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Effect of Water Activity on Sensory, Textural Properties and Shelf Life of Paneer

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ABSTRACT

Paneer is an important indigenous milk product extensively used as a cooking ingredient along with vegetables. Because of its high water activity (a_w 0.994), paneer has a shelf life not more than 1 day at room temperature and up to a week at refrigeration temperature. The important hurdles used in food preservation are temperature (high or low), water activity, acidity (pH), redox potential, preservative and competitive microflora. Out of these aw plays an important role whose effect was studied in paneer. Paneer was prepared by a standardized method. The One cm pieces of the paneer were subjected to partial drying in an oven for different time - temperature combinations. Water activity was reduced by evaporating moisture in oven for different time (0, 2, 4, 6, 8 and 10 hours) at different temperatures (45°C, 55°C and 65°C).Water activity got reduced from 0.994 to 0.986, which was found to be within the sensory acceptance limits. Out of these, combination of 55°C for 4 hrs was chosen, because no visible fat separation took place. Sensory scores of color, body & texture, flavor and overall acceptability of treated samples were lower than those of control. Hardness, gumminess and chewiness increased while springiness decreased with time during storage of treated sample at refrigeration temperature. Shelf life of treated sample was only one day at room temperature which is similar to control sample. While at refrigeration temperature, shelf life of treated sample was 10 days and control sample was only 6 days. Thus, it was concluded that reduced water activity did not enhance the shelf life of paneer at room temperature, while it slightly enhanced at refrigeration temperature in respect of control.

Key words: *Water activity, Sensory properties, Texture profile properties, Shelf life, Paneer.*

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INTRODUCTION

Paneer is a tempting, nutritious indigenous dairy product obtained by acid and heat coagulation of milk. Good quality paneer is characterized by a marble white color, sweetish, mildly acidic taste, nutty flavor, spongy body and closely knit smooth texture. In India, where most people are vegetarian in dietary habits, milk products constitute major source of protein and other essential nutrients. Paneer is widely used as a base material for the preparation of a variety of culinary dishes, stuffing material for various vegetable dishes, snacks and sweet meats[1,10]. It is estimated that about 50% of total milk produced in India is converted into various milk products like ghee, butter, paneer, chhana, khoa etc. Among these paneer is one of the major milk products produced in India, especially in the north. According to an estimate, about 5% of milk produced in India is converted into paneer[4]. Because of its high water activity (a_w 0.994), paneer has a shelf life of not more than one day at room temperature and up to a week at refrigeration temperature[2]. To enhance the shelf life of paneer several attempts have been done in the past, which included addition of preservatives[8], vacuum packaging, low temperature storage, dehydration and heat sterilization[12], treatment with brine, chlorinated water, H_2O_2, sorbic acid, potassium sorbate and antioxidants[11]. The spoilage in paneer occurs mainly due to the growth of microorganisms like yeasts and molds, which bring about various physiochemical changes leading to the development of off-flavor in the product. Hurdles like water activity, pH, redox-potential (Eh) and modified atmospheric packaging (MAP), which are either bacteriostatic or bactericidal in nature, may help to extend shelf life. Present study was undertaken to study the effect of water activity on sensory and textural properties and shelf-life of paneer.

MATERIALS AND METHODS

Preparation of paneer

Fresh toned milk was procured from Students' Experimental Dairy Plant of SRS of NDRI, Bengaluru. Milk was heated at 90°C without holding and cooled to 80°C and was coagulated with citric acid. 1% Citric acid (@ 0.2% of milk) solution at 80°C was added to milk. Acid was added slowly to the milk with continuous slow stirring until a curd and clear slightly yellow-greenish whey separated out. Thereafter, the mixture was allowed to settle down for about 5 min and the whey was drained out through muslin cloth. Pressing of curd was done by applying a weight of 35-40 g/cm^2 for 20 minutes in muslin cloth lined cubical hoop. Finally prepared paneer sample was chilled in cold water at 5-7°C for 2 hours. Then 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.

Analytical methods

Water activity meter (Rotronic Hygroskop, BT-RS1 Ag Switzerland) was used to determine the water activity of paneer.

Sensory evaluation

Samples were evaluated for sensory characteristics like color and appearance, body and texture, flavor and overall acceptability using a 9-point Hedonic scale[9]. Sensory evaluation panel consisted of 7 judges (SRS of ICAR-NDRI) having knowledge about sensory evaluation as well as product characteristics.

Texture Profile Analysis[3]

Texture Analyzer (Stable Microsystems, UK) was used for measuring the hardness, springiness, gumminess and chewiness of paneer at temperature of 30°C, having size of 1 cm cubes (i.e. 1 x 1 x 1 cm). The test settings were: load cell capacity 5 kg, platen probe (P/75) of 75 mm diameter, pre test speed 1 mm/sec, test speed 5 mm/sec, post test speed 5 mm/sec, target mode-distance, distance-5 mm, time-30 sec, trigger type- auto force, trigger force-2 gm, break mode-off and tare mode-auto. All the tests were replicated three times.

Shelf life

Water activity of paneer was decreased to reduce the growth of spoilage microbes for enhancing the shelf-life. Paneer was packed in packaging material (polystyrene cups), stored at ambient temperature (30±1°C) and refrigeration temperature (7±1°C). Samples were taken out at regular interval for evaluating sensory and textural quality.

Statistical analysis

Data of sensory and rheological analysis obtained in the study were subjected to statistical analysis by one way ANOVA using MS-Excel package version 2007.The differences among treatments were measured at 5% level of significance.

RESULT AND DISCUSSION

Effect of drying on sensory quality of paneer

In preliminary trials, paneer was dried at 45, 55 and 65°C for 2, 4, 6, 8 and 10 hours. After sensory analysis, it was found that paneer which was dried for 6, 4 and 2 hours at 45, 55 and 65°C, respectively, was acceptable (Table 1). As drying time increased, water activity decreased due to evaporation of moisture. Figure-1 shows water activity at different drying temperatures for different times. Up to acceptable level of treated sample, water activity was reduced to 0.986, 0.986 and 0.987 from 0.994 in 6, 4 and 2 hours at 45, 55 and 65°C respectively. Color and appearance scores of treated sample were lower ($p \leq 0.05$) compared to control sample due to turning of color of paneer cubes from white to slightly yellowish at surface, probably it may be due to fat separation of paneer. Yellow color was more observed at high temperature. Color and appearance scores decreased ($p \leq 0.05$) with increasing of heating time (Table 1) from 7.96 to 7.17, 7.20 and 7.27 in 6, 4 and 2 hours at 45, 55 and 65°C respectively. The body and texture scores of treated sample decreased ($p \leq 0.05$) with increase in drying time of paneer, possibly due to hardening of paneer. Hardening of paneer may be attributed to evaporation of moisture from paneer. Score decreased from 7.93 to 6.06, 7.10 and 7.00 in 6, 4 and 2 hours drying at 45, 55 and 65°C, respectively,. The flavor of paneer reduced with increase in the heating time, probably due to volatilization of flavor compounds from treated paneer. Flavor score decreased from 7.96 to 7.37, 7.03 and 7.06 in 6, 4 and 2 hours drying treatments at 45, 55 and 65°C respectively. Overall acceptability decreased ($p \leq 0.05$) with increased heating time, score decreased from 7.96 to 7.00, 7.07 and 7.12 in 6, 4 and 2 hours at 45, 55 and 65°C respectively. Among these combinations 55°C for 4 hr was chosen for shelf life study because 45°C took much time and body became slightly harder in comparison to 4 hours heating at 55°C. At 65°C for 2 hours visible fat separation were observed, while at treatment at 55°C for 4 hr no visible fat separation took place.

Sensory analysis of paneer during storage

Sensory analysis during storage at ambient temperature (30±1°C) and refrigeration temperature (7±1°C) of treated and control sample was done by 7 judges of sensory evaluation panel for sensory characteristics like color and appearance, body and texture, flavor and overall acceptability.

Color and appearance

Color and appearance score of control and treated sample during storage are given Table 2 and Table 3 which showed that scores significantly decreased during storage ($p \leq 0.05$) at room and refrigeration temperature. Score of control and treated sample decreased from 7.96 to 5.70 and from 7.20 to 5.93 respectively, in two days storage at ambient temperature (Table 2). Color and appearance of control and treated sample became greenish on surface due to slime production on second day. While at refrigeration temperature, score of control in 8 days and treated paneer in 12 days storage decreased from 7.96 to 6.07 and from 7.20 to 5.76, respectively (Table 3) and dry surface appearance were observed in both.

Body and texture

Body and texture score of control and treated paneer during storage are given Table 2 and Table 3, which showed that scores significantly decreased during storage ($p \leq 0.05$) at room and refrigeration temperature. Score of control and treated paneer decreased from 7.93 to 5.45 and from 7.10 to 5.78 respectively, in two days storage at ambient temperature (Table 2). Body of control and treated paneer became soft; probability may be due to due to slime production by microbes. While at refrigeration temperature, score of control in 8 days and treated paneer in 12 days

storage decreased from 7.93 to 6.23 and from 7.10 to 5.62 respectively. Body and texture score of both decreased due to hardening of paneer. It may be due to slightly evaporation of moisture from paneer (Table 3).

Flavor

Flavor of control and treated paneer during storage are given Table 2 and Table 3 which showed that scores significantly decreased during storage ($p \leq 0.05$) at room and refrigeration temperature. Score of control and treated paneer decreased from 7.96 to 4.95 and from 7.03 to 5.16 respectively, in two days storage at ambient temperature (Table 2). While at refrigeration temperature, score of control in 8 days and treated paneer in 12 days storage decreased from 7.96 to 5.20 and from 7.03 to 5.27 respectively (Table 3). At refrigeration temperature spoilage occurred due to flavor defect; in which paneer gave bitter taste due to proteolysis of protein by microbes.

Overall acceptability

Overall acceptability of control and treated paneer during storage are given Table 2 and Table 3 which showed that scores significantly decreased during storage ($p \leq 0.05$) at room and refrigeration temperature. Score of control and treated paneer decreased from 7.96 to 5.23 and from 7.03 to 5.40 respectively, in two days storage at ambient temperature (Table 2). While at refrigeration temperature, score of control in 8 days and treated paneer in 12 days storage decreased from 7.96 to 5.38 and from 7.07 to 5.23 respectively (Table 3). Table 2 shows that shelf life of control and treated paneer were only one day at ambient temperature. While shelf life of control and treated paneer were 6 and 10 days at refrigeration temperature (Table 3) respectively.

Textural profile analysis of paneer during storage

Initial hardness, springiness gumminess and chewiness of control were 957, 0.939,775 and 727g. After heat treatment to paneer at 55°C for 4 hours; hardness, gumminess and chewiness increased to 1266, 943 and 852gm respectively, while springiness decreased to 0.904. Similarly changes in textural attributes of paneer after heat treatment were also observed by Zanjad[15] and Rao[13]. These results may be due to conformational changes of milk proteins induced during heating and acidification stages, and these changes are expected to continue during storage also. Shrivastav[14] also reported that hardness, gumminess and chewiness of paneer increased with heating.

Change in TPA of paneer at ambient temperature

The data presented in Table 4 indicate that hardness, gumminess and chewiness decreased while springiness increased in control and treated paneer in one day storage at ambient temperature**.** Hardness, gumminess and chewiness of control sample decreased from 957 to 924gm, 775 to 754gm and 727 to 710gm respectively. Springiness of control increased from 0.939 to 0.942. Same way result in treated sample was also obtained. Hardness, gumminess and chewiness decreased of treated sample from 1266 to 1115gm, 943 to 867gm and 852 to 801gm respectively. Springiness increased from 0.904 to 0.923. Similar observations were also obtained by Desai[5] during storage of paneer at 37°C.

Change in TPA of paneer at refrigeration temperature

The data presented in Table 5 indicate that hardness, gumminess and chewiness increased first, there after decreased, while springiness decreased thereafter increased in control and in treated paneer. Similar observation was reported by Dwarakanath[6] during study of effect of freezing on texture attributes of paneer during storage. Hardness, gumminess and chewiness increased from 957 to 1454 gm, 775 to 1058 gm and 727 to 940 gm respectively; Springiness decreased from 0.939 to 0.889 up to 6 day storage of control sample at refrigeration temperature. While on 8^{th} day hardness, gumminess and chewiness of control sample decreased from 1454 to 1423 gm, 1058 to 1021 gm, 940 to 910 gm; Springiness increased from 0.889 to 0.892. In same way, result was also obtained in treated

sample. Hardness, gumminess and chewiness increased of treated sample from 1266 to 1723 gm, 943 to 1174 gm and 852 to 1008 gm respectively; Springiness decreased from 0.904 to 0.859 up to 10th day storage. While on 12th day Hardness, gumminess and chewiness of control slightly decreased from 1723 to 1709 gm, 1174 to 1160 gm, 1008 to 996 gm; Springiness increased from 0.859 to 0.853. Kanawjia and Singh[7] reported in their study appreciable increase in all TPA attributes during refrigerated storage (6-8°C).

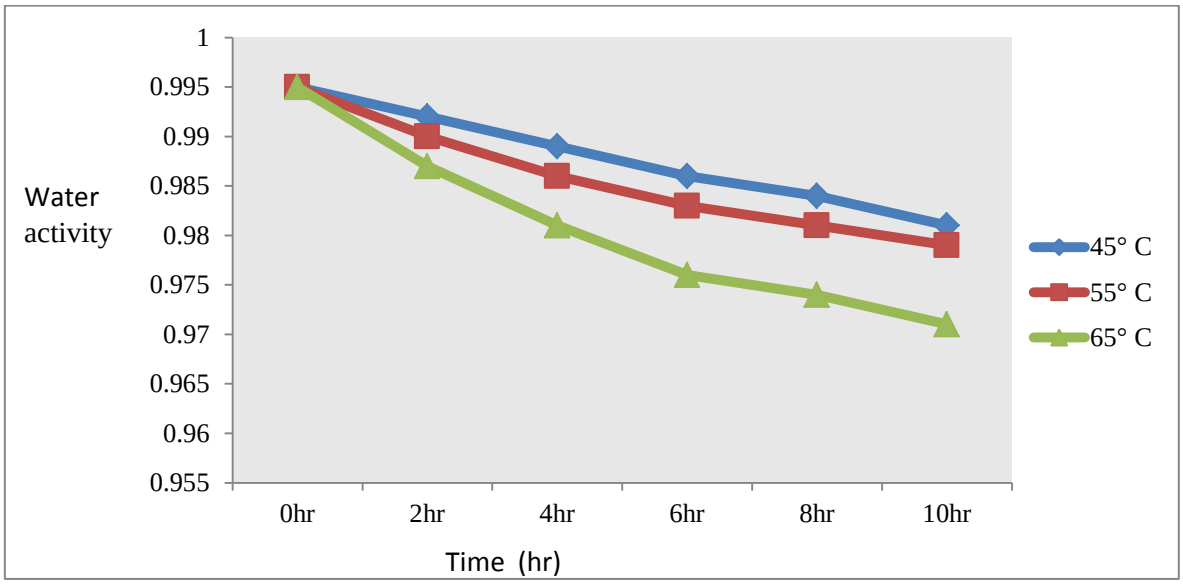

Fig. 1: Change in water activity of paneer at different drying temperature for different time

Table 1: Effect of drying at different temperature for different time on sensory attributes of paneer

Temperature (°C)	Time (hr)					
	0 hr	2 hr	4 hr	6 hr	8 hr	10 hr
Color and appearance						
45°C	7.96±0.05 ^{am}	7.73±0.12^{abm}	7.47±0.05^{bcm}	7.17±0.15^{cdm}	6.83±0.15^{dm}	6.13±0.21^{em}
55°C	7.96±0.05^{am}	7.45±0.10^{abmn}	7.20±0.20^{bm}	6.52±0.35^{cmn}	5.43±0.30^{dn}	5.20±0.26^{dn}
65°C	7.96±0.05^{am}	7.27±0.25^{an}	6.33±0.41^{bn}	5.83±0.32^{bcn}	5.17±0.25^{cdn}	4.83±0.29^{dn}
Body and texture						
45°C	7.93± 0.05^{am}	7.80±0.20^{am}	7.30±0.30^{am}	6.06±0.21^{bm}	5.33±0.35^{cm}	4.53±0.25^{dm}
55°C	7.93± 0.05 ^{am}	7.50±0.30^{abmn}	7.10±0.26^{bm}	5.86±0.30^{cm}	5.06±0.31^{dm}	3.66±0.29^{en}
65°C	7.93± 0.05^{am}	7.0±0.30^{bn}	5.01±0.25^{cn}	4.50±0.30^{cdn}	4.00±0.20^{dn}	3.10±0.29^{en}
Flavor						
45°C	7.96± 0.05 ^{am}	7.93+ 0.05^{am}	7.70±0.20^{abm}	7.37±0.15^{bmn}	7.03±0.15^{cm}	6.56±0.21^{dm}
55°C	7.96± 0.05 ^{am}	7.53+ 0.05^{abn}	7.03±0.25^{bcn}	6.56±0.21^{cn}	5.00±0.20^{dn}	4.23±0.25^{en}
65°C	7.96± 0.05 ^{am}	7.06+ 0.05^{ao}	5.56±0.21^{bo}	5.03±0.25^{bo}	4.43±0.21^{co}	3.46±0.25^{do}
Overall acceptability						
45°C	7.96± 0.05 ^{am}	7.83±0.06^{abm}	7.46±0.25^{bcm}	7.00±0.20^{cm}	5.56±0.21^{dm}	4.50±0.20^{em}
55°C	7.96± 0.05 ^{am}	7.53±0.26^{bn}	7.07±0.11^{bm}	5.97±0.31^{cn}	4.49±0.25^{dn}	3.96±0.25^{emn}
65°C	7.96± 0.05 ^{am}	7.12±0.24^{bn}	5.50±0.30^{cn}	5.03±0.15^{cdo}	4.56±0.21^{dn}	3.60±0.26^{en}

$^{a, b, c}$ Means with different superscripts in a row and $^{m, n, o,.}$ means with different superscripts in a column differ significantly ($p \leq 0.05$)

Table 2. Effect of water activity on sensory score of paneer during storage at ambient temperature (30±1°C)

Days	Control sample	Treated Sample
Color and appearance		
0	7.96 ± 0.05^{am}	7.20 ± 0.20^{an}
1	7.60 ± 0.26^{am}	6.86 ± 0.15^{an}
2	5.70 ± 0.30^{bm}	5.93 ± 0.25^{am}
Body and texture		
0	7.93 ± 0.05^{am}	7.10 ± 0.26^{an}
1	7.53 ± 0.21^{am}	7.03 ± 0.15^{an}
2	5.45 ± 0.25^{bm}	5.78 ± 0.12^{bm}
Flavor		
0	7.96 ± 0.05^{am}	7.03 ± 0.25^{an}
1	7.37 ± 0.21^{bm}	6.90 ± 0.10^{an}
2	4.95 ± 0.20^{cm}	5.14 ± 0.15^{bm}
Overall acceptability		
0	7.96 ± 0.05^{am}	7.06 ± 0.11^{an}
1	7.45 ± 0.25^{am}	6.88 ± 0.22^{an}
2	5.23 ± 0.30^{bm}	5.40 ± 0.26^{bm}

$^{a, b, c}$ Means with different superscripts in a row and $^{m, n, o,.}$ means with different superscripts in a column differ significantly ($p\leq0.05$)

Table 3: Effect of water activity on sensory score of paneer during storage at refrigeration temperature (7±1°C)

Type of paneer	Days						
	0	2	4	6	8	10	12
Color and appearance							
Control sample	7.96 ± 0.05^{am}	7.65 ± 0.33^{am}	7.36 ± 0.25^{abm}	6.80 ± 20^{bm}	6.07 ± 0.21^{cm}	-	-
Treated sample	7.20 ± 0.20^{an}	7.06 ± 0.15^{abn}	6.82 ± 0.17^{abcn}	6.58 ± 0.16^{bcdm}	6.37 ± 0.21^{cdm}	6.07 ± 0.15^{de}	5.76 ± 0.25^{e}
Body and texture							
Control sample	7.93 ± 0.05^{am}	7.56 ± 0.12^{abm}	7.20 ± 0.17^{bm}	6.56 ± 0.12^{cm}	6.23 ± 0.25^{cm}	-	-
Treated sample	7.10 ± 0.26^{an}	6.97 ± 0.06^{abn}	6.77 ± 0.12^{abn}	6.43 ± 0.15^{bcm}	6.17 ± 0.17^{cdm}	5.83 ± 0.29^{d}	5.62 ± 0.23^{d}
Flavor							
Control sample	7.96 ± 0.05^{am}	7.42 ± 0.23^{abm}	6.9 ± 0.15^{bm}	6.13 ± 0.30^{cm}	5.2 ± 0.20^{cm}	-	-
Treated sample	7.03 ± 0.25^{an}	6.92 ± 0.07^{abn}	6.63 ± 0.12^{abcn}	6.32 ± 0.32^{bcdm}	6.12 ± 0.18^{cdn}	5.92 ± 0.32^{d}	5.27 ± 0.15^{e}
Overall acceptability							
Control sample	7.96 ± 0.05^{am}	7.53 ± 0.25^{am}	7.28 ± 0.30^{abm}	6.6 ± 0.26^{bm}	5.38 ± 0.31^{cm}	-	-
Treated sample	7.07 ± 0.12^{an}	7.00 ± 0.10^{an}	6.77 ± 0.25^{abm}	6.53 ± 0.15^{bcm}	6.22 ± 0.12^{cdn}	5.87 ± 0.15^{d}	5.23 ± 0.05^{e}

$^{a, b, c}$ Means with different superscripts in a row and $^{m, n, o,.}$ means with different superscripts in a column differ significantly ($p\leq0.05$).

a_w of control paneer was 0.994 and that of treated sample was 0.98

Table 4: Changes in TPA characteristics of paneer during storage at ambient temperature (30±1°C)

Type of paneer	Storage days	
	0 day	1 day
Hardness (gm)		
Control sample	957±87^{am}	924±37^{am}
Treated Sample	1266±95^{an}	1116±99^{an}
Springiness		
Control sample	0.939±0.008^{am}	0.942±0.004^{am}
Treated Sample	0.904±0.006^{an}	0.923±0.008^{an}
Gumminess (gm)		
Control sample	775±55^{am}	754±24^{am}
Treated Sample	943±43^{an}	867±53^{an}
Chewiness (gm)		
Control sample	727±45^{am}	710±20^{am}
Treated Sample	852±31^{an}	801±41^{an}

$^{a, b, c}$ Means with different superscripts in a row and $^{m, n, o,.}$ means with different superscripts in a column differ significantly ($p \leq 0.05$). a_w of control paneer was 0.994 and that of treated sample was 0.98

Table 5: Changes in TPA characteristics of paneer during storage at refrigeration temperature (7±1°C)

Paneer type	Storage days						
	0	2	4	6	8	10	12
Hardness (gm)							
Control sample	957±87.47^{am}	1107±57^{abm}	1263±76^{bcm}	1454±49^{cdm}	1423±44^{dm}	-	-
Treated Sample	1266±95^{an}	1331±76^{abn}	1395±84^{abcm}	1490±79^{bcdm}	1582±68^{cden}	1723±66^{e}	1709±82de
Springiness							
Control sample	0.939±.008^{am}	0.924±.006^{abm}	0.908±.007^{bcm}	0.889±.005^{cdm}	0.892±.004^{dm}	-	-
Treated Sample	0.904±.009^{an}	0.897±.008^{abn}	0.890±.009^{abn}	0.871±0.007^{bcm}	0.868±.003^{bcn}	0.859±.009^{c}	0.853±0.006^{c}
Gumminess (gm)							
Control sample	775±55^{am}	867±29^{abm}	941±38^{bcm}	1058±28^{dm}	1021±43^{cdm}	-	-
Treated Sample	943±43^{an}	965±29^{an}	969±44.35^{abm}	1049±47^{abcm}	1093±35^{bcdm}	1174±32^{cd}	1160±41^{d}
Chewiness (gm)							
Control sample	727±45^{am}	801±21^{abm}	855±28^{bcm}	940±19^{dm}	910±34^{cdm}	-	-
Treated Sample	852±31^{an}	865±19^{abn}	887±30^{abm}	914±39^{abcm}	949±28 $^{bcd\ m}$	1008±17^{d}	996±28^{cd}

$^{a, b, c}$ Means with different superscripts in a row and $^{m, n, o,.}$ means with different superscripts in a column differ significantly ($p \leq 0.05$). a_w of control paneer was 0.994 and that of treated sample was 0.98

CONCLUSION

Shelf life of treated sample was only one day at room temperature which is similar to control paneer. While at refrigeration temperature, shelf life of treated sample was 10 days and control was only 6 days. Thus reduced water activity did not enhance the shelf life of paneer at room temperature, while it slightly enhanced at refrigeration temperature in respect of control.

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