streptococcus thermophilus* $S_{3855}$ ($S_3$). Pappa et al. (2022) observed that the pH was decreased during storage of soft cheese prepared from goat milk with two different starter cultures viz. one being mixture of thermophilic (C-1) and mesophilic culture and other was mesophilic (C-2).

As proteolysis of cheese affects both the flavour as well as texture of cheese, tyrosine value was considered to be an important factor during the current study to determine extent of proteolysis of the Cream cheese samples during storage at 7 ± 2°C. It is very much evident from the table 5 that tyrosine values of all the samples including control Cream cheese made using mesophilic starter culture (MC), Cream cheese made using thermophilic culture (TC) and Cream cheese made by direct acidification

**Table 2** Changes in moisture content of Cream cheese during storage at 7±2°C

| Cheese sample | Days | | | | | | | Treatment (T) mean |
|---|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | 18 | |
| | Moisture* (%) | | | | | | | |
| MC | 54.91 | 54.31 | 53.91 | 53.28 | 52.65 | 52.16 | 51.98 | 53.31[a] |
| TC | 52.77 | 52.43 | 52.09 | 51.73 | 51.39 | 51.14 | 51.02 | 51.80[b] |
| SLA | 51.09 | 50.69 | 50.46 | 50.15 | 49.84 | 49.62 | 49.40 | 50.18[c] |
| Period (P) mean | 52.92[a] | 52.48[b] | 52.15[c] | 51.72[d] | 51.29[e] | 50.97[f] | 50.08[g] | |
| | T | | | P | | | T × P | |
| CD (0.05) | 0.29 | | | 0.30 | | | NS | |

*All values are average of three replications

**Table 3** Changes in titratable acidity of Cream cheese during storage at 7±2°C

| Cheese sample | Days | | | | | | | Treatment (T) mean |
|---|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | 18 | |
| | Titratable acidity* (%LA) | | | | | | | |
| MC | 0.74 | 0.77 | 0.80 | 0.84 | 0.88 | 0.94 | 0.98 | 0.85[b] |
| TC | 0.78 | 0.81 | 0.85 | 0.88 | 0.91 | 0.95 | 0.99 | 0.88[a] |
| SLA | 0.68 | 0.71 | 0.74 | 0.75 | 0.78 | 0.81 | 0.84 | 0.76[c] |
| Period (P) mean | 0.73[a] | 0.76[b] | 0.79[c] | 0.82[d] | 0.86[c] | 0.90[f] | 0.94[g] | |
| | T | | | P | | | T × P | |
| CD (0.05) | 0.01 | | | 0.02 | | | NS | |

*All values are average of three replications

method (SLA) increased linearly during the storage period of 18 days.

Gursoy et al. (2010) made set type yoghurt using isolated culture of village type yoghurt i.e. *Lactobacillus delbrueckii* spp. *bulgaricus* (B3) and *Streptococcus thermophilus* (W22) with higher production ability of exopolysaccharide (EPS) and stored at 4°C up to 21th day. Here, they found that tyrosine content of set type yoghurt by wild strains (i.e., sample D, containing 1.5 % of B3 and W22) was higher, followed by sample B (having 1.5 % commercial starter and B3 culture) than other samples *viz*. sample A (having 3 % commercial starter) and sample C (having 1.5 % of both commercial starter and B3 culture). Similar increasing trend for tyrosine value for Mozzarella cheese has also been reported by Monika (2012) during storage at 7°C for 35 days and by Ahmed et al. (2011) on 28th day of storage at 4°C.

The FFA content of all the samples i.e., control Cream cheese made using mesophilic starter culture (MC), Cream cheese made using thermophilic culture (TC) and Cream cheese made by direct acidification method (SLA) increased during the storage period of 18 days at 7 ± 2°C (Table 6). The FFA content of all the three samples differed significantly, depicting the role of different cultures (mesophilic and thermophilic) and lactic acid in formation

**Table 4** Changes in pH of Cream cheese during storage at 7±2°C

| Cheese sample | Days | | | | | | | Treatment (T) mean |
|---|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | 18 | |
| | | | | pH* | | | | |
| MC | 4.38 | 4.35 | 4.27 | 4.24 | 4.21 | 4.12 | 4.05 | 4.23$^{b}$ |
| TC | 4.31 | 4.25 | 4.16 | 4.11 | 4.05 | 3.97 | 3.87 | 4.10$^{c}$ |
| SLA | 4.61 | 4.55 | 4.49 | 4.46 | 4.43 | 4.41 | 4.39 | 4.48$^{a}$ |
| Period (P) mean | 4.43$^{a}$ | 4.38$^{b}$ | 4.31$^{c}$ | 4.27$^{c}$ | 4.23$^{d}$ | 4.17$^{e}$ | 4.10$^{f}$ | |
| | | T | | P | | | T × P | |
| CD (0.05) | | 0.03 | | 0.04 | | | NS | |

*All values are average of three replications

**Table 5** Changes in tyrosine value of Cream cheese during storage at 7±2°C

| Cheese sample | Days | | | | | | | Treatment (T) mean |
|---|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | 18 | |
| | | | | Tyrosine value* (mg of tyrosine/ 5 ml of filtrate) | | | | |
| MC | 0.15 | 0.28 | 0.39 | 0.54 | 0.66 | 0.77 | 0.91 | 0.53$^{a}$ |
| TC | 0.11 | 0.24 | 0.36 | 0.49 | 0.60 | 0.68 | 0.74 | 0.46$^{b}$ |
| SLA | 0.10 | 0.19 | 0.25 | 0.33 | 0.51 | 0.57 | 0.63 | 0.37$^{c}$ |
| Period (P) mean | 0.12$^{a}$ | 0.24$^{b}$ | 0.33$^{c}$ | 0.45$^{d}$ | 0.59$^{e}$ | 0.67$^{f}$ | 0.76$^{g}$ | |
| | | T | | P | | | T × P | |
| CD (0.05) | | 0.017 | | 0.025 | | | 0.044 | |

*All values are average of three replications

**Table 6** Changes in free fatty acid content of Cream cheese during storage at 7±2°C

| Cheese sample | Days | | | | | | | Treatment (T) mean |
|---|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | 18 | |
| | | | | FFA* (meq of KOH/ 100g of Fat) | | | | |
| MC | 0.75 | 1.13 | 1.84 | 2.87 | 3.74 | 4.65 | 4.98 | 2.85$^{a}$ |
| TC | 0.70 | 1.12 | 1.55 | 2.43 | 3.30 | 4.05 | 4.47 | 2.52$^{b}$ |
| SLA | 0.54 | 0.88 | 1.24 | 2.11 | 2.91 | 3.46 | 4.05 | 2.17$^{c}$ |
| Period (P) mean | 0.66$^{a}$ | 1.04$^{b}$ | 1.54$^{c}$ | 2.47$^{d}$ | 3.32$^{e}$ | 4.05$^{f}$ | 4.50$^{g}$ | |
| | | T | | P | | | T × P | |
| CD (0.05) | | 0.12 | | 0.18 | | | 0.31 | |

*All values are average of three replications

of free fatty acids. Since, SLA sample was not having any starter bacteria, the FFA content was lower compared to other two samples. Increase in lipolytic activity during storage, that was higher in Cream cheese made by starter cultures, increased FFA content of the products substantially.

Similar increasing trend for total free fatty acid during storage has been reported by Katsiari et al. (2009) in Galotyri-type cheeses made from four different starter culture viz. two mesophilic (MA011 and Probat 222), one thermophilic (CH-1) and one mixed mesophilic/thermophilic (CHOOZIT MT 1). Based on observations reported by Atasoy and Turkoglu (2009), Urfa cheese made without starter bacteria had significantly ($P < 0.05$) higher lipolysis activity than cheese made with mesophilic or thermophilic starter culture. But, no significant ($P > 0.05$) difference was observed among the type of cultures used for making Urfa cheese.

**Microbial Changes in Cream Cheese during Storage**

During storage at 7±2°C, microbial changes of MC (Control), TC and SLA samples are indicated in Table 7.

The Aerobic Plate Count (APC) in any dairy product sample would consist of added lactic acid bacteria (LAB) along with other adventitious micro-organisms. Higher the LAB count, higher would be the APC values in cheese samples. During the present investigation, the changes in APC of Cream cheese samples were evaluated at an interval of 3 days and expressed as log cfu/g that is presented in Table 7. There was continuous increase in APC of all samples i.e., control Cream cheese made using mesophilic starter culture (MC), Cream cheese made using thermophilic culture (TC) and Cream cheese made by direct acidification method (SLA) sample during the entire storage period of 18 days.

The APC of sample MC and TC were higher since they were added with starter cultures, while sample SLA had no bacterial culture added to it.
Similar observations have been reported by Debnath (2016) for the viable lactic acid bacterial count of control Cream cheese as well as low fat, inulin and phytosterol added Cream cheese with no preservative during storage till 20th day but the counts decreased thereafter, while in cheeses with preservatives, lactic acid bacterial count increased up to 25th day of refrigeration storage.

Even Perveen et al. (2011) observed progressive increase in viable count of lactic acid bacteria in Cream cheese during storage, the count being higher at 21±1°C as compared to 4±1°C.

As per FSSAI (2020) the coliform count of Cream cheese shall not be more than 500 cfu/ g, whereas yeasts and molds count of Cream cheese shall not be more than 250 cfu/g.

The changes in yeast and mold count in all three samples (MC, TC and SLA) are delineated in Table 7. There was a continuous increase in yeast and mold count of all samples i.e., control Cream cheese made using mesophilic starter culture (MC), Cream cheese made using thermophilic culture (TC) and Cream cheese made by

**Table 7** Changes in microbiological quality of Cream cheese made using mesophilic culture (MC thermophilic culture (TC) and laboratory grade lactic acid (SLA) during storage at 7±2°C

| Cheese sample | Days | | | | | | | Treatment (T) mean |
|---|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | 18 | |
| | Aerobic plate count* (log cfu/g) | | | | | | | |
| MC | 6.12 | 6.23 | 6.32 | 6.42 | 6.55 | 6.78 | 6.96 | 6.49$^{a}$ |
| TC | 6.11 | 6.18 | 6.26 | 6.35 | 6.44 | 6.68 | 6.76 | 6.40$^{b}$ |
| SLA | 2.40 | 2.49 | 2.59 | 2.65 | 2.77 | 2.93 | 3.09 | 2.70$^{c}$ |
| Period (P) mean | 4.87$^{a}$ | 4.97$^{b}$ | 5.06$^{b}$ | 5.14$^{c}$ | 5.25$^{c}$ | 5.46$^{d}$ | 5.60$^{e}$ | |
| | | T | | P | | T × P | | |
| CD (0.05) | | 2.34 | | 0.12 | | NS | | |
| | Yeast and Mold count* (cfu/g) | | | | | | | |
| MC | 0.0 | 5.67 | 8.67 | 15.67 | 23.67 | 35.67 | 49.67 | 20.00$^{a}$ |
| TC | 0.0 | 3.33 | 7.67 | 13.67 | 23.67 | 34.67 | 46.67 | 18.52$^{b}$ |
| SLA | 0.0 | 2.67 | 6.0 | 11.67 | 19.67 | 29.67 | 40.67 | 15.76$^{c}$ |
| Period (P) mean | 0.0 | 3.89$^{a}$ | 7.45$^{b}$ | 13.67$^{c}$ | 22.34$^{d}$ | 33.34$^{e}$ | 45.67$^{f}$ | |
| | | T | | P | | T × P | | |
| CD (0.05) | | 0.33 | | 0.51 | | 0.88 | | |

*All values are average of three replications

direct acidification method (SLA) sample during the storage period of 18 days.

However, the counts remained well below the acceptable limits for yeast and mold counts as per FSSA regulations for Cream cheese even after 18 days of storage period. No visible mold growth was observed in the products at the end of storage period. Coliforms were absent in 1.0 g Cream cheese samples stored at 7±2°C during the entire storage period. This indicates good, hygienic manufacturing practices and purity of cultures used. Makhal et al. (2015) made Cottage cheese using microGRAD by direct acidification technique to improve shelf life of Cottage cheese. Here, yeast and mold count in the fresh control samples were 0 that increased to 0.60 log cfu/g on 28th day of storage.

Pappa et al. (2022) observed that yeast and mold count were found at end of storage (60 days at 4±1°C) for soft cheese prepared from goat milk with two different starter culture viz. one with mixture of thermophilic (C-1) and mesophilic culture and another one with only mesophilic (C-2).

## Conclusion

Acceptable quality Cream cheese can be obtained by short-set technique by using thermophilic starter (TC) and by direct acidification (SLA) with addition of pure diacetyl flavour. The standardized products along with control (MC, made by using mesophilic culture) remained stable till 15 days of storage at 7±2°C temperature when packaged in re-closable polypropylene (PP) cups. However, there remains further scope for improving the flavour as well as body and texture profile of Cream cheese prepared by direct acidification technique. Also, further improvement in shelf-life of the cream cheese samples can be obtained by technological interventions including thermal treatment and natural preservative addition.

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## References

Ahmed NS, Abd El-Gawad MA, El-Abd MM, Abd-Rabou NS (2011) Properties of buffalo Mozzarella cheese as affected by type of coagulant. Acta Sci Pol Technol Aliment 10(3): 339-357

AOAC (1980) Methods of analysis. Association of Official Analytical Chemists (pp. 272- 274), Washington, DC

AOAC. (1995) Official Methods of Analysis. Association of Official Analytical Chemists, Washington, DC

Arnott DR, Morris, HA, Combs WB (1957) Effect of certain chemical factors on the melting quality of process cheese. J Dairy Sci 40(8): 957-963

Atasoy AF, Turkoglu H (2009) Lipolysis in Urfa cheese produced from raw and pasteurized goats' and cows' milk with mesophilic or thermophilic cultures during ripening. Food Chem 115(1): 71-78

Debnath A (2016) Development of cream cheese fortified with inulin and phytosterol Doctoral dissertation, NDRI, Karnal, Haryana, India, https://krishikosh.egranth.ac.in/handle/1/5810060795.

Deeth HC, Fitz-Gerald CH (1976) Lipolysis in dairy products: a review. Aust J Dairy Technol 31(5): 53-64

FAO/WHO (2007) Codex standard for cream cheese. Codex Alimentarius Milk and Milk Products, pp. 158–164, Communication Division FAO, Rome. (www.codexalimentarius.net/web/standard list)

FSSAI (2012) Manual on method of microbiological testing. Food Safety and Standards Authority of India, New Delhi

FSSAI (2020) Food Safety and Standards (Food Products Standards and Food Additives) Regulations. Food Safety and Standard Authority of India, New Delhi. pp 63-64

Gursoy A, Durlu-Ozkaya F, Yildiz F, Aslim B (2010) Set type yoghurt production by exopolysaccharide producing turkish origin domestic strains of *Streptococcus thermophilus* (W22) and *Lactobacillus delbrueckii* ssp. *bulgaricus* (B3). Kafkas Universitesi Veteriner Facultesi Dergisi, 16, S81-6.

Hirpara K, Patel HG, Gokhale, AJ, Mallik, JM (2016b) Influence of type of culture on compositional, physico-chemical, rheological and sensory attributes of Processed Cream Cheese based (PCCB) spread. Indian J Dairy Sci 69(2): 1-7

Hirpara K, Patel HG, Gokhale, AJ, Patel, AM (2016a) Effect of level of fat on compositional, physico-chemical, rheological and sensory attributes of processed cream cheese based (PCCB) spread. Indian J Dairy Sci 69(1): 1-7

IS (2005) Indian Standard specification for Burfi, Indian Standards Institution, New Delhi

Katsiari MC, Kondyli E, Voutsinas LP (2009) The quality of Galotyri-type cheese made with different starter cultures. Food Control 20(2): 113-118

Kosikowski FV, Mistry VV (1999) Bakers', Neufchatel, cream, quark, and ymer. In Kosikowski FV (ed.) Cheese and Fermented Milk Foods: Procedures and Analysis, Vol. II, L.L.C., Virginia, pp 42-55

Krishna KN, Ghosh BC (2019) Development of reduced fat cream cheese by using inulin and WPC as a fat replacer. Indian J Dairy Sci 72(6): 590-598

Lucey JA (2003) Acid and acid/heat coagulated cheese. In Fox PF, McSweeney PLH (Eds.), Encyclopedia of dairy sciences, Academic Press, London, United Kingdom, pp. 350-356.

Makhal S, Kanawjia SK, Giri A (2015) Effect of micro GARD on keeping quality of direct acidified Cottage cheese. J Food Sci Technol 52(2): 936-943

Meng F, Zhao H, Lu F, Bie X, Lu Z, Lu Y (2021) Novel Bacillus milk-clotting enzyme produces diverse functional peptides in semihard cheese. J Agric Food Chem69 (9): 2784-2792. DOI: 10.1021/acs.jafc.0c08120.

Monika H (2012) To develop technology for manufacture of Mozzarella cheese using recombined milk PhD Dissertation, Punjab Agricultural University, Ludhiana, Punjab, India.

Pappa EC, Kondyli E, Bosnea L, Malamou E, Vlachou AM (2022) Chemical, microbiological, sensory, and rheological properties of fresh goat milk cheese made by different starter cultures during storage. J Food Process Eng 45(7): 1-10

Perveen K, Alabdulkarim B, & Arzoo S (2011) Effect of temperature on shelf life, chemical and microbial properties of cream cheese. African J Biotechnol 10(74): 16924-16928

Pettersen MK, Eie T, Nilsson A (2005) Oxidative stability of cream cheese stored in thermoformed trays as affected by packaging material, drawing depth and light. Intl Dairy J 15(4): 355-362

Salman KH, Ali FAZ, Elhanbaly R (2022) Effect of cultured white soft cheese on the histopathological changes in the kidneys and liver of albino rats. Sci Reports 12(1): 1-17

Singh S, Tewari BD (1990) Optimization of manufacturing technique for cream cheese. Indian J Dairy Sci 43(3): 428-432

Steel RG, Torrie JH (1980) Principles and Procedures of Statistics-a Biometrical Approach, 2nd Edn. New York: McGraw-Hill, pp 137-167