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RESEARCH PAPER

Effect of pH on Sensory, Textural, Microbial Quality and Shelf-life of *Paneer*

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ABSTRACT

Paneer has a very low shelf-life. Hurdles like spices, pH, water activity, temperature, redox potential, packaging etc. can be used to enhance the shelf-life of *paneer*. Present study was conducted to investigate the effect of low pH on sensory, textural, microbial quality and shelf-life of *paneer*. The *paneer* block was dipped in 0.50 percent citric acid solution for 12 hours which, as expected, reduced the pH of the sample from 5.61 to 5.23. Dipping of *paneer* resulted in increase of hardness, gumminess and chewiness from 1088, 889 and 849 g to 1160, 933 and 881 g, respectively while springiness decreased from 0.955 to 0.943. Standard Plate Count (SPC) of control *paneer* increased from 26,000 to 2,96,000 cfu/g on 8th day whereas the figure for treated *paneer* was 2,40,000 cfu/g. Yeast and mould count in control *paneer* increased from 27 to 290 cfu/g and for treated *paneer* from 14 to 127 cfu/g on 8th day of storage at refrigeration temperature. The body and texture, flavor and overall acceptability scores of dipped samples were lower than those of control while color and appearance score of treated *paneer* was higher than the control *paneer*. Reduced pH did not enhance the shelf-life of *paneer* at ambient temperature while it extended from 6 to 12 days at refrigeration (7±1°C) temperature.

Keywords: *Paneer*, citric acid, pH, texture, microbial quality, sensory evaluation, shelf-life

India is the largest producer of milk in the world with a production of about 146.3 million tones during 2014-15 (Anonymous, 2016). About 5% of milk produced in India is converted into *paneer* (Chandan *et al*., 2007). *Paneer* is an important, heat and acid coagulated indigenous milk product extensively used as a culinary ingredient along with vegetables. According to Food Safety and Standards Authority of India (FSSAI, 2011), *paneer* can be defined as the product obtained from cow or buffalo milk or a combination thereof by precipitation with sour milk, lactic acid or citric acid. It shall not contain more than 70% moisture and the milk fat content shall not be less than 50% of the dry matter. *Paneer* has high level of fat (22-25%) and protein (16-18%) and a low level of lactose (2.0-2.7%) (Kanawjia and Singh, 1996). Marble white color, mildly acidic taste, nutty flavor, spongy closely knit body and smooth texture are characteristics of a good quality *paneer*. It is used in a variety of forms *viz*., base for variety of culinary

dishes, ingredient for various vegetable dishes and as snacks etc. The production of *paneer* is now spreading throughout the world but due to its high moisture content (about 55%), it has a shelf-life of not more than one day at room temperature and up to a week at refrigeration temperature (Bhattacharya *et al*., 1971). The spoilage of *paneer* occurs mainly due to the growth of microorganisms, which bring about various physico-chemical changes leading to the development of off-flavor in the product. Hurdles like spices, pH, water activity, low temperature, redox potential, packaging etc., which are either bacteriostatic or bactericidal in nature, can be used to enhance shelf-life of *paneer*. Thippeswamy (2011) prepared *paneer* by application of hurdle technology (HT) and its shelf stability was studied by modified atmospheric packaging (MAP). The hurdles adopted comprised of water activity, pH, preservative and MAP. Sensory scores of all the samples decreased from control during storage at different temperatures. MAP was carried out by using a mixture of CO_2 to N_2 in the ratio of 50:50. The HT adopted paneer with MAP had extended the shelf-life from 1 to 12 days at room temperature (30±1°C) and 6 to 20 days at refrigeration (7±1°C) temperatures. Present study was conducted to investigate the effect of low pH on sensory, textural, microbial quality and shelf-life of *paneer* and the results are reported here.

MATERIALS AND METHODS

***Preparation of paneer*:** *Paneer* was prepared by a standardized method (Bhattacharya *et al.,* 1971). Fresh toned milk was procured from Experimental Dairy Plant of Southern Regional Station of ICAR- National Dairy Research Institute, Bengaluru. Milk was heated to 90°C without holding and cooled to 80°C and was coagulated by adding 1 per cent citric acid (2 g/litre of mik) solution at 80°C. Acid was slowly added to the milk with continuous slow stirring until the curd and clear slightly yellow-greenish whey separated out. The mixture was then allowed to settle down for 5 minutes and whey was drained out through using muslin cloth. Pressing of curd was done with the weight of 35-40 g/cm^2 for 15-20 minutes in muslin cloth lined perforated wooden cubical hoop. Finally prepared *paneer* sample was kept in cold water at 5-7°C for 2 hours. The chilled *paneer* was removed from water and placed on a wooden plank for 10-15 min to drain occluded water and cut into 1cm cubes for further studies.

***Optimization of concentration of citric acid solution for treatment*:** *Paneer* cubes were placed in glass beaker containing 1litre of 0%, 0.25 %, 0.50%, 0.75% and 1% of citric acid solution for 12 hours at refrigeration temperature (7±1°C). After soaking, *paneer* cubes were kept on wire gauze for 20-25 min to drain water. Thereafter, *paneer* was subjected to sensory evaluation by a panel of 7 semi trained judges. After sensory analysis, it was found that *paneer* was acceptable up to 0.50% citric acid solution (Table 1). While soaking of *paneer* at 0.75% and 1% were rejected by judges due to sour taste. So, *paneer* soaked in 0.50% citric acid solution was chosen for further studies.

Table 1: Effect of concentration of citric acid solution on sensory acceptance score of *paneer*

Citric acid solution (%)	Color and appearance	Body and texture	Flavor	Overall acceptability
Control	7.98±0.02^{a}	7.95±0.05^{a}	8.03±0.05^{a}	7.96±0.05^{a}
0	8.00±0.10^{a}	7.91±0.07^{a}	7.93±0.05^{a}	7.96±0.05^{a}
0.25	8.00±0.10^{a}	7.78±0.20^{a}	7.60±0.13^{b}	7.70±0.18^{a}
0.50	8.03±0.05^{a}	7.58±0.17^{ab}	7.12±0.12^{c}	7.22±0.10^{ab}
0.75	8.06±0.06^{a}	7.31±0.10^{b}	5.92±0.14^{d}	6.10±0.10^{c}
1	8.06±0.07^{a}	7.21±0.12^{b}	5.06±0.11^{e}	5.20±0.17^{d}

Note: Mean values with different superscripts (a, b, c..) in a row are significantly different (p≤0.05)

***Analytical methods*:** pH of *paneer* samples was determined using a digital pH meter (Digisun Electronics, Hyderabad, and Model: DI 707) as per the procedure followed for cheddar cheese ISI (1981b).

Texture profile analysis (Bourne *et al.,* 1978): For measuring the hardness, springiness, gumminess and chewiness of *paneer* (1 cm^3), Texture Analyzer (TA.XT Stable Micro systems, UK) was used. The test settings were: load cell capacity 5 kg, platen probe (P/75) made of stainless steel with 75 mm diameter, pre test speed 1 mm/sec, test speed 5 mm/sec, post test speed 5 mm/sec, distance-5mm, time-30 sec and trigger force-2 gm. All the tests were replicated three times.

Microbial analysis

Standard Plate count: The total number of viable bacteria in samples were enumerated by the standard plate count method using milk agar (ISI, 1981). The plates were incubated at 37°C for 48 hours and after that enumeration of colonies was done.

Yeast and mould count: Potato dextrose agar was used to determine the yeast and mould count in samples [ISI, 1981(a)]. The pH of the medium was adjusted to around 5.4 by adding 1-2 drops of sterile tartaric acid solution (10%) to each plate, before pouring the medium. The count was taken after 3-5 days of incubation at 30°C.

***Sensory evaluation*:** Nine-point Hedonic scale method (Lawless and Heymann, 2010) was used for sensory evaluation of all the samples by a panel of 7 semi trained judges. The samples were coded to preserve the identity of the samples presented to the judges. The samples were evaluated for color and appearance, body and texture, flavor and overall acceptability on the Hedonic scale ranging from 1 to 9 and the preferences were recorded in the sensory performa provided to the panelists.

***Shelf-life studies*:** Control and treated *paneer* samples were packed in polystyrene cups and stored at ambient temperature (30±1°C) and refrigeration temperature (7±1°C). The samples were drawn at regular interval for evaluating textural, microbial and sensory quality.

***Statistical analysis*:** Data of sensory and rheological analysis obtained in the study was analyzed using Statistical packages for Social Sciences (SPSS Version 8.0) at 5 percent level of significance.

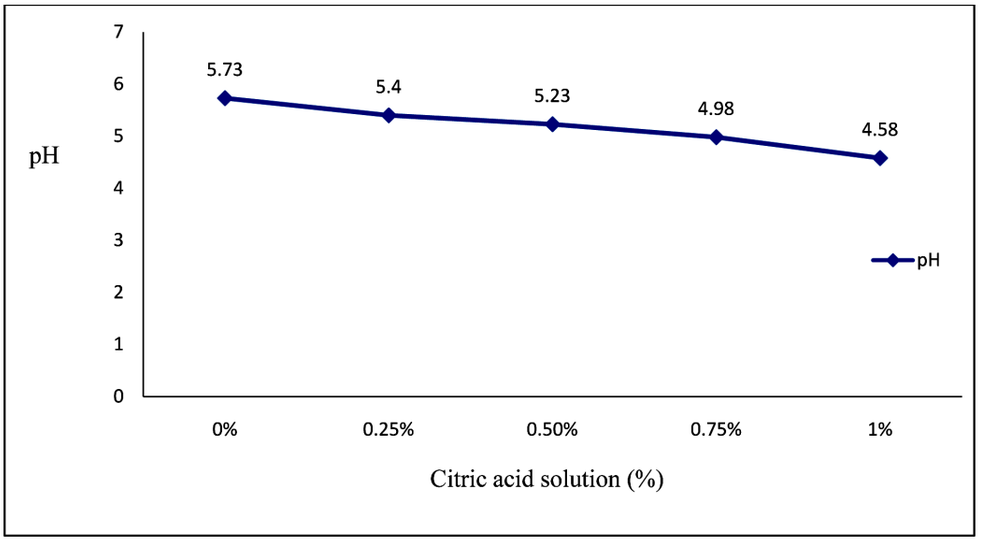

Fig. 1: Change in pH of *paneer* sample after soaking in different concentrations of citric acid solution at refrigeration temperature (7±1°C) for 12 hours

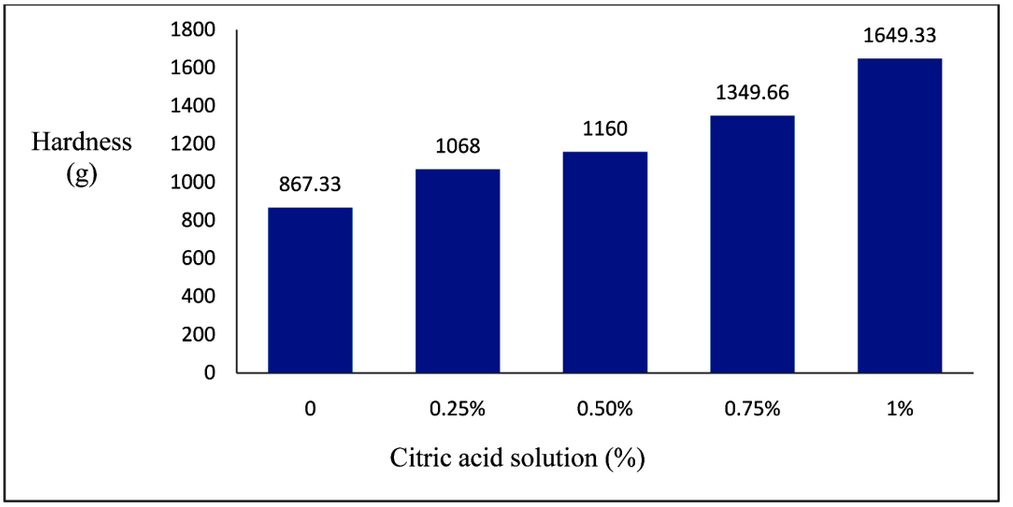

Fig. 2: Changes in hardness of *paneer* sample after soaking in different concentrations of citric acid solution at refrigeration temperature (7±1°C) after 12 hours

RESULTS AND DISCUSSION

Reduction of pH of paneer by soaking in citric acid solution: pH of *paneer* reduced by soaking of 1cm^3 cubes of *paneer* in citric acid solution. As concentration of citric acid solution increased, pH of paneer decreased (Fig. 1). pH of paneer soaked in 0.50% citric acid solution was 5.23 (Fig. 1) While pH of control *paneer* was 5.61.

Effect of soaking on texture of paneer: Initial hardness, springiness, gumminess and chewiness of control were 1088 g 0.955, 889 g and 849 g. After soaking of *paneer* in 0.50% citric acid solution for 12 hrs, hardness, gumminess and chewiness increased to 1160, 933 and 881 g, respectively while springiness decreased to 0.943. This may be due to further denaturation of milk proteins on being exposed to higher concentration of acids. The results are in accordance with those obtained by Sachdeva and Singh (1988) and Kumar (2007).

Effect of soaking on sensory quality of paneer: Color and appearance scores of treated *paneer* were significantly higher ($p \leq 0.05$) than control sample at all concentrations of citric acid solution due to increased whiteness of *paneer*. Score increased ($p \leq 0.05$) from 7.98 for control to 8.03 for treated *paneer*. Body and texture score decreased ($p \leq 0.05$) from 7.95 for control to 7.58 for soaked *paneer* (Table 1), which was due to hardening of *paneer*. Similar trend was noticed in flavor scores, decrease ($p \leq 0.05$) from 8.03 for control to 7.12 for soaked *paneer* was observed (Table 1), which may be due to slight over acidic taste imparted by citric acid solution (Bhattacharya *et al.*, 1971). The overall acceptability scores also decreased ($p \leq 0.05$) from 7.96 for control to 7.22 for soaked *paneer* (Table 1).

***Changes in the texture of paneer during storage at ambient temperature*:** It is evident from Table 2 that hardness, gumminess and chewiness decreased while springiness increased in control as well as treated *paneer* during storage at ambient temperature.

Hardness, gumminess and chewiness of control sample decreased from 1088 to 952 g, 889 to 785 g and 849 to 755 g, respectively. While springiness of control sample increased from 0.955 to 0.962. Both control and treated *paneer* samples turned slimy and gave off flavor on second day of storage so the study was not carried out further for the samples stored at ambient temperature. Similar trend in textural attributes was observed in treated *paneer*. Hardness, gumminess and chewiness decreased from 1160 to 1054 g, 933 to 856 g and 881 to 814 g, respectively while springiness increased from 0.943 to 0.951. Desai

(1988) also reported similar findings during storage study of *paneer* at 37°C.

Table 2: Effect of citric acid solution on textural attributes of *paneer* during storage at ambient temperature (30±1°C)

Type of *paneer*	Storage time (days)	
	0	1
	Hardness (g)	
Control *paneer*	1088±56$^{a\,m}$	952±43$^{b\,m}$
Soaked *paneer*	1160±66$^{a\,m}$	1054±47$^{a\,m}$
	Springiness	
Control *paneer*	0.955±0.0133$^{a\,m}$	0.962±0.018$^{a\,m}$
Soaked *paneer*	0.943±0.015$^{a\,m}$	0.951±0.019$^{a\,m}$
	Gumminess (g)	
Control *paneer*	889±55$^{a\,m}$	785±51$^{a\,m}$
Soaked *paneer*	933±37$^{a\,m}$	856±54$^{a\,m}$
	Chewiness (g)	
Control *paneer*	849±55$^{a\,m}$	755±60$^{a\,m}$
Soaked *paneer*	881±44$^{a\,m}$	814±55$^{a\,m}$

Note: Mean value with different superscripts (a, b, c..) in a row and means with different superscripts (m, n, …) in a column are significantly different (p≤0.05)

Changes in the texture of paneer during storage at refrigeration temperature: From Table 3, it is clear that hardness, gumminess and chewiness increased first, thereafter decreased, while springiness decreased first thereafter increased in control as well as soaked *paneer*. Hardness, gumminess and chewiness increased from 1088 to 1464 g, 889 to 1110 g, and 849 to 1013 g respectively; Springiness decreased from 0.955 to 0.908 up to 6 days of storage of control sample at refrigeration temperature while on 8th day hardness, gumminess and chewiness of control sample decreased from 1464 to 1452 g, 1110 to 1106 g, 1013 to 1008 g, respectively; Springiness increased from 0.908 to 0.915.

In the same way, results were obtained for soaked *paneer*. Hardness, gumminess and chewiness of soaked *paneer* increased from 1160 to 1640 g, 933 to 1181 g and 881 to 1039 g, respectively; Springiness decreased from 0.943 to 0.879 up to 12th day of storage. While on 14th day, hardness, gumminess and chewiness of soaked *paneer* slightly decreased from 1640 to 1610 g, 1181 to 1165 g, 1039 to 1027 g, respectively and springiness increased from 0.879 to 0.881. These changes in textural properties of *paneer* may be due to evaporation of moisture during storage at refrigeration temperature. Similar observations were reported by Dwarakanath (2013) during study of the effect of freezing on textural attributes of *paneer* during storage. Appreciable increase in all textural attributes of *paneer* during refrigerated storage (6-8°C) was also reported by Kanawjia and Singh (1996).

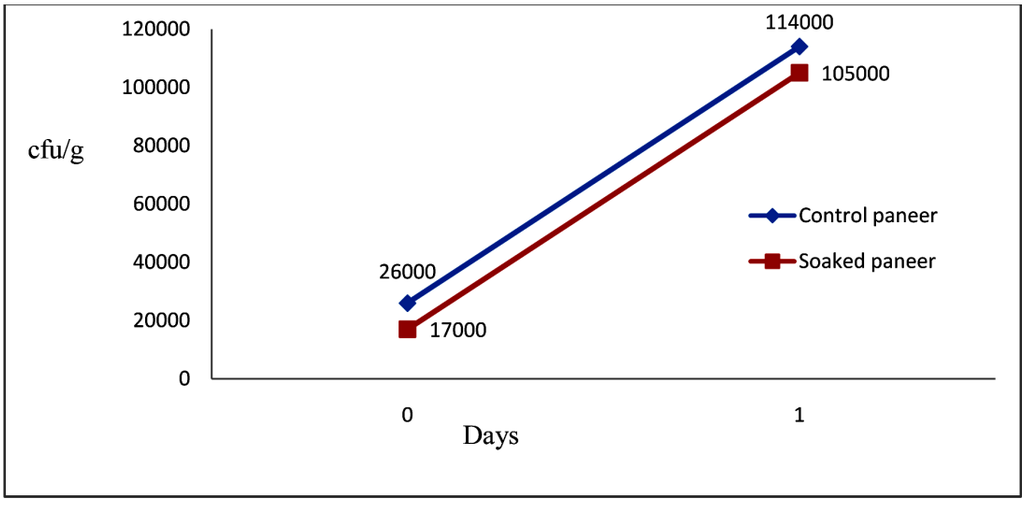

Fig. 3: Changes in standard plate count (SPC) of *paneer* sample during storage at ambient temperature (30±1°C)

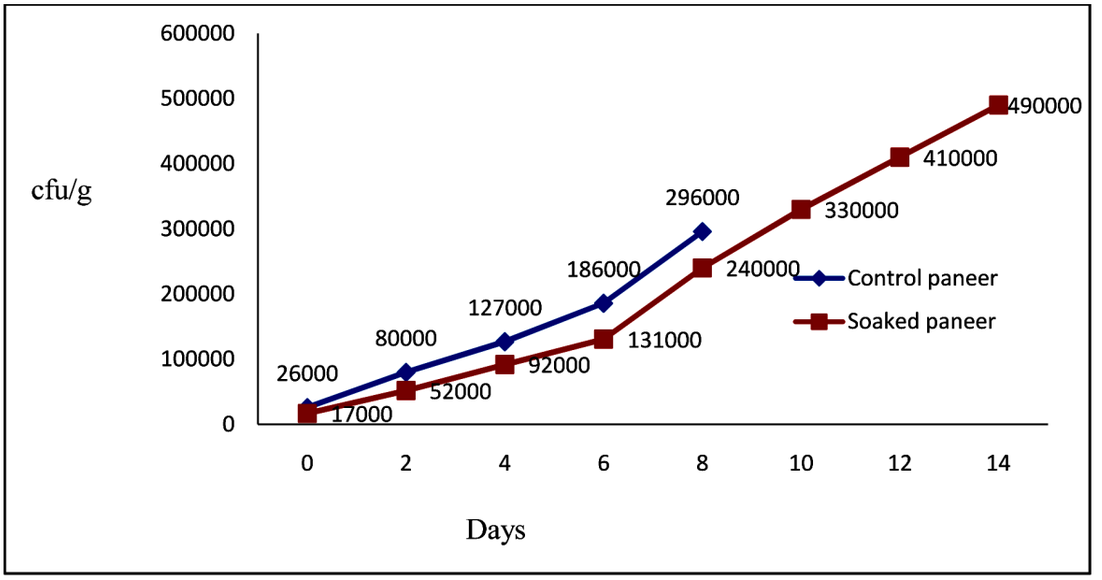

Fig. 4: Changes in standard plate count (SPC) of *paneer* sample during storage at refrigeration temperature (7±1°C)

***Microbial count of paneer*:** The fresh and stored samples of *paneer* were analyzed for microbial counts *viz*. standard plate count (SPC) and yeast and mould count. The data obtained for changes in SPC and yeast and mold count are presented in Fig. 3, 4, 5 and 6.

Standard plate counts (SPC): It is clear from Fig. 3 and 4, that SPC of control and soaked *paneer* continuously increased during the storage at room temperature and refrigeration temperature, the count increased from 26,000 to 1, 14,000 cfu/g in control *paneer* and from 17,000 to 1, 05,000 cfu/g in soaked *paneer* after one day storage at ambient temperature (Fig. 3). Count in control *paneer* increased from 26,000 to 2, 96,000 cfu/g on 8^{th} day, while in soaked *paneer* count increased from 17,000 to 2,40,000 cfu/g on 8^{th} day and to 4, 90,000 cfu/g on 14^{th} day during storage at refrigeration temperature (Fig. 4), which is below the limit of microbial count set by Bureau of Indian Standards for *paneer,* leading to a higher shelf-life of the treated *paneer* sample. Bureau of Indian Standards (BIS, 1983) set limits of *paneer* for microbial count viz., total plate count $<5\times10^5$/g, yeast and mould count <250/g, and coliform count of <90/g. Kumar and Bector (1991) reported an increase in SPC from 3.0×10^3 to 2.8×10^5 cfu/g on 4^{th} day and 9.0×10^6 cfu/g on 7^{th} day of control *paneer* during storage at 15°C.

***Yeast and mold count*:** Fig. 5 and 6 shows that yeast and mould count increased sharply in case of control *paneer*, while in the soaked *paneer* count increased at a slower rate throughout the storage period. Count increased from 27 to 126 cfu/g in control *paneer* and from 14 to110 cfu/g in soaked *paneer* after one day storage at ambient temperature (Fig. 5), which is within the limit of microbial count set by Bureau of Indian Standards for *paneer*. Count in control *paneer* increased from 27 to 290 cfu/g on 8^{th} day, while in soaked *paneer* it increased from 14 to 127 on 8^{th} day and to 310 cfu/g on 14^{th} day storage at refrigeration temperature (Fig. 6) which justifies the longer shelf-life of the treated sample. Yeast and mold count of control *paneer* on 8^{th} day and treated *paneer* on 14^{th} day respectively were above the limit set by Bureau of Indian Standards for *paneer*. Kumar and Bector (1991) reported that the yeast and mold count of control *paneer* increased from 10 per g to 50 per g after 4 days and 250 per g after 7 days of storage at 15°C. Sachdeva and Singh (1990) also reported that SPC and yeast and mold count increased in *paneer* during storage at 8-10°C.

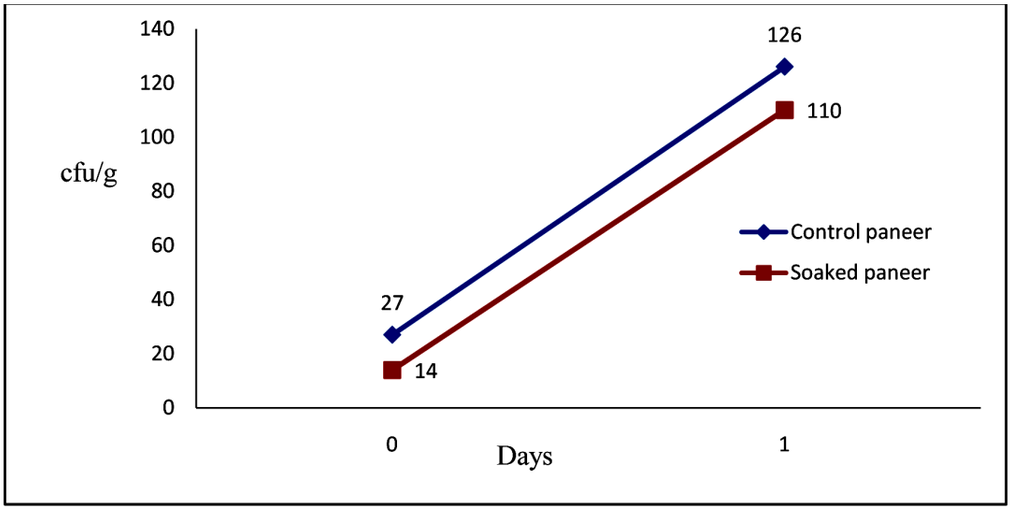

Fig. 5: Changes in yeast and mold count of *paneer* sample during storage at ambient temperature (30±1°C)

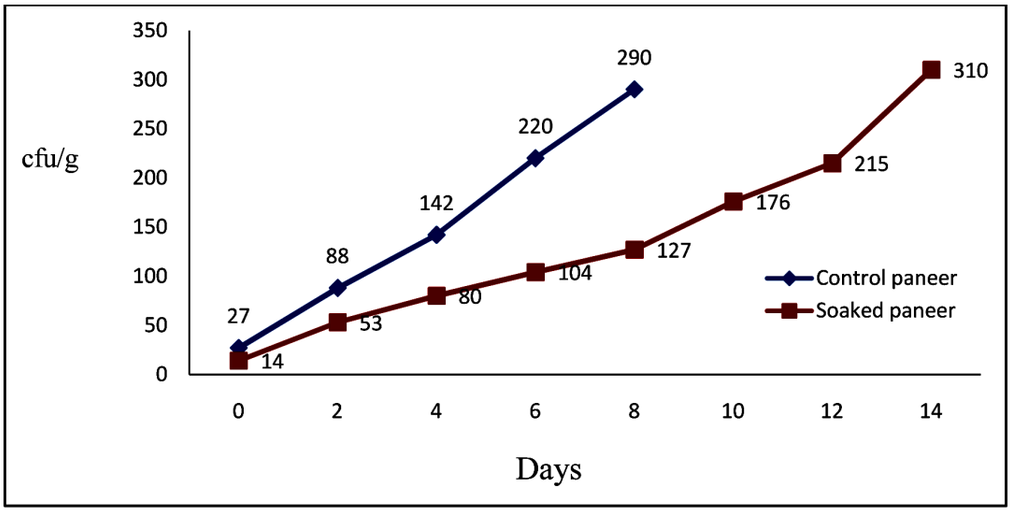

Fig. 6: Changes in yeast and mold count of *paneer* sample during storage at refrigeration temperature (7±1°C)

***Sensory analysis of paneer during storage*:** Sensory analysis of control and soaked *paneer* during storage at ambient (30±1°C) and refrigeration temperature (7±1°C) was done for evaluating changes in sensory characteristics like for color and appearance, body and texture, flavor and overall acceptability of the *paneer* samples.

***Color and appearance*:** Color and appearance scores of control and treated *paneer* during storage are given Table 4 and 5 showing that the scores significantly decreased during storage ($p \leq 0.05$) at room and refrigeration temperature. Scores of control sample and soaked *paneer* in two days' storage at ambient temperature (Table 4) decreased from 7.98 to 6.03 and from 8.03 to 6.33 respectively. On second day of storage, both control and soaked samples became slightly yellow-greenish appearance on surface; it may be due to slime production by molds. While at refrigeration temperature, score of control *paneer* decreased from 7.98 to 6.40 on 8th day and from 8.03

Table 3: Effect of citric acid solution on textural attributes of *paneer* during storage at refrigeration temperature (7±1°C)

Type of *paneer*	Storage time (days)							
	0	2	4	6	8	10	12	14
				Hardness (g)				
Control *paneer*	1088±56$^{a\,m}$	1230±72$^{ab\,m}$	1365±54$^{b\,m}$	1464±67$^{c\,m}$	1452±78$^{c\,m}$			
Soaked *paneer*	1160±66$^{a\,m}$	1280±54$^{ab\,m}$	1398±58$^{bc\,m}$	1491±72$^{cd\,m}$	1530±60$^{cd\,m}$	1578±63^{cd}	1640±66^{d}	1610±74^{d}
				Springiness				
Control *paneer*	0.955±0.013$^{a\,m}$	0.932± 0.016$^{ab\,m}$	0.926± 0.012$^{ab\,m}$	0.908±0.018$^{b\,m}$	0.915± 0.020$^{ab\,m}$			
Soaked *paneer*	0.943±0.015$^{a\,m}$	0.925± 0.013$^{ab\,m}$	0.920± 0.012$^{abc\,m}$	0.905±0.016$^{abc\,m}$	0.899± 0.022$^{abc\,m}$	0.887±0.012^{bc}	0.879±0.015^{c}	0.881± 0.014^{bc}
				Gumminess (g)				
Control *paneer*	889±55$^{a\,m}$	980±71$^{ab\,m}$	1068±21$^{b\,m}$	1110±32$^{b\,m}$	1106±55$^{b\,m}$			
Soaked *paneer*	933±37$^{a\,m}$	1013±38$^{ab\,m}$	1085±63$^{bc\,m}$	112±44$^{bc\,m}$	1135±56$^{bc\,m}$	1160±30^{c}	1181±55^{c}	1165±67^{c}
				Chewiness (g)				
Control *paneer*	849±55$^{a\,m}$	914±68$^{ab\,m}$	989±39$^{b\,m}$	1013±57$^{b\,m}$	1008±41$^{b\,m}$			
Soaked *paneer*	881±44$^{a\,m}$	937±37$^{ab\,m}$	998±44$^{ab\,m}$	1016±52$^{ab\,m}$	1021±64$^{ab\,m}$	1030±40^{ab}	1039±66^{b}	1027±68^{ab}

Note: Mean value with different superscripts (a, b, c..) in a row and means with different superscripts (m, n, .) in a column are significantly different (p≤0.05)

Table 4: Effect of citric acid solution on sensory acceptance score of *paneer* during storage at ambient temperature (30±1°C)

Type of *paneer*	Storage time (days)		
	0	1	2
		Color and appearance	
Control *paneer*	7.98±0.28^{am}	7.70±0.10^{bm}	6.03±0.15^{cm}
Soaked *paneer*	8.03±0.05^{am}	7.83±0.12^{am}	6.33±0.17^{bm}
		Body and texture	
Control *paneer*	7.95±0.05^{am}	7.63±0.16^{am}	5.93±0.15^{bm}
Soaked *paneer*	7.58±0.17^{am}	7.36±0.20^{am}	6.23±0.15^{bm}
		Flavor	
Control *paneer*	8.03±0.05^{am}	7.5±0.15^{bm}	5.13±0.12^{cm}
Soaked *paneer*	7.11±0.12^{an}	7.08±0.14^{an}	5.31±0.16^{bm}
		Overall acceptability	
Control *paneer*	7.96±0.05^{am}	7.56±0.12^{bm}	5.30±0.17^{cm}
Soaked *paneer*	7.21±0.10^{an}	7.11±0.12^{an}	5.50±0.18^{bm}

Note: Mean values with different superscripts (a, b, c..) in a row and means with different superscripts (m, n, ..) in a column are significantly different (p≤0.05)

to 6.51 for soaked *paneer* on 14th day of storage (Table 5). However, the sensory panelists found the control sample to be more dry in comparison to treated sample.

***Body and texture*:** Body and texture scores of control and soaked *paneer* during storage are given Table 4 and 3, which show that scores significantly decreased during storage (p≤0.05) at room and refrigeration temperature. Scores of control and soaked *paneer*

Table 5: Effect of citric acid solution on sensory acceptance score of *paneer* during storage at refrigeration temperature (7±1°C)

Type of *paneer*	Storage time (days)							
	0	2	4	6	8	10	12	14
Color and appearance								
Control *paneer*	7.98±0.02^{am}	7.61±0.12^{abm}	7.43±0.15^{bcm}	7.05±0.18^{cm}	6.40±0.20^{dm}			
Soaked *paneer*	8.03±0.05^{am}	7.86±0.15^{abm}	7.61±0.18^{bcm}	7.30±0.10^{cdm}	7.11±0.12^{den}	6.93±0.15^{de}	6.85±0.13^{ef}	6.51±0.12^{f}
Body and texture								
Control *paneer*	7.95±0.05^{am}	7.56±0.15^{abm}	7.18±0.16^{bm}	6.40±0.20^{cm}	6.11±0.12^{cm}			
Soaked *paneer*	7.58±0.17^{an}	7.31±0.10^{abm}	7.20±0.18^{abcm}	7.05±0.13^{bcdn}	6.81±0.17^{cden}	6.76±0.11^{de}	6.56±0.15^{ef}	6.20±0.10^{f}
Flavor								
Control *paneer*	8.03±0.05^{am}	7.88±0.18^{abm}	7.55±0.13^{bm}	7.03±0.15^{cm}	5.30±0.10^{dm}			
Soaked *paneer*	7.11±0.12^{an}	7.03±0.15^{an}	6.80±0.20^{abn}	6.78±0.10^{abm}	6.58±0.16^{bcn}	6.23±0.12^{cd}	5.95±0.13^{d}	5.23±0.15^{e}
Overall acceptability								
Control *paneer*	7.96±0.05^{am}	7.51±0.12^{bm}	7.20±0.18^{bcm}	6.80±0.20^{cm}	5.41±0.17^{dm}			
Soaked *paneer*	7.21±0.10^{an}	7.13±0.12^{abn}	6.93±0.15^{abcm}	6.76±0.11^{bcdm}	6.60±0.13^{cdn}	6.41±0.17^{de}	6.03±0.15^{e}	5.31±0.12^{f}

Note: Mean values with different superscripts (a, b, c..) in a row and means with different superscripts (m, n, ..) in a column are significantly different (p≤0.05)

on second day storage at ambient temperature decreased from 7.95 to 5.93 and from 7.58 to 6.23 respectively, (Table 4). Control and soaked *paneer* on second day became soft and sticky. This may be due to slime production by microbes. At refrigeration temperature, score of control on 8th day and treated *paneer* on 14th day storage decreased from 7.95 to 6.11 and from 7.58 to 6.20, respectively (Table 5). Body and texture score of both the samples at refrigeration storage decreased due to hardening of *paneer*. It may be due to evaporation of moisture from *paneer* during storage.

***Flavor*:** Flavor scores of control and soaked *paneer* significantly decreased during storage (p≤0.05) at room and refrigeration temperature (Table 4 and 5). Scores of control and soaked *paneer* on second day of storage at ambient temperature decreased from 8.03 to 5.13 and from 7.11 to 5.31, respectively (Table 4). At refrigeration temperature, scores of control on 8th day and soaked *paneer* on 14th day storage decreased from 8.03 to 5.30 and from 7.11 to 5.23, respectively (Table 5). At refrigeration temperature the decrease in flavor scores was due to development of bitter taste in the samples. This may probably be due to proteolysis of protein by microbes to produce bitter peptides. Bitterness flavor defect develops by the accumulation of bitter-tasting peptides formed by the action of proteolytic enzymes on casein as observed in Cheddar and Gouda cheeses (Cream *et al.*, 1978 and Lawrence *et al.*, 1976). Off flavor in stored *paneer* during storage at refrigeration temperature was also observed by Bhattacharya (1971).

Overall acceptability: Overall acceptability of control and soaked *paneer* during storage are given Table 4 and 5, which reveal that the scores significantly decreased during storage (p≤0.05) both at room and refrigeration temperature. Scores of control and soaked *paneer* in two days' storage at ambient temperature decreased from 7.96 to 5.30 and from 7.21 to 5.50, respectively (Table 4). At refrigeration temperature, score of control sample on 8th day and treated sample on 14th day of storage decreased from 7.96 to 5.41 and from 7.21 to 5.31, respectively (Table 5). Thippeswamy (2011) also reported that overall acceptability scores of *paneer* samples decreased during storage at ambient and refrigeration temperature.

From Table 4 it is clear that shelf-life of control and soaked *paneer* was only one day at ambient temperature. Table 5 shows that shelf-life of control and soaked *paneer* were 6 and 12 days, respectively. This improvement in shelf-life of *paneer* may be due to reduction of pH, lower temperature and synergistic effect of these factors.

CONCLUSION

Reduced pH did not enhance the shelf-life of *paneer* at ambient temperature while it extended the shelf-life from 6 to 12 days at refrigeration temperature, without much affecting the sensory quality. It can be concluded that reduced pH is a good preservation technique to enhance the shelf-life of *paneer* at refrigeration temperature.

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