“Effect of sorbic acid on the storage quality of *Kaladhi*-an acid coagulated milk product”

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Abstract The present study was conducted to determine the effect of three different levels of sorbic acid (0.1 %, 0.2 % and 0.3 %) on the shelf life and storage quality of *Kaladhi*. *Kaladhi* was prepared from pasteurized buffalo milk standardized to 6 % fat and 9 % SNF with coagulation at 40 °C using 5 % lactic acid as a coagulant. *Kaladhi* prepared without sorbic acid served as control and was compared with the products treated with different levels of sorbic acid for a storage period of 35 days at ambient temperature. The results showed a significant ($P<0.05$) effect of sorbic acid on most of the physicochemical parameters i.e. titratable acidity, free fatty acid content (% oleic acid) and thiobarbituric acid value which showed a decreasing trend with increasing concentration of sorbic acid. However, a non-significant ($P>0.05$) effect of sorbic acid was observed on pH and proximate parameters of the product. *Kaladhi* treated with 0.3 % sorbic acid retained most desirable physicochemical and sensory properties throughout the storage period hence, was considered the best.

Keywords *Kaladhi* · Sorbic acid · Ambient storage · Quality attributes

Introduction

Traditional dairy products are an integral part of Indian heritage and possess great social, religious, cultural, medicinal and economic importance. In addition to preservation of milk solids for longer time at room temperature, manufacture of traditional dairy products add value to milk and also provide tremendous employment opportunity (Pal and Raju 2007). Traditional dairy products not only have established market in India but also great export potential because of strong presence of Indian diaspora in many parts of the world (Rao and Raju 2003).

Scenario of cheese production in India is quite bright because of the facts that cheese has all the beneficial attributes of an ideal dairy product. Furthermore, emergence of new global economic reforms has unfastened the door to the Indian dairy industry to penetrate the international cheese market (Kanawjia 2007). Technologies have been appropriately standardized for manufacture of various types of cheeses and have evolved to such an extent that most cheese is produced by employing modern technology. Hence, if traditional Indian cheese varieties like *Kaladhi* are proposed to be marketed on commercial scales, it becomes imperative that suitable technologies be developed for their production, packaging and preservation (Bukhari et al. 2012).

Kaladhi is a hard and dry cheese variety of Jammu and Kashmir which is prepared by directly acidifying the milk with organic acids without the use of rennet and starter. It is prepared by acidifying milk with some easily available organic acids as coagulating agents and working out coagulum into a pat. Small balls made out of the pat are later given a circular shape of varying diameters. The product is prepared either from cow's or buffalo's or sheep's milk or a mixture thereof.

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Besides being a salubrious food, it is believed to possess antidiarrhoeal, anticold and antitussive properties (Pal et al. 2003; Bukhari et al. 2011, 2012). Buttermilk cheeses in Europe, Tibet cheese in Tibet, *Chugga* or *Churpi* in Nepal and native *paneer* are some of the documented products with similarities in characteristics and utilization (Pal et al. 2003; Bukhari et al. 2011, 2012). The typical acidic flavor and preparation procedure differentiate *Kaladhi* from similar coagulated milk products. It is mostly prepared as a cottage enterprise with hardly any control over the quality with main problem being its limited shelf life because of spoilage by various microorganisms especially by molds attributed to its low pH. Mold growth not only affects the appearance but also results in the production of off-flavors and off-odors besides causing toxicity in the product. Thus, there is an ample scope for extending the shelf life of the product.

Sorbic acid (2, 4 hexadienoic acid) is a well established natural organic compound used as a food preservative. It acts up to the pH of 6.5 and reduces the various lipolytic changes. Its activity gets enhanced with decreasing pH of the product. Singh et al. (1989) reported a shelf life of 36 days in *paneer* stored at room temperature using sorbic acid at 0.15 %. Thus, in lieu of all these facts and lack of scientific reports on the same, an attempt was made to study the effect of different levels of sorbic acid (0.1 %, 0.2 % and 0.3 %) on the shelf life and storage quality of *Kaladhi*.

Materials and methods

Kaladhi was stored at ambient temperature in the bamboo baskets covered with muslin cloth for 35 days without any packaging. Traditionally the product is also stored in the baskets. The samples were drawn at regular intervals on 0th (after addition of sorbic acid), 14th, 28th and 35th day and evaluated for the various parameters.

Source of milk

Fresh buffalo milk procured from the local market of Jammu was used in all the experiments after suitable standardization as per the Pearson Square Method. Buffalo milk was standardized to 6 % fat level with 9 % SNF to develop the *Kaladhi* with most desirable quality characteristics (Ahmad et al. 2010). Standardized milk was pasteurized and each batch of *Kaladhi* was prepared from 10 kg of milk.

Preparation of *Kaladhi*

Fresh buffalo milk standardized to 6 % fat and 9 % SNF was coagulated at 40 °C to obtain the *Kaladhi* with most desirable

quality characteristics (Ahmad et al. 2010; Bukhari et al. 2012). Traditionally the milk is also coagulated at the same temperature to obtain product with desirable quality.

Standardized buffalo milk was heated to 40 °C and coagulated at this temperature using 5 % lactic acid as a coagulant till the attainment of a uniform curd. The curd was immediately drained through muslin cloth without pressing. The curd was then opened, molded into pieces of convenient size and placed in petri plates of uniform size used as moulds. The curd was then taken out of the moulds and allowed to dry at room temperature in bamboo baskets. Regular turning of the product after 5 h interval was ensured for at least 3 days until sufficient moisture was lost through evaporation. The product was allowed to dry in a clean and moisture free environment abstaining from direct sun drying. *Kaladhi* was dipped in sorbic acid solutions after drying i.e. on 3rd day for 30 s. *Kaladhi* which was not dipped in the sorbic acid solution served as control. The wet yield was taken immediately after production and the dry yield on 3rd day after drying.

Acid coagulant

5 % lactic acid was used as a coagulant in the present study to develop this dairy product with most desirable quality characteristics (Bukhari et al. 2012).

Analytical procedures

pH

The pH of *Kaladhi* was determined as per the method of O'Keeffe et al. (1976) by using a digital pH meter (Systronics Digital pH Meter 802, Serial No. 603).

Proximate composition

The moisture, protein, fat and ash content of *Kaladhi* were determined by standard methods using hot air oven (Yorco sales Pvt. Ltd. India, Model-YS1-431, S. No. 02B2843), Kjeldhal assembly, Soxhlet extraction apparatus, and Muffle furnace respectively (AOAC 1995).

Thio barbituric acid (TBA) value

Thiobarbituric acid value of *Kaladhi* was determined using the method of Witte et al. (1970).

Free fatty acids

The method suggested by Koniecko (1979) was followed to measure the free fatty acids in *Kaladhi* samples.

Titrateable acidity

The method as described by AOAC (1995) for cheese was followed to determine the titrateable acidity in *Kaladhi*.

Sensory evaluation

The sensory evaluation of the product was carried for attributes, namely appearance, flavour, juiciness, sourness, texture and the overall acceptability of fresh and stored samples by a panel of seven experienced members composed of scientists and research scholars of the Division based on a 8-point descriptive scale, wherein 8 denoted “extremely desirable” and 1 denoted “extremely undesirable” (Seman et al. 1987). Coded samples for sensory evaluation were prepared by shallow frying of *Kaladhi* in oil and served warm to panelists.

Statistical analysis

Each experiment was replicated thrice in duplicate. Means and standard errors were calculated for different parameters. Factorial design of experiment was followed. Analysis of variance (Two-way ANOVA for storage studies and One-way ANOVA for sensory studies) was performed using statistical software package (SPSS-16). The data obtained were subjected to Duncan’s multiple range tests for comparing the means to find

the effects between treatments and storage periods for various parameters in different experiments at 5 % level of significance. There were seven sensory judges for each treatments x replication combination.

Results and discussion

Physicochemical parameters

The Mean $\pm$ SE values of various physicochemical parameters of *Kaladhi* at different storage periods are presented in Table 1.

pH

The mean pH values of *Kaladhi* for control samples as well as for all sorbic acid treated samples on 0th day of storage were significantly ($p < 0.05$) higher than the mean values of *Kaladhi* on all other days of storage. The mean values of pH on 14th, 28th and 35th day were comparable to each other for all the treatments as well as control. The highest values were observed on 0th day of storage for all the samples. The values showed a decreasing effect of storage on the pH of the *Kaladhi*. Bukhari et al. (2012) also reported a declining trend in the pH of the *Kaladhi* stored at ambient temperature. Pal and

Table 1 Effect of ambient storage (21–25 °C) on physico-chemical characteristics of *Kaladhi* treated with different concentrations of sorbic acid (Mean $\pm$ SE)*

Treatments	Storage period (days)			
	0	14 pH	28	35
Control	4.2 $\pm$ 0.03 ^A	4.1 $\pm$ 0.03 ^B	4.0 $\pm$ 0.04 ^B	4.0 $\pm$ 0.03 ^B
0.1 % sorbic acid	4.2 $\pm$ 0.03 ^A	4.0 $\pm$ 0.03 ^B	4.0 $\pm$ 0.02 ^B	4.0 $\pm$ 0.02 ^B
0.2 % sorbic acid	4.2 $\pm$ 0.02 ^A	4.1 $\pm$ 0.02 ^B	4.0 $\pm$ 0.02 ^B	4.0 $\pm$ 0.02 ^B
0.3 % sorbic acid	4.2 $\pm$ 0.02 ^A	4.1 $\pm$ 0.03 ^{AB}	4.1 $\pm$ 0.03 ^B	4.1 $\pm$ 0.03 ^B
Titrateable acidity (% Lactic acid)				
Control	0.490 $\pm$ 0.0023 ^A	0.529 $\pm$ 0.0030 ^{aB}	0.550 $\pm$ 0.0031 ^{aC}	0.566 $\pm$ 0.0036 ^{aD}
0.1 % sorbic acid	0.490 $\pm$ 0.0017 ^A	0.525 $\pm$ 0.0030 ^{abB}	0.545 $\pm$ 0.0024 ^{abC}	0.551 $\pm$ 0.0082 ^{abC}
0.2 % sorbic acid	0.489 $\pm$ 0.0021 ^A	0.523 $\pm$ 0.0026 ^{abB}	0.541 $\pm$ 0.0026 ^{bcC}	0.555 $\pm$ 0.0021 ^{abD}
0.3 % sorbic acid	0.489 $\pm$ 0.0020 ^A	0.520 $\pm$ 0.0020 ^{bB}	0.537 $\pm$ 0.0023 ^{bcC}	0.548 $\pm$ 0.0021 ^{bD}
Free fatty acids (% Oleic acid)				
Control	0.0573 $\pm$ 0.0003 ^A	0.0623 $\pm$ 0.0004 ^{aB}	0.0667 $\pm$ 0.0009 ^{aC}	0.0701 $\pm$ 0.0009 ^{aD}
0.1 % sorbic acid	0.0573 $\pm$ 0.0002 ^A	0.0615 $\pm$ 0.0003 ^{abB}	0.0637 $\pm$ 0.004 ^{bcC}	0.0676 $\pm$ 0.004 ^{bD}
0.2 % sorbic acid	0.0573 $\pm$ 0.0002 ^A	0.0608 $\pm$ 0.0004 ^{bB}	0.0624 $\pm$ 0.05 ^{bcC}	0.0654 $\pm$ 0.004 ^{cdD}
0.3 % sorbic acid	0.0573 $\pm$ 0.0003 ^A	0.0596 $\pm$ 0.0004 ^{cB}	0.0612 $\pm$ 0.003 ^{cC}	0.0627 $\pm$ 0.005 ^{cdD}
TBA (mg mal./ Kg)				
Control	0.276 $\pm$ 0.0038 ^A	0.375 $\pm$ 0.0031 ^{aB}	0.792 $\pm$ 0.0032 ^{aC}	1.217 $\pm$ 0.0033 ^{aD}
0.1 % sorbic acid	0.276 $\pm$ 0.0032 ^A	0.363 $\pm$ 0.0030 ^{bB}	0.730 $\pm$ 0.0038 ^{bcC}	1.191 $\pm$ 0.0029 ^{bD}
0.2 % sorbic acid	0.276 $\pm$ 0.0031 ^A	0.337 $\pm$ 0.0034 ^{cB}	0.708 $\pm$ 0.0045 ^{cC}	1.172 $\pm$ 0.0044 ^{cdD}
0.3 % sorbic acid	0.276 $\pm$ 0.0030 ^A	0.318 $\pm$ 0.0031 ^{dB}	0.682 $\pm$ 0.0035 ^{dC}	1.146 $\pm$ 0.0043 ^{dD}

*Mean $\pm$ SE with different superscripts in a column wise (small alphabet) and row wise (Capital alphabet) differ significantly ($P < 0.05$)
 $n = 6$ for each treatment

Garg (1989), Kumar and Bector (1991) and Pal et al. (1993) reported similar findings in *paneer*. Alalade and Adeneye (2007) also reported a decreasing effect of storage on pH values of *Wara Cheese* under frozen storage.

Perusal of the data indicates that the pH values did not fall within the range of reported values for similar coagulated milk products like *paneer* probably because the acid used for coagulation in the present study furnished a higher hydrogen-ion concentration in the final product. Further, the amount of acid used for coagulation of milk for *Kaladhi* preparation is more than that used in *paneer* preparation because of lower temperature of coagulation (40 °C).

Titrateable acidity

The mean values of titrateable acidity of *Kaladhi* increased significantly ($p<0.05$) in all the treatments as well as in control samples throughout the period of storage. However, the mean values of 0.1 % sorbic acid treated *Kaladhi* on 28th and 35th day were comparable ($p>0.05$) to each other. On 0th day, the mean values of titrateable acidity were comparable to all treated and control samples. The mean values of control samples were significantly ($p<0.05$) higher than 0.3 % sorbic acid treated *Kaladhi* samples from the 14th day onwards. However, the values of both 0.1 % and 0.2 % sorbic acid treated samples were comparable ($p>0.05$) with control and 0.3 % sorbic acid treated samples. In treated samples, the rate of increase was slower when compared with control. Bukhari et al. (2012) also reported an increasing trend in the titrateable acidity of *Kaladhi* stored at ambient temperature. Pal and Garg (1989), Kumar and Bector (1991) and Pal et al. (1993) also observed similar findings in *paneer*.

The mean values of titrateable acidity of *Kaladhi* indicate that the rate of increase in sorbic acid treated samples was lower in comparison to control samples because sorbic acid is an antimicrobial agent and it retards the growth of spoilage causing organisms. Similar findings were observed by Pal and Garg (1989), Shukla and Vaid (2004) and Sanyal et al. (2006) in *paneer*, oil based *paneer* pickle and reduced fat *paneer* respectively.

Free fatty acids (% Oleic acid)

The mean free fatty acid values of *Kaladhi* increased significantly ($p<0.05$) in all the treatments as well as in control samples throughout the period of storage. The mean free fatty acid values of control samples were significantly ($p<0.05$) higher than all treated samples from 14th day onwards. However, the values of control on 14th day were comparable to the free fatty acid values of 0.1 % sorbic acid treated samples. Among the treatments, the free fatty acids values showed a significantly ($p<0.05$)

decreasing trend on all days of storage with increasing level of sorbic acid. On 35th day, the values for free fatty acids differed significantly ($p<0.05$) among all the samples, being highest for control and lowest for 0.3 % sorbic acid treated sample.

The free fatty acids values of control samples increased more rapidly. Bukhari et al. (2012) also reported similar increase in the free fatty acid values of *Kaladhi* stored at ambient temperature. The rate of increase of free fatty acid values was lower in case of sorbic acid treated samples in comparison to control. The probable reason may be that sorbic acid is an antimicrobial agent and it retards the growth of spoilage causing organisms. Similar types of findings were observed by Pal and Garg (1989), Shukla and Vaid (2004) and Sanyal et al. (2006) in *paneer*, oil based *paneer* pickle and reduced fat *paneer* respectively.

Thiobarbituric acid value (mg malonaldehyde/ Kg)

The mean thiobarbituric acid values of *Kaladhi* showed significantly ($p<0.05$) increasing trend throughout the period of storage in all the treated samples as well as in control. The mean thiobarbituric acid values of the control *Kaladhi* showed significantly ($p<0.05$) higher values than treated samples from the 14th day of storage onwards whereas on 0th day, the values were comparable. Among the treated samples the values showed a significantly decreasing trend with increasing level of sorbic acid on all days of storage except on 0th day when the values were comparable to each other. In treated samples, the rate of increase was slower when compared with control. The rate of increase was lowest for 0.3 % sorbic acid treated sample (value increased from 0.276 to 1.146) as the rate of increase was indirectly related to the level of sorbic acid. The probable reason may be that sorbic acid being an antimicrobial agent retards the growth of spoilage causing organisms and thus reduces the lipolytic changes. Bukhari et al. (2012) also reported similar increase in the thiobarbituric acid values of *Kaladhi* stored at ambient temperature. Similar types of findings were observed by Pal and Garg (1989), Kumar and Bector (1991), Pal et al. (1993), Shukla and Vaid (2004) and Sanyal et al. (2006) in *paneer*.

All these findings observed during storage could be supported by the fact that the product was exposed to spoilage causing microorganisms since it was stored at temperatures most suitable for the growth of such invasive microorganisms. Therefore, all the changes during storage reported in the present study were probably due to the growth of spoilage causing organisms. Similar findings were reported by a number of other workers as well (Bukhari et al. 2012; Pal and Garg 1989; Kumar and Bector 1991 and Pal et al. 1993).

Proximate composition

The Mean $\pm$ SE values for proximate composition of *Kaladhi* are presented in Table 2.

Moisture

The mean values of moisture percentage of *Kaladhi* decreased significantly ($p < 0.05$) throughout the period of storage for all the treated samples and control up to 28th day of storage. The mean values of moisture percentage of the treated samples and control were comparable to each other on all days of storage except on 28th day of storage when mean moisture value of control was significantly lower than 0.3 % sorbic acid treated sample. Among the treatments, there was a non-significant ($p < 0.05$) difference throughout the storage period. The decrease in moisture content over the storage period might be due to loss of some amount of moisture by evaporation as the product was exposed to open ambient environment. Similar trend was reported by Bukhari et al. (2012) who also reported a decreasing trend in the moisture content of the *Kaladhi* stored at ambient temperature. Rao et al. (1984), Arora and Gupta (1980), Shukla and Vaid (2004) and Sanyal et al. (2006) also reported similar findings in *paneer*.

The mean moisture values of *Kaladhi*, however, are much lower than those reported for *paneer*. Since *paneer*

is kept in water in market practice whereas *Kaladhi* is regularly turned during storage to allow for maximum evaporative loss of moisture, it can be the most appropriate reason for such a variation.

Fat

The mean values of the fat percentage of *Kaladhi* of all treatment samples as well as control decreased significantly ($p < 0.05$) throughout the storage period. However, the difference remained non-significant ($p < 0.05$) between various treatments throughout the storage period. In general, the fat content of *Kaladhi* decreased with increasing storage period but the rate of decrease was slower in sorbic acid treated samples. This decrease in the total fat content of the product stored at ambient temperature might be a result of loss of fat/leaching out of fat from the product during storage which is in agreement with the results of Bukhari et al. (2012) who reported a similar loss of fat/leaching out of fat from the product and also observed a similar decrease in the fat content of *Kaladhi* during storage at ambient temperature. As the product is not stored under refrigerated conditions and is not packaged under traditional conditions, some of the fat and protein leach-out from the product during storage particularly during summer season. This decrease in the fat content can also be attributed to greater microbial load in the product which might have caused lipolysis to a greater

Table 2 Effect of ambient storage (21–25 °C) on proximate composition of *Kaladhi* treated with different concentrations of sorbic acid (Mean $\pm$ SE)*

Treatments	Storage period (days)			
	0	14	28	35
	Moisture (%)			
Control	31.2 $\pm$ 0.22 ^A	29.8 $\pm$ 0.23 ^B	28.8 $\pm$ 0.19 ^{aC}	28.4 $\pm$ 0.23 ^C
0.1 % sorbic acid	31.5 $\pm$ 0.16 ^A	30.1 $\pm$ 0.18 ^B	29.2 $\pm$ 0.16 ^{abC}	28.9 $\pm$ 0.16 ^C
0.2 % sorbic acid	31.3 $\pm$ 0.24 ^A	30.2 $\pm$ 0.16 ^B	29.3 $\pm$ 0.15 ^{abC}	29.1 $\pm$ 0.23 ^C
0.3 % sorbic acid	31.0 $\pm$ 0.36 ^A	30.2 $\pm$ 0.18 ^B	29.4 $\pm$ 0.17 ^{bC}	29.1 $\pm$ 0.17 ^C
Fat (%)				
Control	37.4 $\pm$ 0.20 ^A	36.9 $\pm$ 0.19 ^B	36.4 $\pm$ 0.15 ^{aC}	35.8 $\pm$ 0.14 ^{aD}
0.1 % sorbic acid	37.5 $\pm$ 0.20 ^A	37.1 $\pm$ 0.19 ^{AB}	36.7 $\pm$ 0.18 ^{abBC}	36.2 $\pm$ 0.19 ^{abC}
0.2 % sorbic acid	37.5 $\pm$ 0.18 ^A	37.1 $\pm$ 0.14 ^{AB}	36.8 $\pm$ 0.15 ^{abBC}	36.5 $\pm$ 0.16 ^{bcC}
0.3 % sorbic acid	37.5 $\pm$ 0.19 ^A	37.3 $\pm$ 0.16 ^{AB}	36.9 $\pm$ 0.17 ^{bBC}	36.7 $\pm$ 0.18 ^{cC}
Protein (%)				
Control	25.1 $\pm$ 0.18 ^A	24.8 $\pm$ 0.22 ^{AB}	24.4 $\pm$ 0.22 ^B	24.2 $\pm$ 0.21 ^{aB}
0.1 % sorbic acid	25.2 $\pm$ 0.16 ^A	24.9 $\pm$ 0.17 ^{AB}	24.5 $\pm$ 0.18 ^B	24.4 $\pm$ 0.18 ^{abB}
0.2 % sorbic acid	25.2 $\pm$ 0.17 ^A	24.9 $\pm$ 0.17 ^{AB}	24.6 $\pm$ 0.15 ^B	24.5 $\pm$ 0.16 ^{abB}
0.3 % sorbic acid	25.2 $\pm$ 0.14	25.1 $\pm$ 0.15	24.9 $\pm$ 0.16	24.8 $\pm$ 0.16 ^b
Ash (%)				
Control	2.38 $\pm$ 0.02 ^A	2.42 $\pm$ 0.02 ^{AB}	2.45 $\pm$ 0.02 ^B	2.46 $\pm$ 0.02 ^B
0.1 % sorbic acid	2.37 $\pm$ 0.02 ^A	2.40 $\pm$ 0.02 ^{AB}	2.42 $\pm$ 0.02 ^{AB}	2.44 $\pm$ 0.02 ^B
0.2 % sorbic acid	2.39 $\pm$ 0.01 ^A	2.41 $\pm$ 0.02 ^{AB}	2.45 $\pm$ 0.02 ^{AB}	2.47 $\pm$ 0.02 ^B
0.3 % sorbic acid	2.39 $\pm$ 0.01 ^A	2.41 $\pm$ 0.02 ^{AB}	2.44 $\pm$ 0.02 ^B	2.46 $\pm$ 0.01 ^B

*Mean $\pm$ SE with different superscripts in a column wise (small alphabet) and row wise (Capital alphabet) differ significantly ($P < 0.05$)

$n=6$ for each treatment

extent. As sorbic acid reduced the microbial counts significantly ($p<0.05$), the rate of decrease of fat was slower in sorbic acid treated samples. Rao et al. (1984), Arora and Gupta (1980), Shukla and Vaid (2004) and Sanyal et al. (2006) also reported a decrease in fat content of *paneer* during storage.

Fat content of *Kaladhi* ranged from 35.80 % to 37.50 % which appear to be higher than the values reported for *paneer*. A higher fat content of *Kaladhi* may be attributed to a much lower moisture content of the final product. The values, however, were in agreement with the values of *Kaladhi* prepared by Bukhari et al. (2011) by using citric acid as a coagulant.

Protein

The mean protein percentage values of *Kaladhi* for all the treated samples as well as control were comparable ($p>0.05$) to each other on all days of storage except on 35th day when the control values were significantly lower than 0.3 % sorbic acid treated samples. In general, the protein values of *Kaladhi* showed a significantly ($p<0.05$) decreasing trend throughout the storage period for all the treatment samples as well as control. This decrease in the protein content of the product stored at ambient temperature might be a result of loss of proteins/leaching out of proteins from the product during storage which is in agreement with the results of Bukhari et al. (2012) who reported a similar loss/leaching-out of proteins and fats from the *Kaladhi* during storage at ambient temperature and also observed a similar decrease in the protein content of the *Kaladhi*. The decrease in the protein content during storage can also be attributed to greater microbial load in the product which might have caused proteolysis to a greater extent. Rao et al. (1984), Arora and Gupta (1980), Shukla and Vaid (2004) and Sanyal et al. (2006) also observed a decrease in fat content of *paneer* during storage. Kilic et al. (2004) also reported a similar decrease in protein content of Turkish fresh goat cheese during storage.

The protein values of the *Kaladhi* were higher as compared to the values in *paneer* which may be attributed to a reasonably lower moisture content of *Kaladhi* as compared to *paneer*.

Ash

The mean ash percentage values of *Kaladhi* of control as well as treatment samples showed a significantly ($p<0.05$) increasing trend throughout the period of storage. However, the ash content of control as well as treated samples were comparable ($p>0.05$) to each other on all days of storage. The decrease in the moisture content of the *Kaladhi* over the storage period might be the reason for the increase in the ash content of the *Kaladhi*. Bukhari et al. (2012) also observed a

similar increase in the ash content of the *Kaladhi* stored at ambient temperature. Similar trends were reported by Rao et al. (1984), Arora and Gupta (1980), Shukla and Vaid (2004) and Sanyal et al. (2006) in *paneer* during storage.

Sensory parameters

The Mean $\pm$ SE values for various sensory attributes of *Kaladhi* are presented in Table 3. The values for appearance and color ranged from 7.3 to 7.5 with highest score (7.5) for control samples and the lowest score (7.3) for the samples treated with 0.3 % sorbic acid. The appearance and color scores of control samples were significantly ($p<0.05$) higher than 0.3 % sorbic acid treated samples and were comparable ($p>0.05$) to the scores of 0.1 % sorbic acid and 0.2 % sorbic acid treated samples. All the three samples treated with sorbic acid were comparable ($p>0.05$) to each other however, the scores showed a decreasing trend. In general, the addition of sorbic acid did not cause any deleterious effect on the appearance and color scores of *Kaladhi*. These findings were in agreement with Pal et al. (1993) and Sanyal et al. (2006) who also observed similar trends in case of *paneer*.

The values for flavor ranged from 7.3 to 7.6 with highest score for the control samples and the lowest score for the samples treated with 0.3 % sorbic acid showing a decreasing trend. The scores for control samples were significantly ($p<0.05$) higher than 0.3 % sorbic acid treated samples. However, the samples treated with sorbic acid were comparable ($p>0.05$) to each other. The decreasing trend of the flavor scores may be attributed to the slight bitterness that sorbic acid added to the product and comparatively higher fat levels of the control samples. These findings were in agreement with Pal et al. (1993) and Sanyal et al. (2006) who also reported similar results in case of *paneer*.

The scores for texture ranged from 7.7 to 7.5 with highest scores for the control samples and the lowest scores for the

Table 3 Effect of various concentrations of sorbic acid on the sensory attributes of *Kaladhi* (Mean $\pm$ SE)*

Sorbic acid levels (%)				
Parameters	Control	0.1 %	0.2 %	0.3 %
Appearance & colour	7.5 $\pm$ 0.06 ^a	7.5 $\pm$ 0.08 ^{ab}	7.4 $\pm$ 0.06 ^{ab}	7.3 $\pm$ 0.07 ^b
Flavor	7.6 $\pm$ 0.07 ^a	7.5 $\pm$ 0.07 ^{ab}	7.4 $\pm$ 0.06 ^{ab}	7.3 $\pm$ 0.07 ^b
Texture	7.7 $\pm$ 0.04 ^a	7.6 $\pm$ 0.04 ^b	7.5 $\pm$ 0.03 ^b	7.6 $\pm$ 0.04 ^b
Sourness	7.4 $\pm$ 0.07	7.4 $\pm$ 0.07	7.3 $\pm$ 0.06	7.2 $\pm$ 0.06
Overall acceptability	7.7 $\pm$ 0.08	7.7 $\pm$ 0.07	7.6 $\pm$ 0.07	7.6 $\pm$ 0.08

* Mean $\pm$ SE with different superscripts in a row differs significantly ($P<0.05$)

$n=21$ for each treatment

samples treated with 0.2 % sorbic acid. The mean texture score of control samples was significantly ($p < 0.05$) higher than all samples treated with sorbic acid. However, the samples treated with sorbic acid were comparable ($p > 0.05$) to each other. The mean scores for sourness ranged from 7.2 to 7.4 with highest score observed for control samples followed in order by 0.1 % sorbic acid, 0.2 % sorbic acid and 0.3 % sorbic acid treated samples. The sourness scores of all the sorbic acid treated samples and control were comparable ($p > 0.05$) to each other. The antimicrobial nature of sorbic acid may be responsible for the decreasing sourness of the product with increasing levels of the sorbic acid. The values for overall acceptability ranged between 7.6 and 7.7. The values did not differ significantly ($p > 0.05$) and the scores were within acceptable limits for all treatments. In general, the addition of sorbic acid did not cause any deleterious effect on the sensory attributes of *Kaladhi*. These findings were in agreement with Pal et al. (1993) and Sanyal et al. (2006) who also observed similar trends in case of *paneer*.

Conclusion

Kaladhi prepared from pasteurized buffalo milk standardized to 6 % fat and 9 % SNF with coagulation at 40 °C using 5 % lactic acid as a coagulant and treated with various levels of sorbic acid had acceptable scores for various physico-chemical properties and sensory scores. It may be concluded that sorbic acid effectively retards the various degradation changes in the *Kaladhi*. On the basis of different physico-chemical and sensory parameters, sorbic acid at 0.3 % level proved to be optimum in the preparation of *Kaladhi*.

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