Evaluation of efficacy of turmeric as a preservative in paneer

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Abstract A study was conducted to evaluate turmeric as a preservative for extending shelf life of paneer. In the first part of the study, turmeric was incorporated in the product at the rate of 0.0 (control), 0.2, 0.4, 0.6, 0.8 and 1.0 % by weight of expected yield of paneer. Based on changes in sensory score of paneer, the rate of addition of turmeric to milk was selected as 0.4 % by weight of expected yield of paneer. In the next part the effect of addition of turmeric at the rate of 0.4 % by weight of expected yield of paneer before heat treatment of milk and after heat treatment of milk was studied. The prepared samples of paneer were subjected to sensory evaluation when fresh and after the interval and during storage for 12 days at 7 ± 1 °C. The samples of stored paneer obtained in case of turmeric added before heating of milk scored higher. It was observed that the addition of turmeric before heat treatment of milk markedly reduced taste of raw turmeric in resultant samples of paneer. Therefore, it was decided to try one higher (0.6 %) concentration of turmeric along with 0.4 % in the next part where the effectiveness of turmeric in extending the shelf life of paneer was evaluated. The samples of paneer with 0.6 % turmeric by weight of expected yield of paneer remain

acceptable up to 12 days on storage at 7 ± 1 °C. The present study entailed to conclude that addition of turmeric in paneer at the rate greater than 0.6 % by weight of expected yield of paneer results into sharp decline in sensory score of paneer. Addition of turmeric at the rate of 0.6 % by weight of expected yield of paneer extends the shelf life of paneer up to 12 days on storage at 7 ± 1 °C.

Keywords Paneer · Turmeric · Shelf life · Preservative · Herbs

Introduction

Paneer is an important heat and acid coagulated indigenous dairy product. The poor keeping quality of paneer is a major obstacle in its large scale industrial production. A great deal of study has been carried out for enhancing the shelf life of paneer employing various preservatives and preservation methods. Now-a-days consumers are interested in having foods that are natural or close to natural, minimally processed and free of chemical preservatives. Like other indigenous products, paneer is a highly perishable product and suffers from limited shelf life, largely because of its high moisture content (Arora and Gupta 1980). The shelf life of paneer is reported to be only 6 days at refrigeration temperature (10 °C); but the freshness of the product is lost after 3 days (Bhattacharya et al. 1971). Its flavour remains acceptable even after 120 days when stored at -13 or -32 °C. At room temperature paneer does not keep well for more than 1 day. Various attempts have been made over the years to increase the shelf life of paneer. Food additives such as sorbic acid, potassium sorbate, solutions of H_2O_2 and brine and delvocid (Sachdeva and Singh 1990a) have been tried successfully to increase the shelf-life of paneer. Antioxidants like tertiarybutylhydroquinone (TBHQ) and

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butylated hydroxyl anisole (BHA) have also been tried as possible antimicrobial agents in paneer (Kumar and Bector 1991).

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 (Membre et al. 2001). In recent years many attempts have put emphasis on the search for natural antimicrobial substances that can properly serve the needs of food manufacturers and consumers. Various herbs and spices have been recognized for their antimicrobial activity and used throughout the past as an alternative approach to preserve foods. Inhibitory activity of herbs and derivatives on the growth of bacteria, fungi and microbial toxins has been well reported (Zaika 1988). Many plant essential oils of herbs are active against various food borne bacteria and molds (Aureli et al. 1992). Herbs and spices have also been well known for their medicinal, preservative and antioxidant properties (Souza et al. 2005) hence they could be used for food preservation as main or adjuvant antimicrobial substances. This approach enhances safety of the foods (Farag et al. 1990). Herbs and spices are currently used mainly for enhancing the flavour of foods rather than extending shelf life (Almeida et al. 2000). Kaur et al. (2003) and Bajwa et al. (2005) reported that incorporation of coriander and mint at level of 10 % by weight in paneer improved the overall acceptability score and yield of product. In addition to imparting flavour, certain herbs prolong the shelf life of foods due to their bacteriostatic or bacteriocidal activity and prevent rancidity by their antioxidant activity (Shelef et al. 1980). No work has been reported about use of turmeric in extending shelf life of paneer. Therefore, the present study has been contemplated to select stage for addition of turmeric, a well known antibiotic in paneer and to evaluate turmeric as a preservative for paneer.

Materials and methods

For the preparation paneer full cream milk (6.0% Fat, 9.0 % SNF) and standardized milk (4.5 % fat, 8.5 % SNF) were collected from Vidya Dairy, Anand. Turmeric powder (Ram Dev, AGMARK Grade) was obtained from the local market. Composite polyethylene terephthalate (PET)/low-density polyethylene (LDPE) film (50 μ thickness) was used for packaging of samples during storage study.

Preparation of paneer Paneer was prepared in the laboratory using method described by De (1983). Milk, standardized to 5.5 % fat was heated to 95 °C for 5 min and cooled to 70 °C. Citric acid (1 % solution) was added with continuous agitation until the coagulation was complete. The curd was allowed to settle for 5 min. Whey was drained through a muslin cloth by gentle squeezing with hand and curd was collected. The curd

was then filled in a round shaped per sterilized stainless steel hoop lined with clean muslin cloth. The curd was pressed for 20 min. followed by immersing in chilled water (4 to 6 °C) for 2 h. The blocks removed from chilled water were kept on wooden planks for 15 min for allowing the water to drain off. Paneer was packed in PET/LDPE film pouches and stored at 7 °C $\pm$ 1 °C.

Selection of rate of addition of turmeric

The curd was divided into six equal parts and the herb was incorporated in the product at the rate of 0.0 (control), 0.2, 0.4, 0.6, 0.8 and 1.0 % by weight of expected yield of paneer. Three replications were taken. The samples were subjected to sensory evaluation.

Selection for stage of addition of the turmeric in paneer: From examination of manufacturing process for paneer it can be envisaged that there are four possible ways to add turmeric into paneer, as listed below.

- (1) Before heat treatment of milk.
- (2) After heat treatment of milk but before addition of coagulant.
- (3) Directly into the coagulum when about 90 % of whey is removed.
- (4) Dipping of paneer blocks in turmeric containing chilled water instead of plain chilled water.

In the preliminary trials during investigation of these four stages, it was observed that addition of turmeric directly into the coagulum after draining about 90 % of whey resulted into uneven mixing and adverse effect on body and texture of the product. Similarly, dipping of paneer blocks in turmeric containing chilled water instead of plain chilled water, gave colouration on the surface only with little absorption inside. Therefore, these two stages for addition of turmeric were dropped from the study. To find out the effect of heat treatment given to milk for paneer preparation on ability of turmeric to extend shelf life of paneer, turmeric was added at two different stages. In one experiment, turmeric was directly added to milk before initiating heat treatment and in the other, turmeric was added at 70 °C during cooling of milk after the heat treatment at 95 °C. Seven replications of this experiment were conducted. In final testing of turmeric for their suitability in paneer, turmeric was added at two different rates (0.4 and 0.6 %) before heat treatment of milk. The samples of paneer without addition of turmeric were prepared as control samples. Six replications of this experiment were conducted.

Evaluation for sensory attributes

Each block of paneer was cut into rectangular pieces of approximately 1 cm $\times$ 2 cm. The prepared samples of paneer

were subjected to sensory evaluation by a panel of six judges when fresh and at regular interval of 3 days (except first interval which was of 6 days) during storage using 9-point hedonic scale (Stone and Sidel 2004).

Statistical analysis

In the first part of the experiment to select rate of addition of turmeric 3 replications were conducted. In the next part of the experiment carried of for selecting stage of addition of turmeric, seven replications were conducted. Whereas, in the last part of the experiment to evaluate the effectiveness of turmeric in extending the shelf life of paneer at selected rates viz. 0.4 and 0.6 % by weight of expected yield of paneer, six replications were conducted. Statistical analysis of data was carried out as per Steel and Torrie (1980) using completely randomized design.

Analytical methods

Moisture content in paneer was determined according to BIS (1983) procedure specified for paneer under IS: 10484. Fat content of paneer was estimated by following the method described for cheese (Anon 1972). Protein content was determined by Kjeldahl method as described by Horwitz (1980). Lactose content in paneer was estimated by difference. Ash content of the paneer sample was estimated by the method of BIS (1981). Acidity of the paneer sample was estimated according to BIS (1983) procedure specified for paneer under IS: 10484. Free fatty acid content of paneer was estimated by following the method described for cheese Thomas et al. (1954). Soluble nitrogen content of the paneer sample was estimated by Kjeldahl method as described by Kosikowski (1970) for cheese. Peroxide value of fresh and stored paneer samples was determined by iodometric method as described AOAC (1990). Total viable count of paneer was determined by following the method as described by Messer et al. (1985) except that the diluent used was 2 % sodium citrate. The methods of plating, incubation and counting for the enumeration of yeasts and molds as described by Frank et al. (1985) were followed. The plating, incubation and counting methods to enumerate coliforms in paneer samples were followed as described by Hartman and Lagrange (1985). The values of each attributes under study were subjected to statistical analysis using Completely Randomized Design with equal number of observations. The statistical modal of Steel and Torrie (1980) was adopted.

Results and discussion

Selection of rate of addition of turmeric

The data obtained for changes in sensory attributes of paneer with increasing rate of addition of turmeric in paneer are

presented in Table 1. The flavour score declined slightly on addition of turmeric at 0.2 % by weight of expected yield of paneer and improved on addition of 0.4 % by weight of expected yield of paneer. However, further addition resulted into sharp decline in the flavour score. The body and texture and colour and appearance score declined gradually on addition of turmeric up to 0.4 % by weight of expected yield of paneer. However, further addition resulted into sharp decline in the colour and appearance score. The overall acceptability score declined slightly on addition of turmeric up to 0.4 % by weight of expected yield of paneer. However, the scores were at par ($P>0.05$) with control. Addition of turmeric at higher levels viz. 0.6 % and higher led to a significant ($P<0.05$) decrease in overall acceptability score of the paneer. Therefore, a concentration of 0.4 % (w/w) was selected. In one set of experiment, turmeric was directly added to milk before initiating heat treatment (BH) and in the other set, turmeric was added at 70 °C during cooling of milk after the heat treatment at 95 °C (AH).

Effect of stage of addition of turmeric on changes in sensory attributes

The results obtained for sensory evaluation of fresh and stored samples of paneer are presented below. The data obtained for changes in sensory score of paneer during storage at 7 ± 1 °C are presented in Table 2. Storage period had significant ($P<0.05$) effect on all sensory parameters of the paneer, whereas, effect of stage of addition of turmeric was non significant ($P>0.05$). The interaction between stage of addition and storage period was also non significant. The careful examination of the data on effect of changes in sensory attributes of paneer during storage revealed that the samples of fresh paneer obtained in case of turmeric added after heating of milk scored slightly higher than the samples of paneer obtained in case of

Table 1 Effect of addition of turmeric on sensory score of paneer

Rate of addition of turmeric (%)	Sensory attribute			
	Flavour	Colour & appearance	Body & texture	Overall acceptability
0.0	7.9±0.14	8.2±0.29	7.9±0.14	8.0±0.00
0.2	7.8±0.14	8.0±0.00	7.8±0.25	7.9±0.14
0.4	7.9±0.14	7.8±0.25	7.6±0.14	7.8±0.25
0.6	7.2±0.29	6.9±0.14	6.9±0.14	6.9±0.14
0.8	6.2±0.29	6.2±0.29	6.7±0.29	6.3±0.25
1.0	5.8±0.29	6.1±0.14	6.4±0.14	5.8±0.29
C. D	0.462	0.732	0.554	0.433

Each observation is mean±SD of 3 replications

Table 2 Sensory quality of paneer incorporated with turmeric (added to milk before and after heating at the rate of 0.4 % (w/w) on the basis of expected yield of paneer) during storage at 7±1 °C

	Storage period (days)		
Stage of addition	0	6	9
	Flavour scores		
BH	8.0±0.22	7.2±0.12	6.9±0.21
AH	8.1±0.29	6.8±0.18	6.2±0.15
CD (0.05)	T = NS, S = 0.463, TXS = NS		
	Colour and appearance		
BH	8.0±0.14	7.4±0.23	7.1±0.12
AH	8.2±0.12	7.2±0.12	7.0±0.31
CD (0.05)	T = NS S = 0.281 TXS = NS		
	Body and texture		
BH	7.8±0.19	7.1±0.12	6.9±0.21
AH	8.0±0.22	6.8±0.15	6.2±0.07
CD (0.05)	T = NS S = 0.454 TXS = NS		
	Overall acceptability		
BH	7.9±0.27	7.3±0.14	6.9±0.19
AH	8.1±0.29	6.8±0.15	6.3±0.13
CD (0.05)	T = NS S = 0.406 TXS = NS		

Each observation is mean±SD of 7 replications

BH Before heating of milk; AH After heating of milk

T stage of addition of turmeric S Storage period

Visible mould growth was observed on the 12th day of storage in all the samples

turmeric added before heating of milk. However, trend of the scores was reversed upon storage of the samples. The samples of stored paneer obtained in case of turmeric added before heating of milk scored higher than the samples of paneer obtained in case of turmeric added after heating of milk. Therefore, in further course of study it was decided to add turmeric in milk before heat treatment.

There could be two possible reasons for better performance of turmeric in enhancing the shelf life of paneer, when added before heat treatment of milk during preparation of paneer. Heating milk in presence of turmeric either enhances the bactericidal action of turmeric or increases the susceptibility of the bacteria to turmeric. No data are reported in the literature for effect of stage of addition of turmeric on extending the shelf life of paneer. However, similar observations were made by Hurst (1981) and Maisnier-Patin et al. (1995) in case of nisin, wherein better action of nisin is reported in reducing the growth of bacteria when it was used in combination with heat treatment. According to Maisnier-Patin et al. (1995) nisin enhances the effect of moderate heat and had a greater effect when used along with heat. Taking into account that the mode of action of nisin involves pore formation in the cell membrane, the dramatic increase in thermal destruction of bacteria in the presence of nisin can be attributed to a

synergistic effect of heat and nisin on the membrane damage, leading to rapid efflux of cytoplasmic constituents viz., ATP, amino acids, potassium, etc. However, according to Hurst (1981) it could be merely due to an increase in adsorption of nisin on the cell wall, as a result of modification of its surface properties brought about by heat which increases hydrophobicity by structural changes or loss of some cell wall components. In turn, this increased adsorption would result in better activity of nisin.

Chemical composition of paneer

The data obtained for chemical composition of fresh paneer sample with 0.4 % turmeric contained 50.40 % moisture, 27.77 % fat, 18.41 % protein, 1.67 % ash and 1.75 % lactose and of fresh paneer sample with 0.6 % turmeric contained 50.02 % moisture, 27.73 % fat, 19.15 % protein, 1.60 % ash and 1.40 % lactose. Control paneer had 51.56 % moisture, 26.88 % fat, 18.41 % protein, 1.53 % ash and 1.62 % lactose. The fat-in-dry-matter (FDM) in fresh paneer sample with 0.4 % turmeric was 55.98 and in fresh paneer with 0.6 % turmeric was 55.48. The FDM of control was 55.49 %. The literature on chemical composition of paneer indicates that the moisture, fat, protein, lactose and ash content of paneer vary from 47.68 to 59.70, 22.90 to 27.00, 16.81 to 33.27, 2.07 to 2.61 and 1.30 to 2.18 % respectively (Bhattacharya et al. 1971; Pal and Yadav 1991; Singh et al. 1991; Dhole et al. 2009). Therefore, in the present study data obtained for chemical composition of paneer are well within those reported in the literature. According to PFA (2004), paneer shall not contain more than 70.0 % moisture and milk fat content shall not be less than 50.0 % of the dry matter. According to BIS (1983) moisture content in paneer shall be 60.0 % by mass (max) and milk fat content shall be 50.0 % by mass on dry matter basis (min). Therefore, the samples of paneer prepared in the present study fulfilled both the PFA and the BIS requirements for the chemical composition.

Evaluating the effectiveness of turmeric in extending the shelf life of paneer

Addition of turmeric before heat treatment of milk markedly reduced taste of raw turmeric in paneer. Therefore, it was decided to incorporate turmeric at a higher rate i.e. 0.6 % concentration of turmeric along with 0.4 % and control (0 % addition). Each block of paneer was cut in to four equal parts and packed separately in to PET/LDPE film pouches and stored at 7±1 °C for 12 days. The prepared samples of paneer were subjected to sensory evaluation by panel of judges using 9-point hedonic scale when fresh, after 6 days and there after at an interval of every 3 days up to 12 days of storage.

The results obtained for changes in sensory attributes of fresh and stored samples of paneer are presented in Table 3.

Table 3 Effect of concentration of turmeric (added to milk before heat treatment) on sensory attributes of paneer during storage at 7 ± 1 °C

Concentration (%)	Storage period (days)			
	0	6	9	12
	Flavour			
0.4	8.2±0.10	6.7±0.12	6.9±0.21	Slime formation
0.6	8.0±0.22	7.7±0.19	7.5±0.16	6.5±0.21
CD (0.05)	C = 0.36, S = 0.45, CXS = 0.63			
	Colour and appearance			
0.4	8.2±0.24	6.7±0.34	6.9±0.21	Slime formation
0.6	8.0±0.27	7.6±0.32	7.5±0.19	6.5±0.27
CD (0.05)	C = NS, S = 0.24, CXS = NS			
	Body and texture			
0.4	8.1±0.30	7.2±0.08	7.8±0.16	Slime formation
0.6	8.0±0.21	7.4±0.21	7.8±0.20	7.2±0.16
CD (0.05)	C = NS, S = 0.26, CXS = NS			
	Overall acceptability			
0.4	8.3±0.10	7.7±0.15	6.8±0.15	Slime formation
0.6	8.0±0.17	8.0±0.48	7.7±0.20	6.6±0.30
CD (0.05)	C = 0.35, S = 0.43, CXS = 0.61			

Each observation is mean $\pm$ SD of 6 replications; C concentration of turmeric; S storage period

Concentration and storage period had significant effect on flavour score of the paneer. The interaction between concentration and storage period was also significant ($P<0.05$). The changes in colour and appearance and body and texture scores revealed that storage period had significant ($P<0.05$) effect on these parameters, whereas, effect of concentration was non significant ($P>0.05$). The interaction between concentration and storage period was also non significant. The concentration of turmeric and storage period had significant effect on overall acceptability score of the paneer. The interaction between concentration and storage period was also significant ($P<0.05$). Fresh samples of paneer with 0.4 % turmeric scored slightly better for all the sensory attributes compared to samples of paneer with 0.6 % turmeric. However, during storage, samples of paneer with 0.6 % turmeric scores slightly better for all the sensory attributes compared to samples of paneer with 0.4 % turmeric. On 12th day of storage development of off flavour and/or slime formation was noticed in the samples of paneer with 0.4 % of turmeric. Sensory score of paneer with 0.6 % turmeric remain acceptable on 12th day of storage; however, these samples were found spoiled on 15th day of storage. It was found that control had a shelf life of 7 days when stored at 7 ± 1 C.

Changes in chemical characteristics

The fresh and stored samples of paneer were analyzed for chemical characteristics viz., acidity, free fatty acids content, soluble nitrogen content and peroxide value. The data obtained for chemical changes in paneer during storage at 7 °C are presented in Table 4.

Acidity

The data obtained for changes in acidity content of paneer during storage at 7 °C are presented in Table 4. The average acidity (as % lactic acid) of the fresh control samples of paneer was 0.55 %. The acidity of paneer was reported to vary from 0.20 to 1.17 % (Sachdeva and Singh 1990a). However, these are extreme range of the values, but most of the reports (Kumar and Bector 1991; Venkateswarlu et al. 2003; Yellamanda et al. 2006) suggest as normal range of 0.47–0.59 %. Therefore, acidity value of paneer in the present study was well within the reported normal range. It is surprising to notice that addition of turmeric to paneer decreased the acidity of paneer. This effect may be attributed to possible alkaline nature of turmeric. To test the nature of turmeric, solution of 0.012 g turmeric (equivalent to the amount present in 2 g of paneer taken for acidity determination) was prepared in distilled water and titrated against standard 0.1 N H_2SO_4 using methyl orange as an indicator. A titer value of 0.4 ml was obtained which indicates the alkaline nature of turmeric.

The acidity of all the samples tended to rise slightly on 6th day of the storage. Whereas, visible mold growth observed on the control samples of paneer and development of off flavour and/or slime formation was noticed in the samples of paneer with 0.4 % of turmeric (added to milk before heat treatment). However, samples of paneer with 0.6 % turmeric were found spoiled on 15th day of storage. Kumar and Bector (1991) reported that the initial titratable acidity, 0.54 %, of control samples increased slowly during storage and reached 0.9 % on

Table 4 Effect of turmeric (added to milk before heat treatment) on some chemical parameters of paneer during storage at 7±1 °C

Concentration (%)	Storage period (days)		
	0	6	12
Acidity (% lactic acid)			
0.0	0.55±0.01	0.61±0.01	0.63±0.01 ^a
0.4	0.52±0.00	0.59±0.01	0.59±0.01 ^b
0.6	0.50±0.01	0.58±0.00	0.60±0.02
CD (0.05) C = 0.02, S = 0.02, CXS = NS			
Free fatty acids (% oleic acid)			
0.0	0.03±0.01	0.04±0.01	0.07±0.01 ^a
0.4	0.03±0.01	0.04±0.00	0.06±0.01 ^b
0.6	0.02±0.00	0.03±0.00	0.06±0.01
CD (0.05) C = 0.01, S = 0.01, CXS = NS			
Soluble nitrogen (%)			
0.0	0.10±0.01	0.19±0.02	0.27±0.02 ^a
0.4	0.11±0.00	0.15±0.01	0.2±0.01 ^b
0.6	0.11±0.01	0.14±0.00	0.16±0.00
CD (0.05) C = 0.01, S = 0.02, CXS = NS			
Peroxide value (ml of 0.002 N Na ₂ S ₂ O ₃ /g)			
0.0	0.0	0.06±0.01	0.09±0.0 ^a
0.4	0.0	0.03±0.0	0.07±0.0 ^b
0.6	0.0	0.02±0.0	0.05±0.0
CD (0.05) C = 0.01, S = 0.01, CXS = NS			

Each observation is mean±SD of 6 replications; ^a VMG visible mold growth

^b Slime observed on surface of paneer

C concentration of turmeric; S storage period

day four and thereafter declined and reached a value of 0.59 % on day ten. However, Venkateswarlu et al. (2003) found that acidity of paneer increased gradually from 0.224 to 0.472 % at the end of ninth day, followed by sharp increase towards end of storage. According to Sachdeva and Singh (1990a) the cycle of increase and decrease in acidity value of paneer during storage is similar to that observed in case of feed back inhibition in biological systems. It involves production and subsequent utilization of some of the acidic and/or basic compounds as a result of microbial activity. The observations of present study corroborate with those reported by Kumar and Bector (1991). Bajwa et al. (2004) prepared paneer samples by incorporating 10 % coriander (*Coriandrum sativum*) or mint (*Mentha piperita*) leaves. The acidity increased significantly ($P<0.01$) with advancement in storage period; the rate of increase was lower in samples containing coriander or mint leaves and was further reduced on incorporation of salt. However, no data are reported in the literature for effect of turmeric on acidity of paneer during storage.

Free fatty acids (FFA)

The data obtained for changes in FFA content of paneer (as % oleic acid) during storage at 7 °C are presented in Table 4. It is evident from the data that addition of turmeric slightly reduced the FFA content of paneer. Such effect may be attributed to alkaline nature of turmeric.

Kumar and Bector (1991) reported that the initial level of FFA in control samples was slightly higher than the samples containing 0.05 % TBHQ and BHA, individually or in combination. Venkateswarlu et al. (2003) reported FFA content of 0.11 (% oleic acid) and Gokhale and Pandya (2009) reported a value of 0.04 %. Therefore, FFA content of paneer in the present study was in agreement with those reported by Gokhale and Pandya (2009).

During storage the FFA content of all the samples tended to raise slightly on 6th day of the storage. However, the rate of increase was lower in case of turmeric containing samples. On the 12th day of storage, free fatty acids content of samples of paneer with 0.6 % turmeric declined slightly. Whereas, visible mold growth observed in the control samples of paneer and development of off flavour and/or slime formation was noticed in the samples of paneer with 0.4 % of turmeric on the 12th day of storage. However, samples of paneer with 0.6 % turmeric was found spoiled on the 15th day of storage. Kumar and Bector (1991) reported that the free fatty acids content of paneer increased from 0.28 to 0.5 on 22 days of storage at 5 °C. Increase in FFA content during storage was also observed in the present study. However, no data are reported in the literature for effect of turmeric on free fatty acid content of paneer during storage.

Soluble nitrogen

The data obtained for changes in soluble nitrogen content of paneer during storage at 7±1 °C are presented in Table 4. The results indicated that the soluble nitrogen content of fresh control samples of paneer and the samples with 0.4 and 0.6 % turmeric was almost similar. Thus addition of turmeric had no effect on soluble nitrogen content in fresh samples of paneer. Sachdeva and Singh (1990a) reported the soluble nitrogen content of paneer sample dipped in brine was 0.10 %. Kumar and Bector (1991) found that the soluble nitrogen content was 0.06 % in laboratory made paneer. Soluble nitrogen content of paneer in the present study was in general agreement with those reported in the literature.

A sharp and highest increase in soluble nitrogen content was observed in control samples of paneer on 6th day of storage (0.2 %). In the samples of paneer with 0.4 and 0.6 % turmeric soluble nitrogen content remained almost constant

on the 6th day of the storage. On the 12th day of storage soluble nitrogen content of samples of paneer with 0.6 % turmeric increased slightly. Whereas, visible mold growth observed in the control samples of paneer and development of off flavour and/or slime formation was noticed in the samples of paneer with 0.4 % of turmeric on the 12th day of storage. The samples of paneer with 0.6 % turmeric were found spoiled on the 15th day of storage. Sachdeva and Singh (1990a) observed considerable increase in soluble nitrogen content of paneer up on storage for 6 days at 8–10 °C, wherein the initial value of 0.1 % increased to 0.24 %. Kumar and Bector (1991) found that the soluble nitrogen content increased from 0.06 to 0.08 on 22 days of storage at 5 °C. Increase in soluble nitrogen content during storage was also observed during the present study. However, no data are reported in the literature for effect of turmeric on soluble nitrogen content of paneer during storage.

Peroxide value

The data obtained for changes in peroxide value (ml of 0.002 N $\text{Na}_2\text{S}_2\text{O}_3/\text{g}$) of paneer during storage at 7 ± 1 °C are presented in Table 4. The peroxide value of all the fresh samples of paneer was 0.0. Boghra et al. (1997) also reported that the peroxide value of fresh paneer sample was 0.0.

The peroxide value of the samples of paneer with 0.4 and 0.6 % turmeric was lower than that of the control samples. On 12th day of storage visible mold growth was observed in the control samples of paneer and development of off flavour and/or slime formation was noticed in the samples of paneer with 0.4 % of turmeric. However, samples of paneer with 0.6 % turmeric was found spoiled on 15th day of storage.

Boghra et al. (1997) studied the laboratory made paneer and simulated for approximate concentration of iron and copper based on market survey. The paneer was stored for 8 days at ≤ 10 °C. The peroxide value (ml of 0.002 N $\text{Na}_2\text{S}_2\text{O}_3/\text{g}$) of fresh control sample was 0.0, which increased to 0.173. Thus, values for increase in peroxide value of paneer on storage obtained in present study are in general agreement with those reported by these authors. However, no data are reported in the literature for effect of turmeric on peroxide value of paneer during storage.

Microbial count of paneer containing turmeric

The data obtained for changes in SPC, yeast and mold count and coliform count are presented in Table 5.

Standard plate count

It is evident from the Table that there was a sharp increase in the Standard Plate Count (SPC) on the 6th day of the storage, in control samples. However, the count declined in case of

Table 5 Changes in microbial quality (counts in log cfu/g) in paneer containing turmeric [added to milk before heat treatment at the rate of 0.4 % (w/w) on the basis of expected yield of paneer] during storage of paneer at 7 ± 1 °C

Storage period (days)	SPC		Yeast and mold	
	Control	Turmeric	Control	Turmeric
0	4.2±0.08	4.1±0.10	2.3±0.01	0.0±0.02
6	4.8±0.10	3.8±0.06	3.1±0.05	2.5±0.04
12	4.9±0.04	4.1±0.06	3.5±0.01	3.7±0.08
CD (0.05)	T = 0.16, S = 0.23, TXS = 0.15		T = 0.09, S = 0.13, TXS = 0.12	

T Treatment (with/without turmeric); S storage period

Each observation is mean±SD of 6 replications; *VMG Visible mold growth

Coliforms could not be detected in any of the samples during storage while visible mould growth was observed in control sample on the 12th day of storage

turmeric containing samples on the 6th day. On further storage up to the 12th day visible mold growth was found in control samples and in case of turmeric containing samples the SPC increased. Sachdeva and Singh (1990b) reported that total plate count of paneer treated with different dipping materials during storage. The fresh paneer had a total plate count of 10^1 to 10^3 per g which increased to the number of 10^4 to 10^6 per g regardless of treatment. Kumar and Bector (1991) reported the initial count of control, 3.0×10^3 increased to 2.8×10^5 per g on day four and 9.0×10^6 per g on day seven during storage at 15 °C. Fresh samples of both control and turmeric containing paneer met the standards prescribed by BIS for the SPC. On 12th day of storage, SPC of turmeric containing samples remained within BIS requirement.

Yeast and mold count

In case of the samples of paneer with turmeric the count was nil, which increased gradually up to 6th day on storage but sharp increase was observed on 12th day of storage. Sachdeva and Singh (1990b) found that the initial count of the paneer sample dipped in plain, chlorinated, buffered and acidified water and brine and acidified brine varied over a narrow range of 35×10^1 to 52×10^1 . The yeast and mold count at the time of spoilage in the respective samples ranged from 53×10^2 to 63×10^3 . Kumar and Bector (1991) analyzed the yeast and mold count of paneer samples and found that initial count increased from 10 per g to 50 per g after 4 days and 250 per g after 7 days of storage at 15 °C. Venkateswarlu et al. (2003) reported that yeast and mold count of paneer 2.45 per g. Dhole et al. (2009) evaluated seventy samples of fresh paneer from seven vendors of Ahmednagar City for microbiological quality. The yeast

and mold count in market samples of paneer ranged between 1×10^2 and 99×10^2 cfu per g.

Fresh samples of both control and turmeric containing paneer met the standards prescribed by BIS for the yeast and mold count. The samples containing turmeric, yeast and mold count remained within BIS requirement only up to 6th day of storage.

Coliform count

It is evident from the data presented in Table 5 that no coliform count was found in control and turmeric containing samples when fresh and even during the storage. Sachdeva and Singh (1990b) determined coliform count of paneer treated with different dipping materials and reported that the initial coliform count was not more than 3 to 4 in the first dilution of all the paneer samples and this increased to a maximum of 30 – 50 over the storage period. Kumar and Bector (1991) reported the initial level of coliform count of control increased from 90 per g to 3.5×10^3 per g after 4 days and 8.0×10^6 per g after 7 days of storage. Dhole et al. (2009) evaluated seventy samples of fresh paneer from seven vendors of Ahmednagar City for microbiological quality. The average coliform count in the market samples of paneer were found in the range of 12.6×10^3 to 23.2×10^3 cfu per g. However, effect of addition of turmeric on yeast and mold count during storage of paneer has not been reported.

Conclusion

It can be concluded from the study that turmeric is suitable for incorporation in paneer and also effective in extending the shelf life of paneer. The addition of turmeric in paneer at the rate of greater than 0.6 % significantly decreases the sensory score of paneer. Addition of turmeric at the rate of 0.6 % extends the shelf life of paneer up to 12 days on storage at 7 ± 1 °C.

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