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Enhancement of shelf life of paneer by adopting hurdle technology

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Abstract
Citric acid, lactic acid and vinegar were tested for their relative efficiency in improving shelf life of paneer. Diced paneer cubes (~1.5 cm^3) were dipped in to three different acids viz. citric acid (T1), lactic acid (T2) and Vinegar (T3) each having 4% strength at 30±1 ^{O}C for 10 min followed by drying to a moisture content of 30-35% under vacuum (680-720 mm Hg). The partially dried paneer cubes were packaged in composite polyethylene terephthalate /low-density polyethylene film (50 µ thickness). Treatment of paneer with lactic acid (T2) and vinegar (T3) resulted in enhanced shelf-life up to 90 d under refrigerated (7±2 ^{O}C) storage conditions whereas paneer treated with citric acid was found to be acceptable up to 60 days of storage. Upon rehydration in hot water (70-80 C) for 30 min, the paneer obtained had rheological properties at par (P>0.05) with that of fresh paneer. The paneer so obtained is suitable for use in Indian cuisines.

Keywords: Paneer, soft cheese, unripened cheese, shelf life, hurdle technology

1. Introduction
Paneer the indigenous variety of soft cheese is obtained by heat and acid coagulation of milk at high temperatures. Although paneer manufacture involves heating of milk at near boiling temperature under mild acidic conditions for coagulation of milk the bactericidal advantage so gained from thermal processing of milk, is quickly lost due to direct exposure to the environment during subsequent manual handling, pressing and cooling followed by packaging. The unhygienic conditions normally prevailing at the unorganised sector during manufacturing, packaging, storage and sale leads to lowering the shelf life of paneer. Simultaneously, the high moisture content of paneer viz. 53-55%, presence of rich source of nutrients, and relatively high temperatures prevailing in major parts of the country is the responsible for its lower shelf life.
Because of the above reasons, the shelf life of paneer is severely affected and limited down to only a day or two at ambient temperatures and 6-8 days at refrigeration temperature [3]. The relatively shorter shelf life of paneer is a major handicap in commercial adoption of paneer manufacture. Use of acids have been advocated since time immemorial to increase the shelf-life of foods e.g. pickles. The inhibitory activity of acidic environment on the growth of bacteria, yeasts, fungi and microbial toxins synthesis has been well documented, so they could be used in food preservation in order to assure the production of microbiologically stable foods. No work has been reported about use of organic acids in extending shelf life of paneer.
In literature various workers have attempted to increase the shelf life of paneer. At room temperature paneer does not keep well for more than 1 d. However, its flavour remains acceptable even after 120 d when stored at -13 or -32 °C. Food additives such as sorbic acid, potassium sorbate, solutions of H_2O_2 and brine and delvocid [15] have been tried successfully to increase the shelf-life of paneer. Addition of turmeric at the rate of 0.6% by weight of paneer extended the shelf life of paneer up to 12 d on storage at 7±2 °C [4].
Krishna *et al.* (2013) [12] tested the relative efficacy of black pepper, cardamom, cinnamon and clove in improving shelf life of paneer. Among the spices studied, cardamom was found to be the best spice to improve shelf life of paneer up to 28 d of storage at 7±2 °C. Antioxidants like tertiarybutylhydroquinone (TBHQ) and butylated hydroxyl anisole (BHA) have also been tried as possible antimicrobial agents in paneer. There has been increasing concern of the consumers about foods free of chemical preservatives because of their possible toxic effect in human beings. Hence, limited use of synthetic additives is in demand [13].

Moreover, storage of paneer at sub-zero temperatures greatly deteriorates its body and texture characteristics resulting in a product with crumbly body. Use of natural preservatives like turmeric and cardamom gave a shelf life of only 12 days at refrigeration temperatures.

The microbial spoilage in paneer occurs due to the surface growth of microorganisms. A greenish yellow slime forms on the surface and discoloration is accompanied by an off flavour. Hence, it is invariably the surface that gets spoiled early while the interior remains good for a longer time at refrigeration storage. Therefore, the study was planned to treat the paneer with selected food grade acids viz. vinegar, lactic acid and citric acid followed by partial drying of the treated product under vacuum to reduce its moisture content on the surface and to evaluate its effectiveness in extending shelf life of paneer. It was hypothesized that such treatment would result in an intermediate moisture food with improved shelf life.

2. Materials and methods

Full cream milk (6.0% fat, 9.0% SNF) and standardized milk (4.5% fat, 8.5% SNF) were collected from Vidya Dairy, Anand. AR grade citric acid (99% pure) was supplied by Loba-Chemical Pvt. Ltd and Lactic acid (92% pure) was used. Sunshine brand Vinegar (5.0% acetic acid) was procured from local market at Anand. Composite polyethylene terephthalate (PET)/low-density polyethylene (LDPE) film (50 µ thickness) was used for packaging of samples during storage study.

2.1 Preparation of paneer

Paneer was prepared from after standardizing the milk to 4.5% fat and 8.5% SNF using method suggested by Bhattacharya (1971) [3] with certain modifications. The standardized milk fat was heated to 95 °C for 5 min and cooled to 70 °C. Citric acid (1.0% solution) was added with continuous agitation until the coagulation was complete. The coagulum was allowed to settle for 5 min for complete coagulation. Whey was drained through a muslin cloth. The coagulum was then filled in a sterilized stainless steel hoop lined with clean muslin cloth and pressed for 20 min. followed by immersing in chilled water (4 to 6 °C) for 2 h. The blocks removed from chilled water were allowed to drain for 5 min. Paneer was packed in composite PET/LDPE film pouches and stored at 7±2 °C. After pressing the paneer, was diced in to approximately 1.5 cm^3 size cubes and different dipping treatment was given.

2.2 Dipping of paneer in acid solutions

The diced paneer cubes were dipped in to three different acids (4.0% acid solution at 30+1 ^{O}C) viz. citric acid (T1), lactic acid (T2) and Vinegar (T3) for 10 min. It was found that use of dipping temperatures higher than 30 C resulted in excessively soft paneer cubes. Holding of cubes in acid solution for longer than 10 min resulted in highly acidic taste and dissolution of milk solids. The pH of paneer cubes when dipped for 10 min was found to be around 5.2 which is similar to Cheddar cheese at 0 day and was found to be most acceptable. The approximate moisture content of cubes was found to increase by approximately 10% of original moisture content of paneer after dipping treatment.

The cubes were then completely drained and spread uniformly on a SS tray (1.0' X 2.5') and subjected to vacuum drying (4 h at 660 – 680 mm Hg) in vacuum tray drier (Model: Perfect Engineering and Allied Works Pvt. Ltd., Baroda). Drying was continued till moisture content reduced to approximately 30 to 35% of the original moisture content of paneer and the cubes attained a dry surface. The experimental samples of paneer were packed in composite PET/LDPE film pouches and stored at 7±1 °C. Control (C) sample was prepared using the same method but without dipping in acid solution.

Experimental and control paneer cubes were stored at refrigerated temperature (7±2 ^{O}C) till samples became unacceptable. Paneer was analyzed for its microbiological, physico-chemical and rheological properties. Paneer was rehydrated it, by dipping dried paneer cubes in hot (~ 75 – 80 ^{O}C) water for 10-15 min followed by draining and then dipping of cubes in pasteurized and chilled water (4-5 ^{0}C) for ~ 15 – 20 min. Experimental rehydrated samples were subjected to sensory evaluation by a panel of six judges when fresh and at regular interval of 15 days during storage at 7±2 C using 9-point hedonic scale [17]. During storage the samples were analyzed for physico-chemical, rhelological, microbiological and sensory attributes.

2.3 Chemical analysis

The samples stored at 7±2 °C were subjected to analysis for the chemical characteristics at a regular interval of 15 days during the storage. Moisture content in paneer was determined according to BIS (1983) [6] procedure specified for paneer under IS: 10484. Fat content of paneer was estimated by following the method described for cheese [2]. Protein content was determined by Kjeldahl method as described by Horwitz (1980) [9]. The ash content of the paneer sample was estimated by the method of BIS (1981) [5]. The acidity of the paneer sample was estimated according to BIS (1983) [6] procedure specified for paneer under IS: 10484. Free fatty acids content of paneer was estimated using the method described for cheese [18]. The soluble nitrogen content of the paneer sample was estimated by Kjeldahl method as described by Kosikowaski (1970) [10].

2.4 Rheological attributes

Compression testing of paneer samples was done with Lloyd Instrument, Hampshire, UK (Model No. 01/2962) using 5 KN load-cell which moved at a speed of 20 mm/min. The trigger was set at 10 gf, compressive and tensile load limit were 4900 N and 4000 N respectively. The paneer samples were taken for texture measurement after tempering the same at 23±1ºC for an hour. All the textural measurements were conducted in a room maintained at 23±1ºC temperature and 55 ± 1% relative humidity. Cubic samples of the experimental paneer, with edges of 1.50±0.06 cm, were placed in the compression support plate in such a manner that fibers were oriented perpendicular to the cylindrical compression anvil. The cubic samples were compressed up to 70.0% of their initial size. Five cubic samples were used for each experimental paneer under study and the average value of these readings was reported. The textural characteristics of the paneer samples were directly displayed on the monitor of the computer as graph (load vs. time i.e. Kgf vs. seconds) as well as derived values in tabular form.

2.5 Sensory attributes

The rehydrated paneer samples were tempered to 10±2°C at the time of judging. Sensory analysis of paneer samples was conducted in isolated booths illuminated with incandescent light maintained at 23 + 2 ^{O}C. Samples were served in petri dishes. The plates were labeled with three digit codes. The order of presentation of samples was randomized across subjects. Subjects judged a maximum of 4 samples in one session. The sensory panel (n=7) was composed of staff members and post graduate students working in the institution. Panelists were also trained to detect presence or absence of specific flavour and texture attributes outlined by Aneja *et al*.

(2002) [1]. The sensory panelists were instructed to use lukewarm water as rinsing agent as and when required. The quality characteristics of paneer that were evaluated were colour and appearance, flavour, body and texture and overall acceptability using 9-point hedonic scale [17].

2.6 Microbiological analysis

Total viable count of paneer was determined by following the method was described by Messer *et al*. (1985) [14] except that the diluents used were 2% sodium citrate. The plating, incubation and counting for the enumeration of yeast and mold was done by method described by Frank *et al*. (1985) [7]. The plating, incubation and counting method to enumerate coliforms were carried out as described by Hartman and Lagrange (1985) [8].

2.7 Statistical analysis

The values of each attribute under study were subjected to statistical analysis using Completely Randomized Design with equal number of observations using the model proposed by Steel and Torrie (1980) [16] .

3. Results and Discussion

3.1 Changes in chemical composition, acidity and pH of paneer during storage

The fresh and stored samples of paneer were analyzed for chemical characteristics viz., moisture, fat, protein, acidity and pH. The data obtained for chemical changes in paneer during storage at 7±2 °C are presented in Table 1.

The effect on moisture content of three differently treated paneer sample was found to be significant (P<0.05). This could be ascribed to different rate of absorption of acids in paneer samples and as all paneer samples were partially dried for similar period. Moisture content of paneer sample reduced significantly (P<0.05) from 45.26 to 44.86% during initial 30 days of storage and then it increased but non-significantly (P>0.05) throughout the storage period of 90 days. Combined effect of storage period and treatment had non-significant (P>0.05) effect on moisture content of paneer samples.

The increase in per cent fat content of paneer samples was significant (P<0.05) at 30th day of storage which could be ascribed to the significant decrease in moisture content observed in Table 1. Paneer samples treated with lactic acid and vinegar remained statistically at par, however, paneer treated with citric acid had significantly (P<0.05) higher fat content. This could be due to significantly (P<0.05) lower moisture content observed in paneer treated with citric acid (Table: 1). Similar trend was noted for combined effect of treatment and storage period.

Paneer sample treated with vinegar had significantly (P<0.05) highest percent lactic acid content followed by citric acid and lactic acid treated paneer had lowest percent lactic acid content. During storage acidity of paneer increased significantly (P<0.05) at 15th day and later a non-significant increase was observed. The combined effect of storage period and treatment was significant and paneer treated with vinegar had highest acidity at the end of storage.

Treatment of paneer samples with three different acids resulted in significant difference in pH values. Citric acid treated sample had the lowest pH and lactic acid had highest pH. During storage period of 90 days pH varied but non-significantly (P>0.05). Combined effect of storage period and treatment was non-significant.

Treatment with acids had significant effect on protein content and this could be due to significant difference in moisture content of dried samples. Protein content increased significantly (P<0.05) at 15th day and thereafter it varied non-significantly (P>0.05) during entire storage period. Combined effect of storage period and treatment was non-significant.

Shelf life of paneer can be extended by reducing its pH and removing partial moisture by drying the paneer under vacuum. Moisture content of dried paneer varied on account of different uptake rate of different acid solutions employed in the study. Percent fat and protein content of paneer samples varied and this could be because of variation observed in moisture content. Depending upon basicity of acids, pH varied and it showed profound impact on sensory characteristic and rheological parameters.

Table 1: Effect of type of acid used for dipping paneer on chemical composition of rehydrated paneer during storage at 7±2 °C

Treatment	Storage period (days)						
	0	**15**	**30**	**45**	**60**	**75**	**90**
	Moisture (%)						
T1	43.15	43.06	42.92	43.01	43.09	43.21	43.17
T2	46.97	46.83	46.67	46.59	46.62	46.62	46.79
T3	45.36	45.16	45.00	44.89	44.94	44.94	45.04
CD (0.05) T = 0.176 ; S = 0.115 ; TXS = NS							
	Fat (%)						
T1	25.50	25.25	25.70	26.18	26.00	26.29	26.08
T2	24.07	24.47	24.88	25.63	25.64	25.56	25.31
T3	24.99	24.96	25.52	25.32	25.16	25.10	25.04
CD (0.05) T =0.263 ; S =0.172 ; TXS =0.455							
	Protein (%)						
T1	24.09	24.20	24.07	24.23	24.13	24.17	24.24
T2	22.22	22.30	22.29	22.37	22.40	22.4	22.46
T3	23.28	23.41	23.37	23.40	23.44	23.45	23.54
CD (0.05) T =0.099 ; S =0.065 ; TXS =NS							
	pH						
T1	4.68	4.67	4.63	4.61	4.62	4.67	4.65
T2	4.90	4.94	4.97	4.95	4.94	4.96	4.94
T3	4.81	4.81	4.84	4.84	4.87	4.81	4.81
CD (0.05) T = NS ; S = 0.031 ; TXS = NS							
	Acidity						
T1	1.12	1.11	1.12	1.18	1.17	1.18	1.19
T2	1.09	1.11	1.10	1.14	1.14	1.17	1.19
T3	1.22	1.28	1.3	1.23	1.19	1.20	1.21
CD (0.05) T = 0.01 ; S = 0.006 ; TXS = 0.017							

Each observation is a mean of three replicate experiments (n=3); T=Type of acid (Citric acid=T1, Lactic acid=T2, Vinegar=T3); S=Storage Period

3.2 Changes in soluble nitrogen and FFA of paneer during storage

The shelf life of paneer samples were monitored on basis of FFA content and soluble nitrogen content as is presented in Table 2. FFA content and soluble nitrogen content increased during storage for paneer samples under study. However, paneer sample treated with vinegar had significantly (P<0.05) higher FFA content and soluble nitrogen content. FFA content of other two samples remained statistically at par (P>0.05) but soluble nitrogen content of lactic acid treated paneer samples were higher as compared to paneer samples treated with citric acid.

Soluble nitrogen content of paneer samples had significantly (P<0.05) increased during storage and such increase was found to be significant (P>0.05) at each successive storage period. This could be due to presence of proteolytic enzymes present in samples. Treatment of paneer with different acids also showed significant effect on soluble nitrogen content. Similar trend was noted for combined effect of treatment and storage period. Paneer treated with lactic acid had initially lower soluble nitrogen content but it increased significantly (P<0.05) in paneer samples treated with vinegar followed by lactic acid and significantly (P<0.05) lowest value was noted for citric acid treated paneer.

Paneer treated with three different acids had significant effect on % FFA content. Samples of paneer treated with vinegar had significantly (P<0.05) higher values for % FFA content, while paneer treated with lactic acid and citric acid remained statistically at par. During storage all three samples showed significant increase in % FFA content at each evaluation period. Combined effect of treatment and storage period on % FFA content was significant and up to 45 days of storage all paneer samples were significantly (P<0.05) different from each other and thereafter paneer samples T1 and T3 remained statistically at par during storage period of 90 days.

Table 2: Effect of type of acid used for dipping paneer on soluble Nitrogen and FFA of rehydrated paneer during storage at 7±2 °C

Treatment		Storage period (days)					
	0	15	30	45	60	75	90
	Soluble Nitrogen (%)						
T1	0.0213	0.0243	0.0387	0.042	0.0643	0.096	0.1177
T2	0.0203	0.0237	0.0367	0.0447	0.0683	0.1	0.1247
T3	0.0207	0.0243	0.0407	0.0483	0.0723	0.1047	0.1293
CD (0.05) T = 0.001 ; S = 0.001 ; TXS = 0.002							
	FFA (% oleic acid)						
T1	0.047	0.0493	0.067	0.0977	0.1127	0.1243	0.1323
T2	0.039	0.053	0.0713	0.1033	0.1163	0.1213	0.1267
T3	0.0573	0.0623	0.0773	0.0983	0.1113	0.1223	0.1343
CD (0.05) T =0.001 ; S =0.002 ; TXS =0.003							

Each observation is a mean of three replicate experiments (n=3); T=Type of acid (Citric acid=T1, Lactic acid=T2, Vinegar=T3); S=Storage Period

3.3 Changes in sensory attributes of paneer during storage

Dipping of paneer cubes in acid resulted in a sour acidic taste of paneer. However it was found that after rehydration there was a marked decrease in acidic taste of paneer cubes. Since paneer is used in vegetable dishes preliminary studies indicated that use of paneer cubes dipped in acid solution were found to be highly acceptable because of it pleasant slightly acidic taste on the surface of such cubes.

The rehydrated samples of paneer were subjected to sensory evaluation by panel of judges using 9-point hedonic scale when fresh and after at an interval of every 15 days till the samples were found to be unacceptable sensorily. It was found that control had a shelf life of 7 days only when stored at 5±1 C. The results obtained for changes in sensory attributes of fresh and stored samples of paneer are presented in Table 4.

Type of acid used and storage period had significant effect on flavour score of the paneer. The interaction between type of acid used and storage period was also significant (P<0.05). It can be seen from changes in colour and appearance and body and texture scores that storage period had significant (P<0.05) effect on these parameters, whereas, effect of type of acid was non significant (P>0.05). The interaction between type of acid used and storage period was also found to be non-significant (P>0.05).The type of acid used and storage period had significant effect on overall acceptability score of the paneer. The interaction between type of acid used and storage period was also significant (P<0.05). Fresh samples of paneer dipped in vinegar scored slightly better for all the sensory attributes compared to samples of paneer with citric and lactic acid. On the 60th day of storage the overall acceptability score obtained for T1 was 6.83 which was below the minimum acceptable limit fixed i.e. 7.0. On 90th day of storage development of off flavour was noticed in the samples of paneer dipped in citric acid. Sensory score of paneer dipped in lactic acid and citric acid remain acceptable upto 90th day of storage.

Table 3: Effect on rate of hydration (%) of dried Paneer treated with Citric acid (T1), Lactic acid (T2) and Vinegar (T3) during storage under refrigeration condition (7±2 ^{O}C)

Treatment		Storage period (days)					
	0	15	30	45	60	75	90
T1	80.33	77.67	78.33	76.00	72.67	70.33	61.67
T2	83.00	82.33	81.00	78.67	76.00	73.00	70.00
T3	84.33	85.00	84.00	79.67	78.00	74.33	68.00
CD (0.05) T = 1.670; S = 1.093; TXS =NS							

Each observation is a mean of three replicate experiments (n=3); T=Type of acid (Citric acid=T1, Lactic acid=T2, Vinegar=T3); S=Storage Period

Table 4: Effect of type of acid used for dipping paneer on sensory characteristics of rehydrated paneer during storage at 7±2 °C

Treatment		Storage period (days)					
	0	15	30	45	60	75	90
	Flavour scores						
C	8.58	8.63	8.58	8.63	8.58	8.63	8.63
T1	8.08	7.75	7.50	7.50	7.00	7.00	7.00
T2	8.25	8.00	8.00	7.83	7.67	7.33	7.25
T3	8.00	8.08	8.08	7.75	7.35	7.17	7.25
CD (0.05) T = 0.189 ; S = 0.124 ; TXS =0.09							
	Body and texture scores						
C	8.58	8.60	8.50	8.67	8.50	8.53	8.57
T1	8.25	8.00	7.83	7.83	7.67	7.33	7.00
T2	8.25	8.00	8.00	7.83	7.67	7.33	7.25
T3	8.00	8.08	8.17	7.83	7.75	7.83	7.25
CD (0.05) T = 0.33 ; S =0.25 ; TXS = 0.15							
	Colour and appearance scores						
C	8.48	8.63	8.58	8.63	8.58	8.63	8.63
T1	8.17	8.17	8.00	7.67	7.58	7.47	7.08
T2	8.25	8.08	7.67	7.67	7.50	7.08	6.75
T3	8.17	8.08	7.75	7.67	7.42	7.41	7.17
CD (0.05) T =0.288 ; S =0.189 ; TXS =NS							
	Overall acceptability scores						
C	8.51	8.51	8.60	8.65	8.51	8.50	8.52
T1	7.92	7.58	7.33	7.33	6.83	6.83	6.75
T2	8.08	8.08	8.00	7.75	7.67	7.25	7.08
T3	8.17	8.08	8.08	7.67	7.22	7.17	7.08
CD (0.05) T = 0.422 ; S =0.276 ; TXS = NS							

Each observation is a mean of three replicate experiments (n=3); T=Type of acid (Citric acid=T1, Lactic acid=T2, Vinegar=T3); S=Storage Period

3.4 Changes in rate of hydration of paneer during storage

Quality of paneer could be judged only after its rehydration as dried paneer is obviously very hard due to reduction in moisture content. Hence rehydration property of dried paneer is an important parameter affecting the sensorial and rheological acceptability of the product.

A significant decrease in rate of hydration of paneer samples was noted in order of paneer treated with vinegar had highest and it significantly (P<0.05) decreased in lactic acid treated paneer and citric acid treated paneer had lowest rate of hydration (Table 8). During storage upto 30 days period a non-significant decrease in rate of hydration was observed but thereafter it decreased significantly (P<0.05) at each evaluation period. Combined effect of period of storage and treatment on rate of hydration was non-significant.

3.5 Changes in microbial count of paneer during storage

The effect of treatment of paneer with acids on microbiological count during storage is presented in Table 6. It can be seen from Table 6 that the Standard Plate Count (SPC) of treated paneer samples had significantly (P<0.05) varied and citric acid samples had significantly (P<0.05) lower SPC count and it increased significantly (P<0.05) in samples treated with vinegar and paneer samples treated with lactic acid had highest SPC count. During storage SPC count of paneer samples increased significantly (P<0.05) at each evaluation period. Upto 15 day storage period all three paneer samples had significant variation in SPC, however, after 15 days of storage period samples T1 and T3 remained statistically at par (P>0.05) and sample T2 had significantly (P<0.05) higher SPC count.

Yeast and Mold count (Y&M) of paneer samples varied significantly in all three treatment and vinegar had significantly (P<0.05) lower count followed by citric acid and lactic acid treated samples. During storage Y&M count increased significantly (P<0.05) only during 15 and 30th days of storage and similar effect was noted at the end of storage period. In combined effect of period of storage and treatment Y&M count increased significantly (P<0.05), however, it decreased significantly (P<0.05) on 45th day onwards.

All paneer samples under study, showed increase in SPC and Yeast and Mold count, however the count observed had lower values compared to standards laid down by FSSAI till end of storage period (90 days). Thus microbiologically all paneer samples under study could be considered safe and acceptable.

3.6 Changes in rheological properties of paneer during storage

The rheological properties as indicated in Table 5, suggests that hydrated paneer samples treated with vinegar had lower hardness, higher springiness and lower adhesiveness, comparable to that of fresh control sample, closely followed by that treated with lactic acid. Chewiness, Stiffness and Gumminess values were observed to be lowest in hydrated paneer samples treated with lactic acid.

Table 5: Rheological Properties of dried Paneer treated with Citric acid (T1), Lactic acid (T2) and Vinegar (T3) during

Rheological Parameters	Control	T1		T2		T3	
		Dried	Hydrated	Dried	Hydrated	Dried	Hydrated
Hardness N	33.16	125.49	70.12	57.86	47.15	70.89	42.01
Chewiness Nmm	78.68	136.88	90.92	96.99	73.69	107.69	75.68
Gumminess N	7.93	21.13	11.47	10.21	8.75	12.34	9.21
Stiffness N/mm	4.80	20.16	11.02	9.69	5.62	15.62	5.78
Springiness (mm)	11.14	6.22	7.92	5.56	8.41	4.89	10.78
Springiness Index	0.74	0.60	0.65	0.55	0.69	0.53	0.77
Adhesive Force (N)	0.44	0.91	0.54	0.63	0.50	0.59	0.46
Adhesiveness Nmm	1.01	1.45	1.28	1.89	1.17	1.74	1.09

Table 6: Effect on Standard Plate Count (log_{10}) and yeast and mould count (log_{10}) of dried Paneer treated with Citric acid (T1), Lactic acid(T2) and Vinegar(T3) during storage under refrigeration condition (7±2 ^{O}C)

Treatment		Storage period (days)					
	0	**15**	**30**	**45**	**60**	**75**	**90**
	Standard Plate Count (log_{10})						
T1	5.21	5.26	5.35	5.37	5.41	5.45	5.48
T2	5.39	5.43	5.44	5.46	5.49	5.51	5.53
T3	5.26	5.32	5.36	5.38	5.42	5.46	5.49
CD (0.05) T = 0.008 ; S = 0.005 ; TXS =0.014							
	Yeast and mold count (log_{10})						
T1	1.92	1.9	1.91	1.99	2.01	2.07	2.13
T2	2.23	2.23	2.28	2.3	2.33	2.35	2.38
T3	1.08	1.19	1.3	1.18	1.16	1.02	0.84
CD (0.05) T =0.031 ; S =0.020 ; TXS =0.053							

Each observation is a mean of three replicate experiments (n=3); T=Type of acid (Citric acid=T1, Lactic acid=T2, Vinegar=T3); S=Storage Period

4. Conclusion

Based on the results obtained in this study both Vinegar and Lactic acid can be used successfully for extending the shelf-life of paneer. Treatment of paneer with lactic acid and vinegar resulted in enhanced shelf-life up to 90 d under refrigerated (7±2 ^{O}C) storage conditions whereas paneer treated with citric acid was found to be acceptable up to 60 days of storage.

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